Horseshoe Crab
Limulus Polyphemus

Management Unit: Maine - Florida

Common Name: Horseshoe crab; once called "horse-foot crabs" because of their semblance to a horse's hoof.

Interesting Facts:
*** Horseshoe crabs have existed for up to 400 million years, predating flying insects, dinosaurs and man.**
*** Horseshoe crabs are more closely related to spiders than crabs.**
***A female horseshoe crab will lay 90,000 eggs or more during a spawning cycle. From so many eggs, it is estimated that only about 10 horseshoe crabs will make it to adulthood.**

Stock Status: Unknown

Species Profile: Horseshoe Crab
New Assessment Finds Trends in Horseshoe Crab Populations Vary by Region

Introduction

Horseshoe crabs are at the epicenter of one of the most interesting marine resource management issues along the Atlantic coast. They play a vital ecological role in the migration of shorebirds from South America to the Arctic, as well as providing bait for commercial American eel and conch fisheries along the Atlantic coast of the United States. Additionally, their unique blood is used by the biomedical industry to produce Limulus Amoebocyte Lysate (LAL), an important tool for detecting contaminated medical devices and drugs. The challenge of fisheries managers is to ensure that horseshoe crabs are managed to meet all these diverse needs, while conserving the resource for the future. The recent stock assessment and external peer review concluded precautionary management is still warranted and that a new Adaptive Resource Management (ARM) framework should be used to inform managers' decisions.

Life History

Horseshoe crab distribution extends along the Atlantic coast from northern Maine to the Yucatan Peninsula and the Gulf of Mexico. The Delaware Bay supports the largest spawning population in the world. Adults either remain in estuaries or migrate to the continental shelf during the winter months. Migrations resume in the spring when the horseshoe crabs move to beach areas to spawn. Juveniles hatch from the beach environment and spend the first two years in nearshore areas.

Spawning usually coincides with the high tide during the full and new moon. Breeding activity is consistently higher during the full moon than the new moon and is also greater during the night. Adults prefer sandy beach areas within bays and coves that are protected from surf. Eggs are laid in clusters or nest sites along the beach with females laying approximately 90,000 eggs per year in different egg clusters.

The eggs play an important ecological role in the food web for migrating shorebirds. The Delaware Bay Estuary is the largest staging area for shorebirds in the Atlantic Flyway. An estimated 425,000 to one million migratory shorebirds converge on the Delaware Bay to feed and rebuild energy reserves prior to completing their northward migration.

Juvenile and adult horseshoe crabs feed mainly on mollusks, although they also prey on a variety of benthic organisms and vascular plants. The horseshoe crab must molt or shed its chitinous exoskeleton to grow and can increase size by up to 25 percent after each molt. Molting occurs several times during the first two

Photo courtesy of Sheila Eyler, USFWS

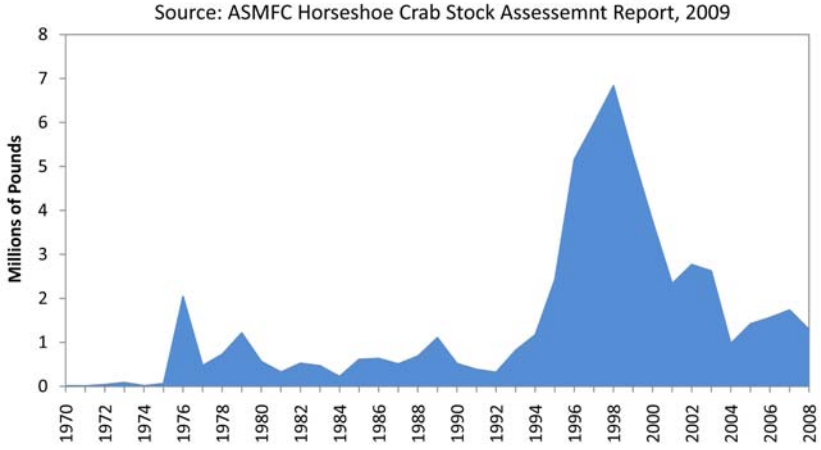
to three years of a horseshoe crab's life. As it grows larger, more time occurs between molts. It usually takes 17 molts to reach sexual maturity (9 – 12 years).

Commercial Fisheries & Biomedical Harvest

From the 1850s to the 1920s, between 1.5 and two million horseshoe crabs were harvested annually for fertilizer and livestock feed. Harvest dropped throughout the 1950s and ceased in the 1960s. Between 1970 and 1990, reported commercial harvest ranged from less than 20,000 pounds to greater than two million pounds annually.

