

*Atlantic States Marine Fisheries Commission*

**DRAFT ADDENDUM VII TO THE INTERSTATE FISHERY  
MANAGEMENT PLAN FOR HORSESHOE CRABS  
FOR PUBLIC COMMENT**

*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*

November 2011

## Public Comment Process and Proposed Timeline

In August 2011, the Atlantic States Marine Fisheries Commission's Horseshoe Crab Management Board approved a motion to initiate the development of an addendum to the Interstate Fishery Management Plan for Horseshoe Crabs to consider implementing the Adaptive Resource Management Framework for management of the fishery. This draft addendum was presented to the Board in November 2011 and approved for public comment. The draft addendum presents background on the Commission management of horseshoe crabs, the addendum process and timeline, a statement of the problem, and provides horseshoe crab management options for public consideration and comment.

The Board is seeking comments from the public on the following options:

- 1) Should the Board take no action and have management measures revert back to Addendum III?
- 2) Should the Board take action and extend the status quo management measures under Addendum VI?
- 3) Should the Board take action and implement the Adaptive Resource Management Framework? If so,
  - a. How much of each state's harvest is comprised of Delaware Bay-origin crabs,  $\lambda$ ?
  - b. 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- $w_i$ )?
  - c. Should there be an overall cap placed on Maryland and Virginia's harvest to protect non-Delaware Bay-origin horseshoe crabs (Harvest cap)?
  - d. 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 public is encouraged to submit comments regarding this document at any time during the addendum process. The final date comments will be accepted is **January 31, 2012 at 5:00 pm EST**. Comments may be submitted by mail, email, or fax. If you have any questions or would like to submit comment, please use the contact information below.

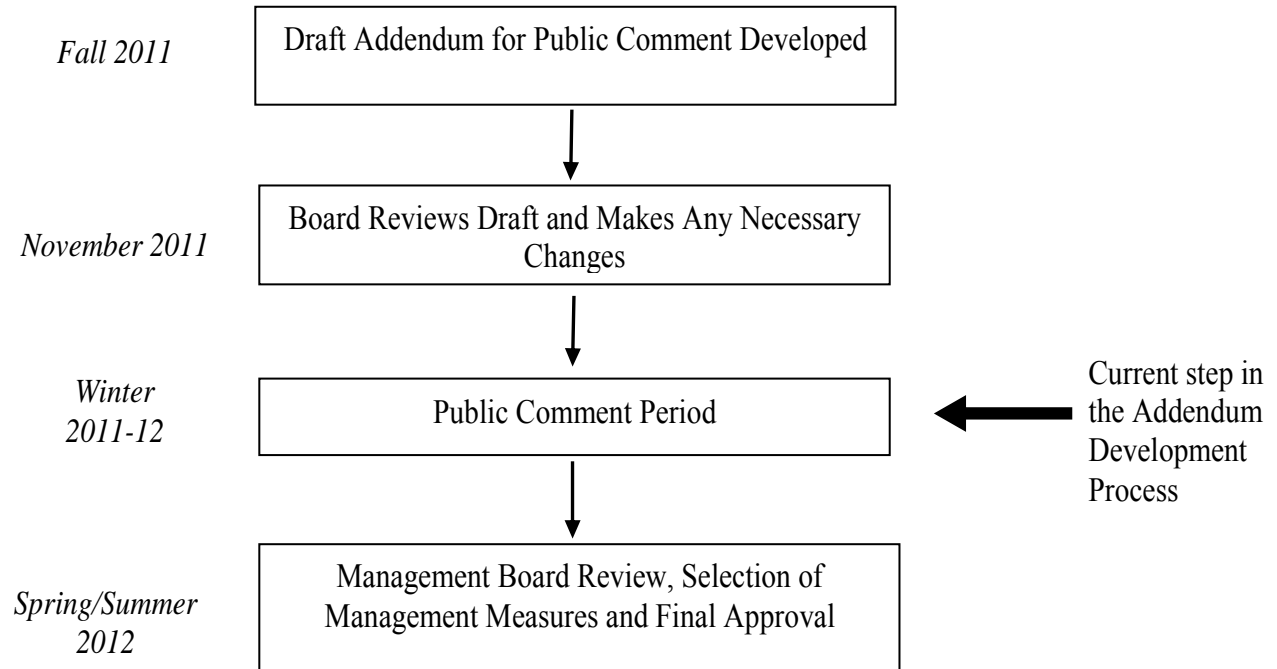
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## ASMFC's Addendum Process and Timeline

The development of Addendum VII to the Horseshoe Crab Fishery Management Plan will follow the general process outlined below. Tentative dates are included to illustrate the timeline of the addendum process.



