Atlantic States Marine Fisheries Commission

ADDENDUM VII TO THE INTERSTATE FISHERY MANAGEMENT PLAN FOR HORSESHOE CRABS

ADAPTIVE RESOURCE MANAGEMENT FRAMEWORK

ASMFC Vision Statement:
Healthy, self-sustaining populations for all Atlantic coast fish species or successful restoration well in progress by the year 2015

Approved February 2012

1.0 Introduction

The Atlantic States Marine Fisheries Commission's (ASMFC) Horseshoe Crab Management Board (Board) approved the Interstate Fishery Management Plan for Horseshoe Crabs (FMP) in October 1998. The goal of the FMP includes management of horseshoe crab populations for continued use by current and future generations of the fishing and non-fishing public, including the biomedical industry, scientific and educational researchers; migratory shorebirds; and, other dependent fish and wildlife, including federally listed sea turtles. ASMFC maintains primary management authority for horseshoe crabs in state and federal waters. The management unit for horseshoe crabs extends from Maine through the east coast of Florida.

Additions and changes to the FMP have been adopted by the Board through various addenda. The Board approved Addendum I (2000), establishing a coastwide, state-by-state annual quota system to reduce horseshoe crab landings. Addendum I also includes a recommendation to the federal government to create the Carl N. Shuster Jr. Horseshoe Crab Reserve. The Board approved Addendum II (2001), establishing criteria for voluntary quota transfers between states. Addenda III (2004) and IV (2006) required additional restrictions on the bait harvest of horseshoe crabs of Delaware Bay-origin and expanded the biomedical monitoring requirements. Addenda V (2008) and VI (2010) extended the restrictions within Addendum IV. The provisions of Addendum VI are set to expire after April 30, 2013. If allowed to expire without additional action, the FMP would revert back to the Addendum III requirements unless modifications are enacted.

Addendum VII establishes a management program for the Delaware Bay Region (i.e., coastal and bay waters of New Jersey and Delaware, and coastal waters only of Maryland and Virginia).

2.0 Management Program

2.1 Statement of the Problem

Addendum VII responds to the ongoing public concern regarding the horseshoe crab population and its ecological role in the Delaware Bay. The 2009 horseshoe crab stock assessment found increases in crab abundance in the Southeast and Delaware Bay Regions and decreases in abundance in the New York and New England Regions, over the respective time series. Following the 2008 fishing season, New York and Massachusetts adjusted their regulations to account for the existing and projected declines in abundance and increased harvest pressure resulting from stricter harvest restrictions in the Delaware Bay during the early to mid-2000s.

While horseshoe crab abundance in the Delaware Bay Region continues rebuilding, the red knot (*rufa* subspecies), one of many shorebird species that feed on horseshoe crab eggs, is at low population levels. Red knots have shown no sign of recovery (Niles et al. 2008) despite a nearly four-fold reduction in horseshoe crab landings since 1998 (Figure 1). Technical advisors recommend continued precautionary management.

