MEETING OVERVIEW

Horseshoe Crab Management Board Meeting
August 3, 2022
10:15 - 11:45 a.m.
Hybrid Meeting

Chair: John Clark (DE) Assumed Chairmanship: 10/19	Horseshoe Crab Technical Committee Chair: Natalie Ameral (RI)	
Vice Chair: VACANT	Horseshoe Crab Advisory Panel Chair: Brett Hoffmeister (MA)	Law Enforcement Committee Representative: Nick Couch (DE)
Delaware Bay Ecosystem Technical Committee Chair: Wendy Walsh (FWS)	Adaptive Resource Management Subcommittee Chair: Dr. John Sweka (FWS)	Previous Board Meeting: May 3, 2022
Voting Members: MA, RI, CT, NY, NJ, DE, MD, DC, PRFC, VA, NC, SC, GA, FL, NMFS, USFWS (16 votes)		

2. Board Consent

- Approval of Agenda
- Approval of Proceedings from May 3, 2022

3. Public Comment – At the beginning of the meeting public comment will be taken on items not on the agenda. Individuals that wish to speak at this time must sign-in at the beginning of the meeting. For agenda items that have already gone out for public hearing and/or have had a public comment period that has closed, the Board Chair may determine that additional public comment will not provide additional information. In this circumstance the Chair will not allow additional public comment on an issue. For agenda items that the public has not had a chance to provide input, the Board Chair may allow limited opportunity for comment. The Board Chair has the discretion to limit the number of speakers and/or the length of each comment.

4. Consider Draft Addendum VIII: Implementation of Recommended Changes from 2021 ARM Revision and Peer Review Report for Public Comment (10:30-11:15 a.m.) Action

Background

- In October 2019, the Board directed the Adaptive Resource Management (ARM) Subcommittee to begin working on updates to the ARM Framework to revisit several aspects of the ARM model to incorporate horseshoe crab population estimates from the Catch Multiple Survey Analysis (CMSA) model used in the 2019 Benchmark Stock Assessment and the most current scientific information available for horseshoe crabs and red knots.
- In January 2022, the Board accepted the ARM Revision and Peer Review for management use, and initiated a Draft Addendum to consider allowing its use in setting annual specifications for horseshoe crabs of Delaware Bay-origin. The Horseshoe Crab PDT met multiple times throughout the spring to develop a draft addendum document for Board consideration (**Briefing Materials**).

Presentations

- Overview of Draft Addendum VIII for Board Consideration by C. Starks

Board actions for consideration at this meeting

- Approve Draft Addendum VIII for Public Comment

5. Update on PDT Review of Biomedical Mortality, Biologically-based Options for Setting the Threshold, and Best Management Practices for Handling Biomedical Collections (11:15-11:35 a.m.)

Background

- In October 2021, The Board tasked the Plan Development Team to review biomedical mortality, discuss biologically-based options for setting the threshold, and consider updates to best management practices for handling biomedical collections.
- The PDT requested advice from the Technical Committee (TC) on this issue. The TC met multiple times to discuss potential strategies for setting a biologically-based threshold for biomedical collections, and to review the 2011 best management practices (BMPs). The TC provided recommendations to the PDT regarding the mortality threshold (**Briefing Materials**) and a process for considering changes to the BMPs (**Supplemental Materials**).
- The AP met in July to consider this Board task and the TC's recommendations, and to provide input on the best management practices for handling biomedical collections (**Supplemental Materials**).

Presentations

- Update on Task to Review Biomedical Mortality and Best Management Practices for Biomedical Collections by C. Starks

6. Review and Populate Advisory Panel Membership (11:35-11:40 a.m.) Action

Background

- Massachusetts has submitted a nomination to the Horseshoe Crab Advisory Panel: David Meservey, an inshore commercial otter trawler (**Briefing Materials**).
- Delaware has submitted two nominations to the Horseshoe Crab Advisory Panel: Jordan Giuttari, a commercial fisherman and dealer/processor, and Matt Sarver, a conservationist (**Supplemental Materials**).

Presentations

- Nominations by T. Berger

Board actions for consideration at this meeting

- Approve Advisory Panel Nomination

7. Elect Vice-Chair

8. Other Business/Adjourn

Atlantic States Marine Fisheries Commission

DRAFT ADDENDUM VIII TO THE HORSESHOE CRAB FISHERY MANAGEMENT PLAN

Implementation of the 2021 ARM Revision

This draft document was developed for Management Board review and discussion. This document is not intended to solicit public comment as part of the Commission/State formal public input process. Comments on this draft document may be given at the appropriate time on the agenda during the scheduled meeting. If approved, a public comment period will be established to solicit input on the issues contained in the document.

August 2022

Sustainable and Cooperative Management of Atlantic Coastal Fisheries

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 seven addenda. The Board approved Addendum I (2000), establishing a coastwide, state-by-state annual quota system to reduce horseshoe crab landings. Addendum I also included 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 were set to expire after April 30, 2013. Addendum VII replaced the Addendum VI requirements by establishing 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).

Draft Addendum VIII considers implementing the 2021 Revision to the Adaptive Resource Management (ARM) Framework originally established under Addendum VII.

2.0 Overview

2.1 Statement of the Problem

The Board initiated Draft Addendum VIII in January 2022 to consider use of the recent 2021 Revision of the ARM Framework (ASMFC 2021) in setting annual bait harvest specifications for horseshoe crabs of Delaware Bay-origin. Delaware Bay horseshoe crab management using the ARM Framework was originally established under Addendum VII for use during the 2013 fishing season and beyond. The Framework considers the abundance levels of horseshoe crabs and shorebirds in determining the optimal harvest level for the Delaware Bay states of New Jersey, Delaware, Maryland, and Virginia (east of the COLREGS).