## **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 reserve was established in 2000 as a no-take zone for horseshoe crabs and spans nearly 1,500 square miles of federal waters off the mouth of Delaware Bay. 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. Once expired, the FMP would revert back to the Addendum III requirements unless modifications are enacted.

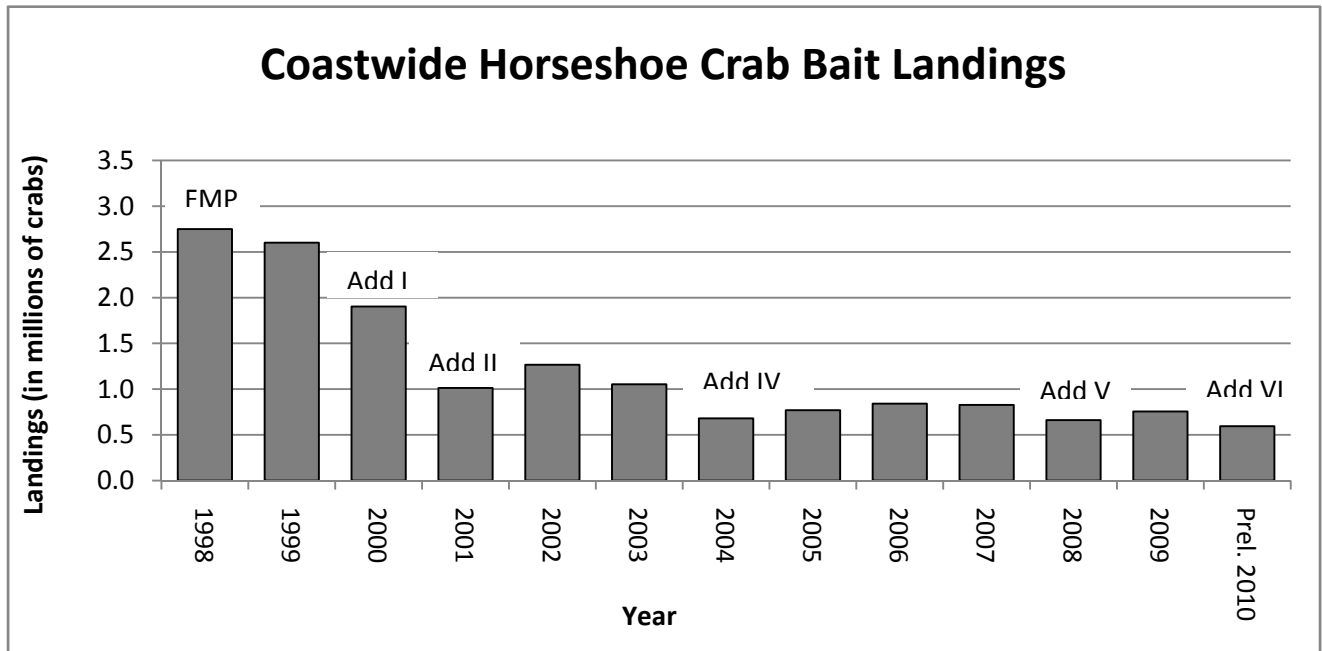
The Board initiated the current Draft Addendum VII to develop and establish a management program for the Delaware Bay Region (i.e., coastal and bay waters of New Jersey and Delaware, and coastal waters only of Maryland and Virginia). The purpose of this document is to provide context for the Board's decisions and solicit public comment on the management options therein.

## **2.0 Management Program**

### **2.1 Statement of the Problem**

This Draft Addendum 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



**Figure 1. Atlantic Coastwide Landings of Horseshoe Crabs for Bait**

## 2.2 Background

Provisions of the current Addendum VI 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 initiated the development of Draft Addendum VII at its August 2011 meeting. The 2009 horseshoe crab stock assessment and 2011 peer review reports provide 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.