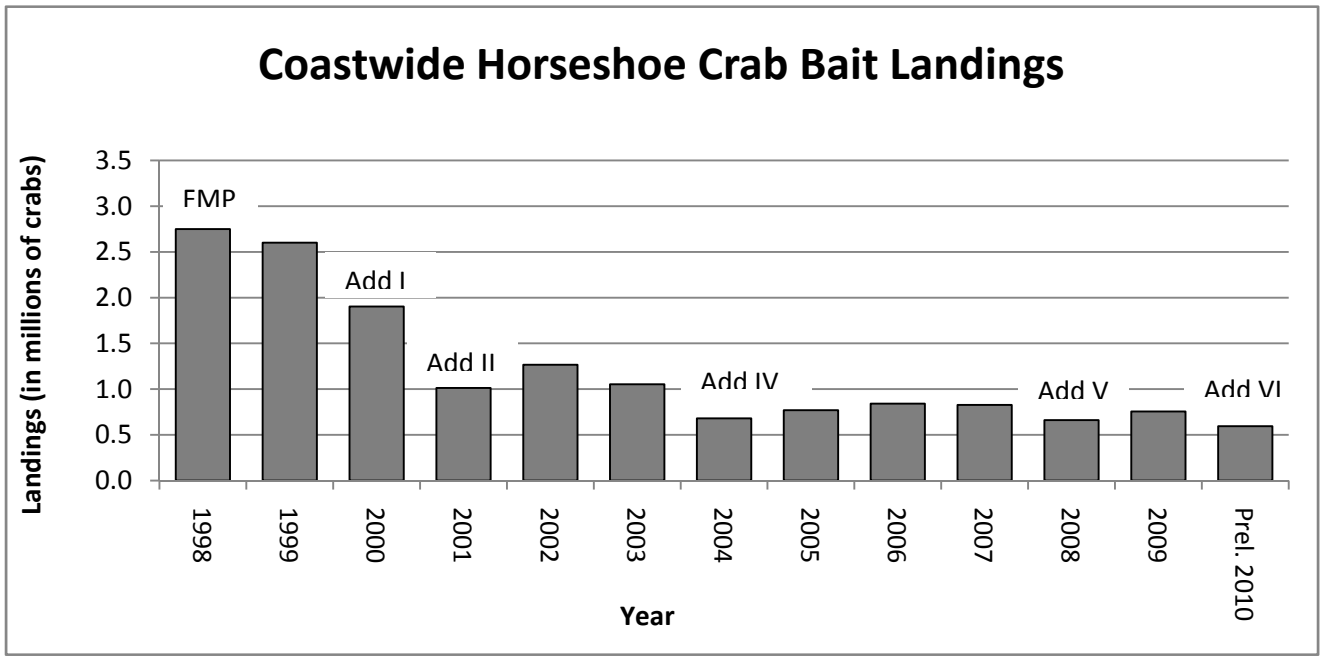

Figure 1. Atlantic Coastwide Landings of Horseshoe Crabs for Bait

2.2 Background

Provisions of Addendum VI were set to expire after April 30, 2013. In order to adopt provisions through the addendum process and avoid a reversion of management to Addendum III, the Board adopted Addendum VII at its February 2012 meeting. The 2009 horseshoe crab stock assessment and 2011 peer review reports provided managers information and recommendations to guide their decision making. In addition, an Adaptive Resource Management (ARM) Framework was completed and accepted by the peer reviewers and Board in 2009. The ARM Framework is designed to assist managers with future horseshoe crab harvest regulations by accounting for multiple species effects, focusing on red knot rebuilding in the Delaware Bay Region.

2.2.1 ARM Framework

A goal of the ARM Framework is to transparently incorporate the views of stakeholders along with predictive modeling to assess the potential consequences of multiple, alternative management actions in the Delaware Bay Region.

The ARM process involves several steps: 1) identify management objectives and potential actions, 2) build alternative predictive models with confidence values that suggest how a system will respond to these management actions, 3) implement management actions based on those predictive models, 4) monitor to evaluate the population response to management actions, validate the model predictions, and provide timely feedback to update model confidence values and improve future decision making, 5) as necessary, incorporate new data into the models to generate updated, improved predictions, and 6) revise management actions as necessary to reflect

the latest state of knowledge about the ecosystem. The ARM Framework is an iterative process that adapts to new information and success of management actions (Figure 2).

Within this ARM Framework, a set of alternative multispecies models have been developed for the Delaware Bay Region to predict the optimal strategy for horseshoe crab bait harvest. These models account for the need for successful red knot stopover feeding during migrations through the region. These models incorporate uncertainty in model predictions and will be updated with new information as monitoring and management progress (Figure 2).

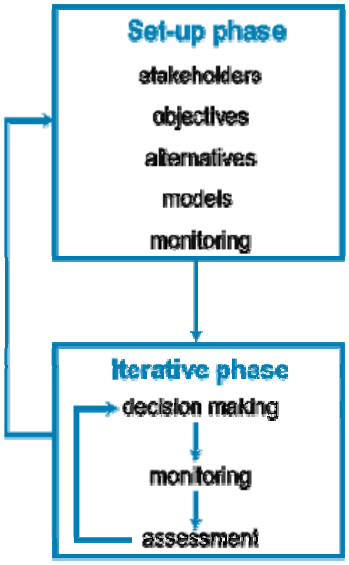

Figure 2: Double loop learning process of adaptive management (Williams et. al 2007)

The current harvest packages for horseshoe crab bait harvest, developed through the set-up phase, are:

Package 1) Full harvest moratorium on both sexes
Package 2) Harvest up to 250,000 males and 0 females
Package 3) Harvest up to 500,000 males and 0 females
Package 4) Harvest up to 280,000 males and 140,000 females
Package 5) Harvest up to 420,000 males and 210,000 females

The numbers of horseshoe crabs in the alternatives listed above are totals for the Delaware Bay Region, and not per state. Harvest package #4 approximately reflects current bait harvest allowance in the region.

