



Introduction

This document summarizes the 2024 stock assessment update for horseshoe crab. The assessment is an update to the 2019 benchmark stock assessment and extends the fishery-independent and -dependent data for horseshoe crab through 2022, reruns the models, and determines stock status. The horseshoe crab assessment represents the most recent and best information on the status of the coastwide horseshoe crab stock for use in fisheries

management. This coastwide assessment is different from the Adaptive Resource Management (ARM) Framework, which evaluates the population in the Delaware Bay and recommends harvest levels with consideration for migratory shorebirds.

Management Overview

Horseshoe crab fisheries are managed solely by the Atlantic States Marine Fisheries Commission (Commission) through the 1998 Horseshoe Crab Fishery Management Plan (FMP). Addendum I (2000) to the FMP established a coastwide, state-by-state annual quota system to further reduce horseshoe crab landings. Addendum II (2001) established criteria for voluntary quota transfers between states.

Addendum III (2004) sought to further conserve horseshoe crab and migratory shorebird populations of red knot in and around the Delaware Bay by reducing horseshoe crab harvest quotas; implementing seasonal bait harvest closures in New Jersey, Delaware, and Maryland; and revising monitoring components for all jurisdictions. Addendum IV (2006) further limited bait harvest in New Jersey and Delaware to 100,000 crabs (male only) and required a delayed harvest in Maryland and Virginia. The provisions of Addendum IV were extended by Addendum V, and Addendum VI extended Addendum IV's measures through the 2013 fishing season.

Addendum VII (2012) implemented the Adaptive Resource Management (ARM) Framework for use during the 2013 fishing season and beyond. The Framework considers the abundance levels of horseshoe crabs and shorebirds in determining the harvest level for horseshoe crabs of Delaware Bay-origin. Addendum VIII (2022) adopted the revision to the ARM Framework that incorporated more data from the region and advanced the modeling approach.

Based on tagging, genetic studies, and the management of the species, the coastwide horseshoe crab stock is assessed as four populations: the Northeast (Maine-Rhode Island), New York (Connecticut-New York), Delaware Bay (New Jersey-Virginia), and Southeast Regions (North Carolina-Florida).

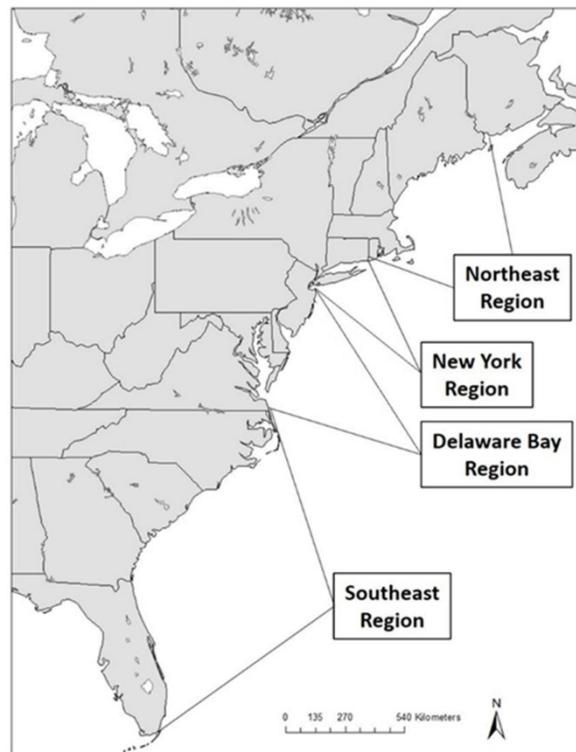
What Data Were Used?

The horseshoe crab stock assessment update extends the fishery-dependent and independent data and modeling approaches used in the 2019 benchmark. There are three sources of fishery-dependent data used in the stock assessment: bait landings,

biomedical harvest and mortality, and commercial discards from other fisheries. Fishery-independent data are collected through scientific research and surveys.

Commercial Data

Since 1998, states have been required to report annual landings to the Commission through the compliance reporting process and to the Atlantic Coastal Cooperative Statistics Program (ACCSP) Data Warehouse. Landings used in this assessment for 1998 through 2022 were validated by state agencies through ACCSP. Since the 2019 benchmark, coastwide landings decreased in 2020 due to the COVID-19 pandemic and then increased in 2021 and 2022 to levels similar to the recent years preceding 2020. Landings have remained well-below the coastwide quota since its implementation in 2000. Regionally, the majority of bait landings are harvested from the Delaware Bay region and are predominately males due to harvest restrictions from the ARM Framework.