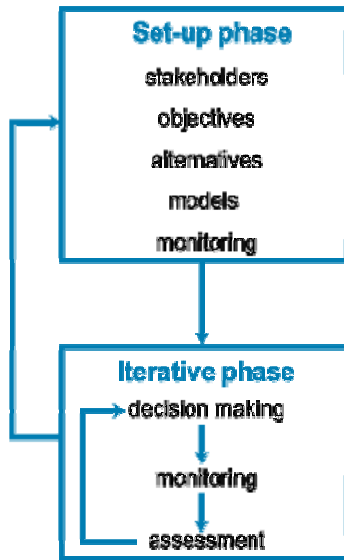
### 2.2.1 ARM Framework

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. ARM 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 alternative #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. Options for allocation are incorporated into 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 populations. 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. The model includes four components, on which public comment is being sought. These components include:

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

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. This assumption is likely correct, as most of the fishery occurs by hand on the spawning beaches or during the spawning period, and thus the crabs are in the Delaware Bay at that time to spawn. Their lambda values,  $\lambda$ , 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 used 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 either a full or female-only moratorium AND should the Lambda values for Maryland and Virginia be set at some value less than 1.0. The current recommended ARM harvest package, Package 3 (500,000 male crabs only, see 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.

## **2.4 Management Options**

The Board may select a management option contained in this draft document or an option that is within the range of options presented below.

### Option 1: No Action (Revert to Addendum III provisions)

If the Management Board chooses to not take action on Draft Addendum VII, horseshoe crab management for the Delaware Bay Region would revert to the Commercial Fisheries Management provisions of Addendum III. Addendum III permitted annual bait harvest and landing of up to 150,000 crabs total (male and female) in New Jersey and Delaware, and an annual bait harvest and landing of up to 170,653 crabs total (male and female) in Maryland. Under Addendum III, Virginia's annual bait harvest and landings would remain the same as under Addendum VI; however, the requirement to land no more than 40% of the total quota (60,998 crabs) with a 2:1 male:female ratio east of the COLREGS line would be removed. In addition, for these states Addendum III prohibited harvest and landing for bait from May 1 through June 7.

### Option 2: Status Quo (Continuation of Addendum VI management provisions)

This option prohibits directed bait harvest and landing of all horseshoe crabs in New Jersey and Delaware from January 1 through June 7, and female horseshoe crabs in New Jersey and Delaware from June 8 through December 31. It also limits New Jersey and Delaware's bait harvest to 100,000 horseshoe crabs (male only) per state per year.

It also prohibits directed harvest and landing of horseshoe crabs for bait in Maryland from January 1 through June 7, and the landing of horseshoe crabs in Virginia, harvested from federal waters, from January 1 through June 7. No more than 40% of Virginia's annual quota may be harvested east of the COLREGS line in ocean waters. It also requires that horseshoe crabs harvested east of the COLREGS line and landed in Virginia be comprised of a minimum male to female ratio of 2:1.

- Option 2a: These provisions are to remain in place until replaced through another addendum process.
- Option 2b: These provisions are to expire one year after the date of implementation.
- Option 2c: These provisions are to expire three years after the date of implementation.
- Option 2d: These provisions are to expire five years after the date of implementation.

### Option 3: Management Using the ARM Framework

If this option is chosen, the ARM Working Group would present to the Board at its August 2012 meeting the optimal harvest package as identified by the models (i.e. one of the five harvest quota alternatives listed in Section 2.2.1). The Board would review the harvest package and allocate the bait harvest quota among the four states (New Jersey through Virginia [only harvest east of the COLREGS line]) that comprise the Delaware Bay Region, according to the allocation spreadsheet model. Although each of the decision options in the allocation model is presented separately, they interact with each other when calculating the final allocation values.

Annual management decision making would 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 in August at the Commission's Summer meeting.

If this option is chosen, implementation of the ARM Framework could occur after the August 2012 Board meeting and would be comprised of two cycles (i.e., double loop learning; Figure 2): 1) *Annual Cycle* (i.e., the 'iterative phase'); and 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).