2.3 Allocation of the ARM harvest output

The ARM Framework incorporates horseshoe crabs from the Delaware Bay Region as one unit. The modeling and optimization portions of the Framework do not address distribution and allocation of the harvest among the four Delaware Bay states. Thus, allocation is addressed in this document. Based on tagging (Swan 2005, USFWS 2011) and genetic analysis (Pierce et al. 2000, Shuster 1985), there is very little exchange between Chesapeake Bay and Delaware Bay

horseshoe crabpopulations. However, there is movement of horseshoe crabs between coastal embayments (from New Jersey through Virginia) and Delaware Bay (Shuster 1985).

An allocation model for the four Delaware Bay states was developed to allocate the optimized harvest output by the ARM Framework and uses the options in Section 2.4.

2.4 Management using the ARM Framework

The annual specification process will determine the following year's ($t + 1$) harvest requirements by populating the ARM models with horseshoe crab data from the previous year ($t - 1$) and shorebird data from the current year (t). This exercise is expected to occur at the Commission's Summer meeting but could occur at the Commission's annual meeting.

Implementation of the ARM Framework shall occur for the 2013 fishing season, with Board review and decision-making likely to occur at the Board's 2012 Summer meeting. Implementation shall be comprised of two cycles (i.e., double loop learning; Figure 2):

1) *Annual Cycle* (i.e., the 'iterative phase'); and
   - ASMFC Summer Meeting (year t) – Board decides harvest
   - June (year $t + 1$) – Delaware Bay Ecosystem Technical Committee compiles monitoring data
   - July (year $t + 1$) – ARM Working Group runs models/optimization
   - ASMFC Summer Meeting (year $t + 1$) – Board revisits harvest decision
2) *Longer Term Cycle* (i.e., revisiting the 'set-up phase' every 3 or 4 years, likely coordinating the first review with the stock assessment).
   - Solicit formal stakeholder input on ARM Framework to be provided to the relevant technical committees
   - Technical committees review stakeholder input and technical components of ARM models and provide recommendations to the Board
   - At the ASMFC Spring Meeting, Board selects final components of the ARM Framework, and tasks technical committees to work with ARM Working Group to run models /optimization
   - Merge with the *Annual Cycle*
     - In July, ARM Working Group runs models/optimization
     - At the ASMFC Summer Meeting, the Board revisits harvest decision

Allocation

3a: Lambda

Lambda indicates how much of a state's harvest is of Delaware Bay-origin (i.e. has spawned at least once in Delaware Bay) and shall be assumed to be 1.0 for New Jersey and Delaware and based upon the recent genetics data and analysis, performed and reviewed by the Delaware Bay Ecosystem Technical Committee in 2011, for Maryland and Virginia.

Genetics data

State	Lambda, λ
NJ	1.0
DE	1.0
MD	**0.51**
VA	**0.35**

3b: Weighting

Weight allocation values determine how the optimized harvest level will be apportioned among the four states. Virginia's quota level and landings refer to those quota and landings that occur east of the COLREGS line, as these crabs have been shown to be part of a mixed stock (Shuster 1985). Note that these values are impacted, as well, by the chosen Lambda values. Weighting of the optimized harvest shall be based upon the Addendum VI quota levels.

Current management quotas (Addendum VI):

State	Allocation weight w_i
	Genetics λ
NJ	32.4%
DE	32.4%
MD	28.2%
VA	7.0%

3c: Harvest cap for Maryland and Virginia

The harvest cap places a maximum limit on the total level of allowed harvest by Maryland and Virginia, providing protection to non-Delaware Bay-origin crabs. The cap shall be based on Addendum VI quota levels for Maryland and Virginia. The cap shall apply except when the ARM Framework outputs an optimized harvest that prohibits harvest of female horseshoe crabs. In this situation, female horseshoe crab harvest in Maryland and Virginia will be prohibited but an Option 3d, a 2:1 offset of males:females, shall apply and allow the total male harvest of Maryland and Virginia to rise above the cap level.