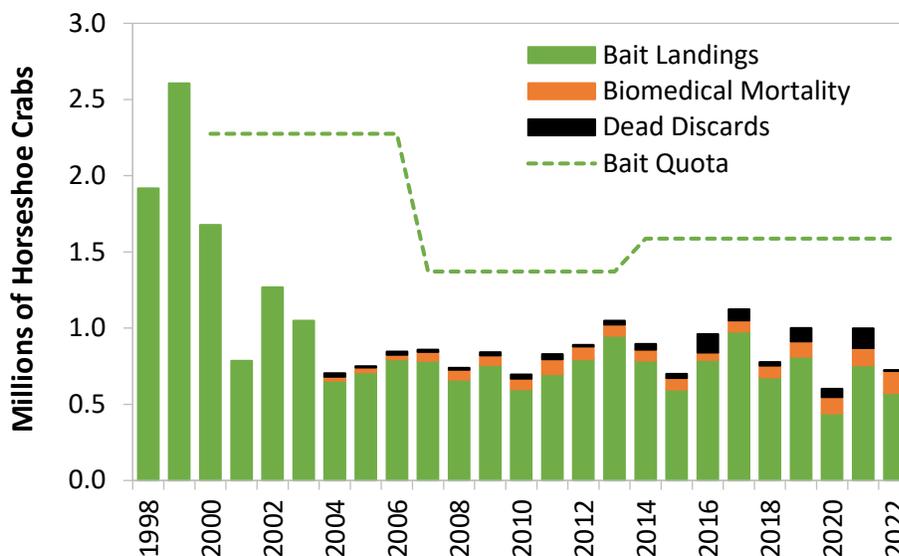
Map of the regional stock populations of horseshoe crab.

Horseshoe crabs are also collected by the biomedical industry to support the production of Limulus amebocyte lysate (LAL), a clotting agent in horseshoe crab blood cells that is used in the detection of pathogens in health patients, drugs, and intravenous devices. Blood from the horseshoe crab is obtained by collecting and extracting a portion of their blood. As required by the FMP, most crabs collected and bled by the biomedical industry are released alive to the water from where they were collected; however, a portion of these crabs die from the procedure. A mortality rate of 15% is applied to the number of horseshoe crabs bled and released alive to estimate the number of crabs that are presumed dead as a result of the capture and bleeding process. Biomedical use has increased since 2004, when reporting began, and the estimated mortality in 2022 is the highest in the time series.

Horseshoe crabs are also encountered in several other commercial fisheries. Discard mortality occurs in various dredge, trawl, and gillnet fisheries, impacting both mature and immature horseshoe crabs. Commercial discards were estimated for the Delaware Bay region as part of this assessment with data from the NOAA Fisheries Northeast Fisheries Science Center’s Northeast Fisheries Observer Program, although substantial uncertainty is associated with the estimates.

Coastwide Horseshoe Crab Removals

*Data collection for biomedical and commercial dead discards began in 2004



Fishery-Independent Surveys

The horseshoe crab assessment used several fishery-independent surveys to characterize trends in abundance of horseshoe crab. Two surveys were located in the New England region, four in the New York region, five in the Delaware Bay region, and five in the Southeast region. Recent trends are difficult to interpret since several surveys did not collect any or limited data in 2020-2021 due to the COVID-19 pandemic and two other surveys changed their sampling design (South Carolina Trammel Net and Southeast Area Monitoring and Assessment Program-South Atlantic) since 2019.

What Models Were Used?

A tagging model was developed to estimate survival and mortality rates. A trend analysis was used to assess regional and coastwide stocks and the catch multiple survey analysis was used to assess the Delaware Bay region. For the trend analysis, 1998 was used as the benchmark year for comparison of survey trends since it was the first year of FMP implementation.

Regional Survival Rates

Tagging model. Tagging data from the US Fish and Wildlife Service horseshoe crab database were explored by region to estimate survival rates. The highest survival rates (67%) were in Delaware Bay and the lowest survival rates (41%) were in the Southeast region. Tagging release and resight effort was greatly reduced in 2020-2022 due to COVID and reduced effort impacts survival estimates by accounting for “missing” tag recaptures as mortalities. As expected, survival rates declined and associated errors increased in nearly all regions but is likely an artifact of reduced tagging effort and should be reconsidered during the next benchmark when tagging resumes to pre-pandemic levels.

