Research Priorities and Recommendations to Support Interjurisdictional Fisheries Management

HORSESHOE CRAB

(Full Citation: Atlantic States Marine Fisheries Commission. 2019. Horseshoe Crab Benchmark Stock Assessment. Arlington, VA. 296 pp.)

* * While all recommendations are high priority, the first recommendation is the highest priority.

2019 Benchmark Stock Assessment Recommendations

Future Research

- Determine relationship between age, stage, and size for horseshoe crabs.
- Compare densities of horseshoe crabs nearshore, offshore, and in bays, compare different stages (i.e., primiparous and multiparous), and look at movements among embayments within regions (i.e., around Cape Cod, Long Island).
- Characterize the proportion of states' landings that comprise crabs of Delaware Bay origin. This can be done through a directed tag/release study, genetics/microchemistry study, or both.
- Collect more life history information, particularly for juveniles, on growth, molt timing, and distribution.
- Evaluate the effect of warming temperatures on distribution and timing of spawning for horseshoe crabs.
- Address the issue of gear saturation for spawning beach surveys and/or explore analyses that would be less sensitive to gear saturation. Explore the methodology and data collection of spawning beach surveys and the ability of these surveys to track spawning abundance.
- Determine if there is illegal take-and-use at sea, transfer at sea, and poaching from spawning areas for horseshoe crabs and estimate the amount if possible.

Data Collection

- Continue to fund and operate the full Virginia Tech Trawl Survey annually.
- Conduct a gear efficiency study of the Virginia Tech Trawl Survey given the importance of using swept-area estimates of abundance in modeling the Delaware population.
- Better characterize the discards, landings, and discard mortality by gear.
- Increase the priority of maintaining and managing horseshoe crab data in and among states, both fishery-dependent and –independent, and improve communication between data providers.
- Continue current biosampling for sex and weight and expand where possible.

- Develop a standardized biosampling protocol to cover different seasons and obtain weights, ages, stages, and widths of horseshoe crabs using a random sampling design.
- Expand or implement fishery-independent surveys (e.g., spawning, benthic trawl, tagging) to target horseshoe crabs throughout their full range including estuaries. Highest priority should be given to implementing directed surveys in the Northeast and New York regions.
- Collect sex and stage data in fishery-independent surveys. Surveys should consider using similar methods as the Virginia Tech Trawl Survey and collect biological data by sex and stage, particularly by primiparous and multiparous.
- Continue to evaluate biomedically bled crabs' mortality rates. Consider a tagging study of biomedically bled horseshoe crabs to obtain relative survival and collaborations between researchers and biomedical facilities that would result in peer-reviewed mortality estimates.
- Maintain consistent data collection and survey designs for spawning beach surveys each year and encourage spawning beach surveys to conduct the data collection for the survey and tagging resights separately.

Assessment Methodology

- The ARM working group should consider using the population estimates from the CMSA model as an input to the ARM model as well as estimated mortality from discards and the biomedical industry.
- Further develop the catch-survey analysis and apply assessment modeling beyond the Delaware Bay region, which would require more stage-based data collection.
- Develop a stage-based or length-based model specific for horseshoe crabs that addresses their life history characteristics.
- Estimate the survival of early life stages (e.g., age-zero, juveniles) and growth rates.
- Explore the possibility of using a delay-difference model for future assessments. Because of the life history of horseshoe crab, this would require 20-30 years of data before it could be developed.
- Continue to evaluate tagging data by fitting capture-recapture models that include a short-term (1 year) bleeding effect, account for spatial distribution of harvest pressure, account for capture methodology, and account for disposition of recaptured tagged individuals. Potential methodological approaches include use of time-varying individual covariates to indicate which crabs are 1 year from bleeding and use of hierarchical models to estimate interannual variation in survival within time periods defined by major regulatory changes.

HORSESHOE CRAB: Adaptive Resource Management Research Recommendations for the Delaware Bay Region

(Full Citation: Atlantic States Marine Fisheries Commission. 2021. Revision to the Framework for Adaptive Management of Horseshoe Crab Harvest in the Delaware Bay Inclusive of Red Knot Conservation. Arlington, VA. 237 pp.)