Note again that Virginia's quota only refers to the amount able to be harvested east of the COLREGS line.

MD Cap	VA Cap
170,653	60,998

3d: 2:1 male:female offset for female crabs below the Addendum VI levels

For female crab harvest in Maryland and Virginia that is restricted below the Addendum VI quota levels, due to a female harvest moratorium output by the ARM Framework, male harvest would be increased at a 2:1 ratio. These increases are the only allowable increases above the designated harvest cap in 3c. The offsets assume an allowed harvest under Addendum VI in Virginia of 20,333 female crabs and in Maryland of 85,327 female crabs.

3e: Plan B/fallback option

As part of the ARM Framework, the models are dependent on annual data sets for the yearly harvest setting, and include the following:

- Horseshoe crab abundance estimates from the Virginia Tech Horseshoe Crab Trawl Survey
- Red knot abundance estimates, including stopover counts and re-sightings, from the Delaware Bay Shorebird Project

There are additional data needs for the ARM Framework's double-loop process, such as the proportion of horseshoe crabs spawning during shorebird stopover and sex ratios from the Delaware Bay horseshoe crab spawning survey; however, it is the annual data sets that are required to maintain the yearly harvest outputs.

The absence of these annually-collected data sets would inhibit the use of the ARM Framework. If these data were not available for the summer harvest decision, the Board, via Board action and after consultation of the relevant Technical Committees and Advisory Panels, may set the next season's harvest:

- Based upon Addendum VI quotas and management measures for New Jersey, Delaware, and Maryland, and Virginia coastal waters; or,
- Based upon the previous year's ARM Framework harvest level and allocation for New Jersey, Delaware, and Maryland, and Virginia coastal waters.

3.0 Compliance

Affected states must implement this Addendum no later than the following dates:

June 1, 2012: States must submit state programs to implement Addendum VII, including management and monitoring programs, for approval by the Management Board.

January 1, 2013: States shall implement approved management and monitoring programs for Addendum VII.

4.0 Literature Cited

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United States Fish and Wildlife Service (USFWS). 2011. Horseshoe Crab Tagging Program. Report to the Atlantic States Marine Fisheries Commission Delaware Bay Ecosystem Technical Committee (January 24, 2011). 6 pgs.

Williams, B. K., R. C. Szaro, and C. D. Shapiro. 2007. Adaptive management: the US Department of the Interior technical guide. Adaptive Management Working Group, U.S. Department of the Interior, Washington, DC.

Appendix

This appendix provides background information originally included in the draft for public comment. The information is included for informational purposes only and includes options not approved for management use.

1) How much of each state's harvest is comprised of Delaware Bay-origin crabs, Lambda λ?

New Jersey, Delaware, Maryland, and Virginia all draw some portion of their yearly quota from Delaware Bay crabs. For New Jersey and Delaware, this level is assumed to be 100%; that is, all horseshoe crabs harvested by fishermen in New Jersey and Delaware come from the Delaware Bay population. The fishery occurs by hand on the spawning beaches or during the spawning period, thus likely validating this assumption. Their lambda values, λ, would equal one (1.0).

For Maryland and Virginia, the proportion of crabs is not as straight-forward to assess. Both states have spawning areas along their coasts and within the Chesapeake Bay that support separate spawning aggregations. Tagging data and genetics studies offer information on the movement and origins of crabs. The U.S. Fish and Wildlife Service (USFWS) tagging program, operating since 1999, is the longest time series for horseshoe crab tagging data. The program experienced a large increase in participation in 2008, when the number of released tags jumped nearly 3-fold in a single year. In 2009, four new tagging programs were implemented in Massachusetts, New York/New Jersey (the Raritan/Sandy Hook Bays), Georgia (near Wassaw Island), and the upper Chesapeake Bay. Tagging data through 2010 revealed that over 165,000 horseshoe crabs had been tagged and 17,000 of those tagged crabs were recaptured.