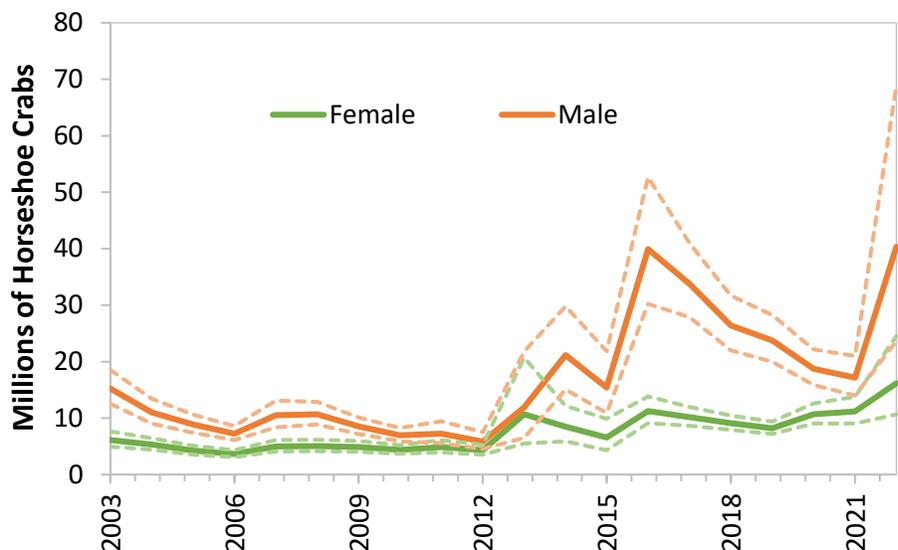
Coastwide and Regional Trend Analysis

Autoregressive Integrated Moving Average (ARIMA). A smooth trend was generated for each survey, then the probability that the most recent year’s survey value had dropped below the 1998 level was estimated. In the Northeast region, 1 out of 2 surveys were likely lower than the 1998 reference point. In the New York region, 3 out of 4 surveys were likely lower than the 1998 reference point. In the Delaware Bay region, 0 out of 5 surveys were likely lower than the 1998 reference point. Finally, in the Southeast region, no survey was below the 1998 reference point. Coastwide, 4 out of 13 surveys were likely below the 1998 reference point.

Delaware Bay Region Analysis

Catch multiple survey analysis (CMSA). The CMSA was developed in the 2019 benchmark stock assessment to estimate the Delaware Bay population, and further developed for the ARM Framework (ASMFC 2022). It is a simple, stage-based model that essentially sums the newly mature and mature crabs, subtracts harvest and accounts for natural mortality, and predicts the next

Delaware Bay Population Estimates with 95% confidence intervals



year’s population. The CMSA is not used for management in the coastwide stock assessment, although the results are included in the report. Based on the CMSA, there were approximately 40 million mature male and 16 million mature female horseshoe crabs in the Delaware Bay region in 2022. Mature female horseshoe crabs have been steadily increasing in the region since the implementation of the initial ARM Framework in 2012.

What is the Status of the Stock?

To date, no overfishing or overfished definitions have been adopted by the Management Board. Stock status is based on the percentage of surveys within a region (or coastwide) having a >50% probability of the final year being below the ARIMA reference point. “Poor” status was assigned when >66% of surveys meeting this criterion, “Good” status with <33% of surveys, and “Neutral” status with 34 – 65% of surveys. The stock status of the New England region was neutral; New York region was poor; Delaware Bay region was good; and Southeast region was good. The coastwide status includes surveys from all regions and indicates a good trend.

Applying these stock status criteria to summary ARIMA results from the last several stock assessments gives a general idea of how status has changed through time. The stock status of the Delaware Bay region, Southeast region, and coastwide have remained neutral and good through time. The status of the Northeast region has changed from poor to neutral. The status of the New York region has trended downward from good, to neutral, and to poor. These trends in time should be viewed with caution because the number of surveys in each region has changed in the current assessment and the index values have changed due to a change in methods for developing indices.

**Number of Surveys Below the Index-based 1998 Reference Point
in the Terminal (Final) Year of ARIMA Model**

Region	2009 Benchmark	2013 Update	2019 Benchmark	2024 update	2024 Stock Status
Northeast	2 out of 3	5 out of 6	1 out of 2	1 out of 2	Neutral
New York	1 out of 5	3 out of 5	4 out of 4	3 out of 4	Poor
Delaware Bay	5 out of 11	4 out of 11	2 out of 5	0 out of 5	Good
Southeast	0 out of 5	0 out of 2	0 out of 2	0 out of 2	Good
Coastwide	7 out of 24	12 out of 24	7 out of 13	4 out of 13	Good

Data and Research Needs

Maintaining fishery-independent surveys and tagging efforts is important for the continued assessment of horseshoe crabs coastwide. Horseshoe crab assessments would be improved by expanding data collection and analysis of current fishery-independent surveys. Implementing new surveys that target horseshoe crabs throughout their full range would reduce uncertainty about horseshoe crab stock status. Better characterization of discards, landings, and discard mortality by gear type would also improve future assessments. Further development of the CMSA, or other stage-based model, and biological reference points coastwide are priorities that will require additional data collection and modeling efforts. Re-examining stock structure and re-running the tagging model when tagging efforts return to normal levels are priorities added in this stock assessment update.

Whom Do I Contact for More Information?

Atlantic States Marine Fisheries Commission
 1050 N. Highland Street
 Arlington, VA 22201
 703.842.0740 | info@asmfc.org

Glossary

Adaptive Resource Management (ARM): a structured, iterative process for decision making in the face of uncertainty whereby predictive population or ecosystem models are regularly updated with new information from scientific monitoring programs and associated management plans are adjusted accordingly.

Autoregressive Integrated Moving Average (ARIMA): a data analysis method that generates smooth trends in abundance indices and estimates the probability that an index has dropped below a specified level.

Catch multiple survey analysis (CMSA): a stock assessment method that divides the population into two or more life stages, then uses relative catch of animals in those stages within multiple surveys over time to estimate population abundance and fishing mortality.

References

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