#### *Annual Cycle*

- 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

#### *Longer Term Cycle (every 3-4 years)*

- 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:* Multiple choices exist for each of the allocation sub-options (3a – 3d), which would allocate the ARM optimized harvest output among the four Delaware Bay states.

Option 3a: What option for lambda ( $\lambda$ ) best represents how much of each state's horseshoe crab harvest originates in Delaware Bay?

Lambda indicates how much of a state’s harvest is of Delaware Bay-origin (i.e. has spawned at least once in Delaware Bay). Options for lambda ( $\lambda$ ) values for the four states include those based on tagging data (#1), a risk-averse default option (#2), and those based on genetics data (#3).

#1: Tagging data

State	Lambda, $\lambda$
NJ	1.0
DE	1.0
<b>MD</b>	<b>0.13</b>
<b>VA</b>	<b>0.09</b>

#2: Default values

State	Lambda, $\lambda$
NJ	1.0
DE	1.0
<b>MD</b>	<b>1.0</b>
<b>VA</b>	<b>1.0</b>

#3: Genetics data

State	Lambda, $\lambda$
NJ	1.0
DE	1.0
<b>MD</b>	<b>0.51</b>
<b>VA</b>	<b>0.35</b>

Option 3b: 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- $w_i$ )?

Weight allocation values among the four states are presented with four options: historic landings, current quota levels, estimated abundance levels, and average landings. Virginia’s quota level and landings referred to throughout Option 3 only 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.

1) Historical, unregulated harvest levels (Reference Period Landings):

State	Allocation weight, $w_i$		
	Genetics $\lambda$	Tagging $\lambda$	Default $\lambda$
<b>NJ</b>	41.1%	51%	25%
<b>DE</b>	32.8%	41%	32%
<b>MD</b>	21.3%	7%	32%
<b>VA</b>	4.8%	1%	11%

2) Current management quotas (Addendum VI):

State	Allocation weight, $w_i$		
	Genetics $\lambda$	Tagging $\lambda$	Default $\lambda$
<b>NJ</b>	32.4%	44%	23%
<b>DE</b>	32.4%	44%	23%
<b>MD</b>	28.2%	10%	40%
<b>VA</b>	7.0%	2%	14%

3) Current estimated abundance levels (Virginia Tech Horseshoe Crab Trawl Survey):

State	Allocation weight, $w_i$		
	Genetics $\lambda$	Tagging $\lambda$	Default $\lambda$
<b>NJ</b>	28%	28%	28%
<b>DE</b>	47%	47%	47%
<b>MD</b>	18%	18%	18%
<b>VA</b>	7%	7%	7%

4) Past four years' average landings:

State	Allocation weight, $w_i$		
	Genetics $\lambda$	Tagging $\lambda$	Default $\lambda$
<b>NJ</b>	0%	0%	0%
<b>DE</b>	46%	77%	29%
<b>MD</b>	45%	19%	56%
<b>VA</b>	9%	4%	15%

Option 3c: Should there be an overall harvest cap placed on Maryland and Virginia's harvest to protect non-Delaware Bay-origin horseshoe crabs (harvest cap)? If yes, what timeframe or management period should be used to establish the cap ?

The harvest cap would place a maximum limit on the total level of allowed harvest by Maryland and Virginia, providing protection to non-Delaware Bay-origin crabs. Cap levels may be based on past management measures or landings levels. A cap based on the Reference Period Landings or Addendum I levels would do little to limit harvest levels, except in extreme circumstances.

Addenda III and VI are similar, except that Addendum VI specifies a limit on Virginia harvest east of the COLREGS line. Average landings would provide the strictest cap.

Note again that Virginia’s current quota is based on that amount able to be harvested east of the COLREGS line.

Cap Basis	Current MD quota 170,653	Current VA quota 60,998
	MD Cap	VA Cap
RPLs	613,225	203,326
Add I	459,919	152,495
Add III	170,653	152,495
Add VI	170,653	60,998
2007-2010 Avg Landings	160,746	21,280

Option 3d: 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) and at what level should that harvest be set?