The tagging data were analyzed according to tag recovery rate, which is the probability that a tagged individual in one area will be recaptured in another area. This probability is a function of survival, the probability of moving from one area to another, and the likelihood of being recaptured. Recapture of crabs within three months (generally includes the same spawning season) were not included. Much of the tagging and recapture data fall within these parameters for Delaware Bay, thus limiting the amount of information available on the degree of population mixing along the coast.

Genetics data also have the potential to provide insight into different populations of horseshoe crabs. By screening microsatellite DNA markers, researchers can estimate levels of genetic relatedness among different groups of crabs. An "assignment" procedure, performed for the Delaware Bay Ecosystem Technical Committee's analysis, was used to examine the genetic composition of sampled horseshoe crabs to determine the most likely mix of source populations for the sample. As part of the genetics analysis where different source populations were identified, it was noted that low levels of genetically effective migration, or breeding across populations, can maintain genetic similarity.

2) On what basis should the total recommended ARM harvest output be divided among the four states of New Jersey, Delaware, Maryland, and Virginia (Weight allocation-w_i)?

Based on the optimized harvest level, a total Delaware Bay horseshoe crab harvest will be set. The weighting system will determine how that harvest will be apportioned among the four states of New Jersey, Delaware, Maryland and Virginia. Possibilities include historic harvest levels, current quota levels, estimated abundance levels, and average landings. The Reference Period Landings (RPLs) represent the historic distribution of the catch, and presumably, the historic distribution of the fishery. The current quota levels, as set by Addendum VI, recognize the current distribution of quota among the four states. The annual Virginia Tech Horseshoe Crab Trawl Survey can estimate state waters' abundance based on location of the survey trawls, although the survey was not specifically designed for state-by-state estimates. Average landings represent the regulation- and market-controlled catch for each state, averaged over the past four years. It is important to note that New Jersey instituted a state-wide moratorium on bait harvest and landings since 2007, which reduces their average harvest over the past four years to zero.

All options are impacted by the lambda values chosen for use.

3) Should there be an overall harvest cap placed on Maryland and Virginia's harvest to protect non-Delaware Bay-origin horseshoe crabs (Harvest cap)?

Placing a cap on the total allowed harvest within Maryland and Virginia (harvest east of the COLREGS line) would prevent increases in the harvest of non-Delaware Bay crabs. This is currently possible, as Maryland and Virginia harvest crabs from a mixed population. Thus, a cap would protect non-Delaware Bay crab populations. The basis for the cap can include past effort, landing levels or caps from past management addenda.

4) Should there be an allowable harvest of Delaware Bay-origin horseshoe crabs for Maryland and Virginia if the ARM-recommended harvest option requires a moratorium on one or both genders (Delaware Bay Stock Allowance)?

The Delaware Bay Stock Allowance decision is only relevant should the ARM model suggest a harvest package that has a full or female-only moratorium AND the Lambda values for Maryland and Virginia set at some value less than 1.0. The current recommended ARM harvest package, Package 3 (500,000 male crabs only, Section 2.2.1), contains a female-only moratorium, and general technical and advisory consensus is that Maryland and Virginia fisheries target a "mixed stock" of horseshoe crabs that originate from the Delaware Bay and elsewhere.

This option, if chosen, would still allow Maryland and Virginia to harvest some Delaware Bay-origin horseshoe crabs that are under a moratorium (e.g. females under Harvest Package 3) at a defined minimal level. The option recognizes that at least some portion of the Maryland and Virginia harvest is composed of non-Delaware Bay-origin crabs. Without this option, a moratorium on Delaware Bay-origin crabs would impose a similar moratorium on Maryland and Virginia's harvests of non-Delaware Bay-origin crabs. Use of the allowance recognizes that a certain number of Delaware Bay-origin crabs may still be caught by Maryland and Virginia along with non-Delaware Bay-origin crabs.

Proposed values for the Delaware Bay Stock Allowance have included 1%, 5%, and 10% (~current female harvest under Addendum VI) of the two-year averaged coastwide harvest, as well as of the two-year averaged Delaware Bay states' harvest. Proposed implementation includes the option to maintain overall harvest at the level of the harvest cap, with no decrease in total crab harvest compared to the harvest cap. An additional option includes offsetting lost female harvest with male crabs at a 2:1 ratio, thus allowing two male crabs to be harvested for every female crab that is not allowed, according to previous quota levels under Addendum VI.