Future Research

- Evaluate the effect of climate change on horseshoe crabs and red knots. This includes the effects of warming temperatures, sea level rise, and storm frequency and intensity on the timing and duration of spawning, movement of crabs into and out of Delaware Bay, and effects on spawning habitat. For red knots, this includes effects of climate change on breeding conditions in the arctic and resulting recruitment of red knots.
- Incorporate potential climate change effects into the optimization (e.g., predicted trends in arctic snow cover).
- Evaluate the relationship between horseshoe crab egg density on spawning beaches and abundance of horseshoe crabs in the bay-wide spawning survey and total population estimates derived from the catch multiple survey analysis.
- Improve the understanding of horseshoe crab recruitment for the purpose of updating the stock-recruitment relationship.
- Continue evaluation of catchability and factors influencing catchability of the Virginia Tech horseshoe crab trawl survey.
- Address the issue of gear saturation for spawning beach surveys and/or explore analyses that would be less sensitive to gear saturation. Explore the methodology and data collection of spawning beach surveys and the ability of these surveys to track spawning abundance.
- Quantify the amount of contemporary suitable horseshoe crab spawning habitat in the Delaware Bay.
- Further explore the multi-state mark-recapture analysis of red knot tagging data to estimate the probability of gaining weight and survival as a function of horseshoe crab abundance. Examine the effects of tagging biases, time periods of stopover, short- versus long-distance migrants, and selection of states (i.e., weight thresholds).
- Evaluate the proportion of New York bait landings that could be comprised of Delaware Bay-origin crabs and the movement between the two regions.
- If possible, include other sources of horseshoe crab removals (e.g., illegal take, poaching) in the CMSA. Other sources of removals are currently unknown, but can be added in the future if quantified.

Data Collection

- Continue funding and support for the annual Virginia Tech horseshoe crab trawl survey. Consider increasing the sampling effort within the Delaware Bay region or expanding the survey along the Atlantic coast if future funding allows.
- Better characterize horseshoe crab discards in other commercial fisheries and refine estimates of discard mortality.
- Continue to collect horseshoe crab sex and stage (primi- and multiparous stages) information from the Delaware Bay Adult Trawl Survey and the New Jersey Ocean Trawl Survey.
- Continue to evaluate biomedically bled crabs' mortality rates and effects on spawning behavior. Consider a tagging study of biomedically bled horseshoe crabs to obtain relative survival and collaborations between researchers and biomedical facilities that would result in peer-reviewed mortality estimates.
- Maintain consistent data collection and survey designs for spawning beach surveys each year.
- Increase effort for tagging resights for horseshoe crabs.
- Improve estimates of counting error during red knot aerial surveys by recording and maintaining records of additional information such as observer ID, tide state, and weather conditions. The integration of simultaneous ground count data or a double-observer method could also be used to improve this component of the IPM.

Data analysis and modeling

- Update horseshoe crab stock-recruitment relationships as more data become available and refine methodologies to characterize uncertainty.
- Update parameters describing the influence of horseshoe cabs on red knot survival and recruitment though re-fitting the red knot integrated population model to new data.
- Integrate red knot "proportion marked" data into the IPM so that analyses conducted to determine the state of the system can be used to update model parameters with no additional effort.
- Investigate alternative utility functions for red knots with additional stakeholder input.
- Continue to evaluate horseshoe crab tagging data by fitting capture-recapture models that include a short-term (1 year) bleeding effect, account for spatial distribution of harvest pressure, account for capture methodology, and account for disposition of recaptured tagged individuals. Potential methodological approaches include use of time-varying individual covariates to indicate which crabs are 1 year from bleeding and use of hierarchical models to estimate interannual variation in survival within time periods defined by major regulatory changes.
- Explore the possibility of modeling stopover persistence as a function of boreal-wintering area of marked birds using observations away from Delaware Bay.