A Delaware Bay Stock Allowance (DBSA) would allow continued harvest of females by Maryland and Virginia under the recommended Harvest Package 3 female moratorium (no impact on New Jersey or Delaware as these fisheries are considered to be completely comprised of Delaware Bay-origin crabs). The options include 0% (no Delaware Bay Stock Allowance), 1%, 5%, and 10% (~status quo). The levels are impacted by the values for the other three decisions. If the default Lambda values are chosen, it is assumed that all crabs harvested in Maryland and Virginia (east of the COLREGS) are of Delaware Bay-origin, and thus there would be no Delaware Bay Stock Allowance. The corresponding male quota is shown parentheses, indicating that even if the female quota is decreased, the total quota (allowed under the harvest cap and other management conditions) will not decrease.

Add. VI Harvest cap, 1:1 male:female ratio cap of 85,327, male quota in parentheses (10% Delaware Bay Stock Allowance originally based on maintaining Maryland’s self-imposed 2:1 male:female ratio: 56,885 crabs)

% of coastwide	Maryland Total Female Quota, Option #3 for Lambda (0.51)			
	W <sub>i</sub> = RFPs	W <sub>i</sub> = Add. VI	W <sub>i</sub> = Est. Abundance	W <sub>i</sub> = Av. Landings
0%	0 (170,653)	0 (170,653)	0 (170,653)	0 (170,653)
1%	5,395 (165,258)	5,318 (165,335)	4,688 (165,965)	5,581 (165 072)
5%	26,973 (143,680)	26,589 (144,064)	23,442 (147,211)	27,906 (142,747)
10%	53,946 (116,707)	53,177 (117,476)	46,885 (123,768)	55,813 (114,840)

% of coastwide	Maryland Total Female Quota, Option #1 for Lambda (0.13)			
DBSA level	W <sub>i</sub> = RFPs	W <sub>i</sub> = Add. VI	W <sub>i</sub> = Est. Abundance	W <sub>i</sub> = Av. Landings
0%	0 (170,653)	0 (170,653)	0 (170,653)	0 (170,653)
1%	21,129 (149,524)	20,826 (149,827)	18,393 (152,260)	21,866 (148,787)
5%	85,327* (85,326)	85,327* (85,326)	85,327* (85,326)	85,327* (85,326)
10%	85,327* (85,326)	85,327* (85,326)	85,327* (85,326)	85,327* (85,326)

\*Female cap reached

Add. VI Harvest cap, 2:1 male:female ratio cap of 20,333, male quota in parentheses

% of coastwide	Virginia Total Female Quota, Option #3 for Lambda (0.35)			
DBSA level	W <sub>i</sub> = RFPs	W <sub>i</sub> = Add. VI	W <sub>i</sub> = Est. Abundance	W <sub>i</sub> = Av. Landings
0%	0 (60,998)	0 (60,998)	0 (60,998)	0 (60,998)
1%	1,789 (59,209)	1,901 (59,097)	2,818 (58,180)	1,517 (59,481)
5%	8,943 (52,055)	9,504 (51,494)	14,088 (46,910)	7,583 (53,415)
10%	17,887 (43,111)	19,008 (41,990)	20,333* (40,665)	15,167 (45,831)

% of coastwide	Virginia Total Female Quota, Option #1 for Lambda (0.09)			
DBSA level	W <sub>i</sub> = RFPs	W <sub>i</sub> = Add. VI	W <sub>i</sub> = Est. Abundance	W <sub>i</sub> = Av. Landings
0%	0 (60,998)	0 (60,998)	0 (60,998)	0 (60,998)
1%	7,006 (53,992)	7,444 (53,554)	10,957 (50,041)	5,942 (55,056)
5%	20,333* (40,665)	20,333* (40,665)	20,333* (40,665)	20,333* (40,665)
10%	20,333* (40,665)	20,333* (40,665)	20,333* (40,665)	20,333* (40,665)

\*Female cap reached

Option 3e: Should the Delaware Bay Stock Allowance include a 2:1 male:female offset for female crabs below the Addendum VI levels?