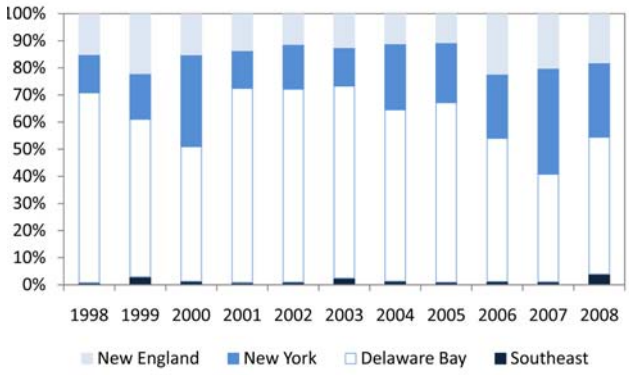
Since the mid- to late 1990s, commercial harvest has been sold primarily as bait for the American eel and whelk pot fisheries. Increased need for bait in the whelk fishery likely caused an increase in horseshoe crab harvest in the 1990s, with a peak of nearly six million pounds in 1997. Coastwide commercial landings for bait in 2009 were approximately 717,888 horseshoe crabs, almost a fourfold reduction in landings since 1998 (Figure 1). The reduction is partly due to regulation and partly because of decreased demand. Commercial fishermen have adopted new gear such as bait bags and cups allowing them to effectively catch eel and conch while using as little as a tenth of the bait.

Figure 1. Horseshoe Crab Coastwide Landings
Source: ASMFC Horseshoe Crab Stock Assessemnt Report, 2009



The majority of horseshoe crab harvest comes from the Delaware Bay Region, followed by the New York, New England, and Southeast Regions (Figure 2). Trawls, hand harvests, and dredges make up the bulk of commercial horseshoe crab bait landings. Discard mortality occurs in various dredge fisheries and may vary seasonally with temperature, impacting both mature and immature horseshoe crabs; however, the actual rate of discard mortality is unknown.

Figure 2. Percent of Total Landings by Region



Some states allow a minimal number of crabs to be retained for per-

Horseshoe Crab Assessment Q&A

What Data Were Used?

The horseshoe crab assessment used both fishery-dependent and independent data as well as information about horseshoe crab biology and life history. Fishery-dependent data come largely from commercial bait and biomedical fisheries, while fishery-independent data are collected through scientific research and surveys.

With regards to fishery-independent data, the horseshoe crab assessment used over 30 state and federal surveys to characterize trends in abundance of horseshoe crab. Nine surveys were located in the New England Region, six in the New York Region, 11 in the Delaware Bay Region, and five in the Southeast Region. The National Marine Fisheries Service trawl survey was associated with the Delaware Bay Region because the data used corresponded to tows taken south of Long Island and north of Albemarle Sound.

What Models Were Used?

Two trend-based methods (Trend Analysis and Autoregressive Integrated Moving Average) were used to assess all four regional stocks, with the peer review panel supporting ARIMA as the preferred stock assessment method for tracking horseshoe crab trends coastwide. Two additional methods (Surplus production model and Catch-survey analysis) were used to assess the Delaware Bay Region. The peer review panel supported catch-survey analysis as the preferred stock assessment method for horseshoe crab in Delaware Bay, but data limitations preclude its use in the other three geographic regions.

For several of the above methods, 1998 was used as the benchmark year for comparison of survey trends, assuming that abundance was relatively low in the year preceding implementation of the FMP. Not all surveys were used in each assessment method. Note that traditional age-based methods could not be used because there is no technique available to measure the ages of horseshoe crabs.

sonal use, but landings are not quantified. The limit for personal use is typically 25 crabs/person/day.

Horseshoe crabs are also collected by the biomedical industry to support the production of LAL (short for *Limulus* amoebocyte lysate), a clotting agent that aids in the detection of human pathogens in patients, drugs, and intravenous devices. No other procedure has the same accuracy as the LAL test. Blood from the horseshoe crab is obtained by collecting adults, extracting a portion of their blood, and releasing them alive. Following bleeding, most crabs are returned of the waters where they were captured. However, since 2004, states have the ability to enter bled crabs into the bait market and count those crabs against the bait quota. In recent years, the total estimate of horseshoe crabs caught for medical usage is around 500,000 per year on the Atlantic coast. Estimated mortality on biomedical crabs not counted against state bait quotas has increased from about 45,000 in 2004 to 63,000 in 2008.

Stock Status

The status of the stock is unknown largely due to the lack of long-term data sets for commercial landings and stock abundance. However, the 2009 peer-reviewed benchmark stock assessment indicates that the Delaware Bay horseshoe crab population is experiencing positive population growth. Increasing trends were most evident for juveniles, followed by adult males. A significant increase in adult females was observed in the Virginia Tech Benthic Trawl Survey. These patterns are indicative of population recovery, given that horseshoe crab females take longer to mature than males. Positive trends in horseshoe crab numbers are also being seen in the Southeast region.