This option would implement the Delaware Bay Stock Allowance according to the same aspects of Option 3d, impacting only the harvests of Maryland and Virginia due to their mixed-stock fishery. For female crab harvest that is restricted below the Addendum VI quota levels, male harvest would be increased at a 2:1 ratio. Thus, if no Delaware Bay Stock Allowance is chosen and the harvest cap is set at Addendum VI levels (170,653 crabs for Maryland and 60,998 crabs for Virginia), the total harvest for each state would be 255,890 male crabs for Maryland (170,653 base + 85,327 in offset) and 81,331 male crabs for Virginia (60,998 base + 20,333 in offset). These increases would be the only allowable increases above any designated harvest cap chosen in Option 3c. As in Option 3d, the options for the Delaware Bay Stock Allowance level include 0% (no Delaware Bay Stock Allowance), 1%, 5%, and 10% (~status quo). The levels are impacted by the values for the other three decisions. If the default Lambda values are chosen, it is assumed that all crabs harvested in Maryland and Virginia (east of the COLREGS) are of Delaware Bay-origin, and thus there would be no Delaware Bay Stock Allowance. The corresponding male quota is shown parentheses.

Add. VI Harvest cap, 1:1 male:female ratio cap of 85,327, male quota in parentheses  
(10% Delaware Bay Stock Allowance originally based on maintaining Maryland's self-imposed  
2:1 male:female ratio: 56,885 crabs)

% of coastwide	Maryland Total Female Quota, Option #3 for Lambda (0.51)			
	W <sub>i</sub> = RFPs	W <sub>i</sub> = Add. VI	W <sub>i</sub> = Est. Abundance	W <sub>i</sub> = Av. Landings
0%	0 (255,890)	0 (255,890)	0 (255,890)	0 (255,890)
1%	5,395 (245,190)	5,318 (245,344)	4,688 (246,604)	5,581 (244,818)
5%	26,973 (202,034)	26,589 (202,802)	23,442 (209,096)	27,906 (200,168)
10%	53,946 (148,808)	53,177 (149,626)	46,885 (162,210)	55,813 (144,354)

% of coastwide	Maryland Total Female Quota, Option #1 for Lambda (0.13)			
	W <sub>i</sub> = RFPs	W <sub>i</sub> = Add. VI	W <sub>i</sub> = Est. Abundance	W <sub>i</sub> = Av. Landings
0%	0 (255,890)	0 (255,890)	0 (255,890)	0 (255,890)
1%	21,129 (213,722)	20,826 (214,328)	18,393 (219,194)	21,866 (212,248)
5%	85,327* (85,326)	85,327* (85,326)	85,327* (85,326)	85,327* (85,326)
10%	85,327* (85,326)	85,327* (85,326)	85,327* (85,326)	85,327* (85,326)

\*Female cap reached

Add. VI Harvest cap, 2:1 male:female ratio cap of 20,333, male quota in parentheses

% of coastwide	Virginia Total Female Quota, Option #3 for Lambda (0.35)			
	W <sub>i</sub> = RFPs	W <sub>i</sub> = Add. VI	W <sub>i</sub> = Est. Abundance	W <sub>i</sub> = Av. Landings
0%	0 (81,331)	0 (81,331)	0 (81,331)	0 (81,331)
1%	1,789 (77,753)	1,901 (77,529)	2,818 (75,695)	1,517 (78,297)
5%	8,943 (63,445)	9,504 (62,323)	14,088 (53,155)	7,583 (66,165)
10%	17,887 (45,557)	19,008 (43,315)	20,333* (40,665)	15,167 (50,997)

% of coastwide	Virginia Total Female Quota, Option #1 for Lambda (0.09)			
	W <sub>i</sub> = RFPs	W <sub>i</sub> = Add. VI	W <sub>i</sub> = Est. Abundance	W <sub>i</sub> = Av. Landings
0%	0 (81,331)	0 (81,331)	0 (81,331)	0 (81,331)
1%	7,006 (67,319)	7,444 (66,443)	10,957 (59,417)	5,942 (69,447)
5%	20,333* (40,665)	20,333* (40,665)	20,333* (40,665)	20,333* (40,665)
10%	20,333* (40,665)	20,333* (40,665)	20,333* (40,665)	20,333* (40,665)

\*Female cap reached

Option 3f: If the data used to implement the ARM Framework becomes unavailable, should the Commission include a 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, 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:

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

XXXXXXX: States with approved management and monitoring programs shall begin implementing Addendum VII.



#### 4.0 Literature Cited

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