In contrast, the stock assessment showed declining abundance in New York and New England. Declines in the New England population were also apparent in the 2004 assessment. However, declines in New York represent a downturn from the 2004 assessment. The Technical Committee believes decreased harvest quotas in Delaware Bay encour-

Regional Trends in Horseshoe Crab Abundance

Region	Time series duration of longest dataset	Conclusion about population change
New England	1978 - 2008	Declined
New York	1987 - 2008	Declined
Delaware Bay	1988 - 2008	Increased
Southeast	1993 - 2009	Increased

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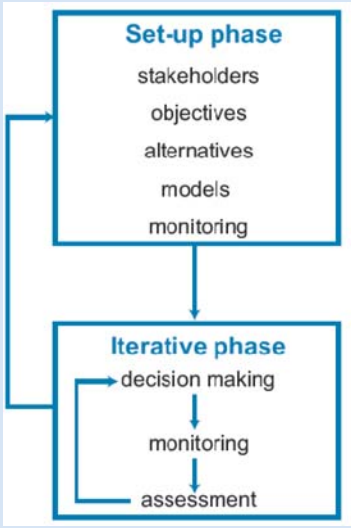
Adaptive Resource Management Framework

Horseshoe crab eggs are considered essential food for several shorebird species in the Delaware Bay, the second largest migratory staging area for shorebirds in North America. The 2004 horseshoe crab assessment suggested a framework be developed that linked management of horseshoe crab harvest to multispecies objectives, particularly red knot shorebird recovery. In 2007, the Commission Horseshoe Crab and US Fish and Wildlife Service Shorebird Technical Committees met jointly and formed a working group that was tasked with development of a multispecies Adaptive Resource Management (ARM) framework for Delaware Bay. The goal of the ARM framework was to transparently incorporate views of stakeholders and utilize predictive modeling to assess the potential consequences of multiple, alternative management actions in Delaware Bay.



After setting objectives and identifying alternative management actions, ARM involves several steps: 1) building models that make predictions about how a system will respond to management actions, 2) implementing management actions based on those predictions, 3) monitoring the ecosystem to evaluate the accuracy of model predictions, 4) inserting new data into the models to generating updated predictions, and 5) revising management actions as necessary to reflect the latest state of knowledge about the ecosystem. ARM is an iterative process that evolves continuously as new information is gathered and the effects of management actions are evaluated.

Within this ARM framework, a set of alternative multispecies models have been developed for the Delaware Bay Region to predict the optimal horseshoe crab harvest strategy that would still allow enough eggs to be available for red knot population needs. These models incorporate uncertainty in model predictions and will be updated with new information as monitoring progresses. Above figure illustrates the double loop learning process of adaptive management.

aged increased harvest in nearby regions. The Technical Committee recommends continued precautionary management to address effects of redirected harvest from Delaware Bay to outlying populations. Since the 2008 fishing season, New York and Massachusetts continue to adjust their regulations to address recent increased harvest in their respective waters. (See side-bar for additional information on the data and models used in the recent assessment.)

The 2009 peer review also included an evaluation of the multispecies Adaptive Resource Management (ARM) framework. The ARM framework includes modeling that links management of horseshoe crab harvest to multispecies objectives, particularly red knot shorebird recovery. It was developed jointly by the Commission, U.S. Fish and Wildlife Service, and U.S. Geological Survey in recognition of the importance of horseshoe crab eggs to several shorebird species in the Delaware Bay. Within the ARM framework, a set of alternative multispecies models have been developed for the Delaware Bay to predict the optimal horseshoe crab harvest strategy that would address the needs of red knot population as well as the fishing industry. Both the peer review panel and Horseshoe Crab Management Board accepted use of the ARM framework as a tool to provide guidance for the multispecies management of horseshoe crab. (See side-bar on page 6 for additional information on ARM Framework.)

Atlantic Coastal Management

In 1998, the Commission approved the Interstate Fishery Management Plan (FMP) for Horseshoe Crabs. The goal of the FMP is to conserve and protect the horseshoe crab resource by maintaining sustainable levels of spawning stock biomass, which ensures that the species can continue to occupy its role in the ecology of coastal ecosystems and provide for its continued use over time. Addendum I to the FMP, approved in February 2000, established individual state caps on horseshoe crab bait landings and recommended a harvest area closure in federal waters off of Delaware. On March 7. 2001, NOAA Fisheries established the Carl N. Shuster Jr. Horseshoe Crab Reserve, which encompasses nearly 1,500 square miles of federal waters off the mouth of Delaware Bay.

In March 2004, the Horseshoe Crab Management Board approved Addendum III in response to recommendations made by the U.S. Fish and Wildlife Service Shorebird Technical Committee. The addendum furthered the conservation of horseshoe crab and migratory shorebird populations in and around the Delaware Bay. Approved in May 2006, Addendum IV further restricted bait harvest in the Mid-Atlantic region. It was designed to maximize egg availability to migratory shorebirds in the Delaware Bay by prohibiting harvest of horseshoe crab prior to and during the peak spawning season for the crabs as well as the peak feeding period for shorebirds. Addendum V extends Addendum IV's provisions through fall of 2010.

Photo courtesy of Mary Hollinger, National Oceanic and Atmospheric Administration

In February 2010, the Management Board initiated a new addendum to establish a management program after Addendum V expires. The Draft Addendum will propose options to extend the current management measures under Addendum V as well as incorporate a number of options that have been included in the ARM framework. The Board will meet during the Commission's Spring Meeting in May 2010 to consider approval of the Draft Addendum for public comment.