In the past decade, more data has been collected on shorebirds and horseshoe crabs and modeling software and techniques have advanced. Additionally, the original ARM Framework used software that is now antiquated, not supported, does not run on current computer operating systems, and is limited in its capacity to incorporate uncertainty when determining optimum harvest strategies. Thus, the ARM Subcommittee was tasked with revising the ARM

Framework to address critiques from the previous peer review panel, include newly available data, and transition to new modeling software.

Following the recommendations of the independent peer review panel, which endorsed the ARM Revision as the best and most current scientific information for the management of horseshoe crabs in the Delaware Bay Region, the Board reviewed and accepted the ARM Revision in January 2022. Draft Addendum VIII considers incorporating the recommended changes in the ARM Revision into the management program for bait harvest of Delaware Bay-origin horseshoe crabs.

2.2 Background

The original ARM Framework and Addendum VII were developed in response to public concern regarding the horseshoe crab population and its ecological role in the Delaware Bay. While the stock assessment at that time (ASMFC 2009a) found increases in the Delaware Bay horseshoe crab abundance, the red knot (*rufa* subspecies), one of many shorebird species that feed on horseshoe crab eggs, was at low population levels. To address these concerns, an effort began to develop a multi-species approach to managing horseshoe crabs by employing the tools of structured decision making and adaptive management. In 2007, the Horseshoe Crab and Shorebird Technical Committees met and endorsed the development of a structured decision making (SDM) framework and adaptive management approach. An ARM subcommittee was formed including representatives from state and federal partners, as well as horseshoe crab and shorebird biologists. The subcommittee produced a framework for adaptive management of horseshoe crabs in the Delaware Bay that was constrained by red knots. It was peer-reviewed with a coastwide benchmark stock assessment for horseshoe crab in 2009 (ASMFC 2009a, 2009b).

Addendum VII, approved in February 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 optimal harvest level for the Delaware Bay states of New Jersey, Delaware, Maryland, and Virginia (east of the COLREGS). Since 2013, the Board has annually reviewed recommended harvest levels from the ARM Subcommittee, who run the ARM model, and specified harvest levels for the following year in New Jersey, Delaware, Maryland, and Virginia.

2.3 Original 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 involved 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.

Underlying the original ARM model are population models for both red knots and horseshoe crabs. The optimization routine in the ARM model determines the best choice among five potential harvest packages (numbers of male and females that can be harvested) given the current abundance of each species in order to maximize the long-term value of horseshoe crab harvest. The ARM model values female horseshoe crab harvest only when the abundance of red knots reaches 81,900 birds (a value related to the historic abundance of red knots in the Delaware Bay) or when the abundance of female horseshoe crabs reaches 80% of their predicted carrying capacity (11.2 million assuming a carrying capacity of 14 million; ASMFC 2009b). On an annual basis, the ARM model is used to select the optimal harvest package to implement for the next year given the current year's estimate of horseshoe crab abundance from the swept area estimate from the VA Tech trawl survey and a mark-resight estimate of red knot abundance.

Within this ARM Framework, a set of alternative multispecies models were developed for the Delaware Bay Region to predict the optimal strategy for horseshoe crab bait harvest. These models accounted for the need for red knot stopover feeding during migrations through the region. These models incorporated uncertainty in model predictions and are meant to be updated with new information as monitoring and management progress.

On an annual basis, the ARM model is used to select the optimal harvest package to implement for the next year given the current year's estimate of horseshoe crab abundance from the swept area estimate from the VA Tech trawl survey and a mark-resight estimate of red knot abundance. The current harvest packages for horseshoe crab bait harvest that can be selected by the ARM model 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 packages listed above are totals for the Delaware Bay Region, and not per state. Since its implementation in 2013, neither the 81,900 red knot threshold nor the 11.2 million female horseshoe crab thresholds have been met and harvest package 3 has been selected every year by the Framework and specified by the Board for the Delaware Bay bait harvest limit.

2.4 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. Allocation of the overall Delaware Bay harvest allowance was established in Addendum VII. Based on tagging and genetic analysis (ASMFC 2019, 2021), there is very little exchange between Chesapeake Bay and Delaware Bay horseshoe crab populations. However, there is movement of horseshoe crabs between coastal embayments (from New Jersey through Virginia) and Delaware Bay.

An allocation model for the four Delaware Bay states was developed to allocate the optimized harvest output by the ARM Framework, which is described in Section 2.4 of Addendum VII, and summarized below.

Each state's allocation of the total Delaware Bay-origin harvest recommended by the ARM Framework was determined by multiplying the state's quota under Addendum VI by the proportion of the state's total harvest that is of Delaware Bay-origin (lambda, λ), then dividing this value by the sum of the values for each of four states (Table 1). The state lambda values established in Addendum VII were based on the genetic data available at the time. 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.

Table 1. Calculation of State Allocations of Delaware Bay Harvest Established in Addendum VII

State	Lambda	Addendum VI Quota	Delaware Bay-Origin Quota	Add VII Allocation of Delaware Bay-Origin Quota
NJ	1.00	100,000	100,000	32.4%
DE	1.00	100,000	100,000	32.4%
MD	0.51	170,653	87,033	28.2%
VA (east of COLREGS)	0.35	60,998	21,349	7.0%

Along with the state allocation percentages, Addendum VII also established two additional provisions impacting the state quotas for Maryland and Virginia. First, it established a harvest cap for Maryland and Virginia, which set a maximum limit on the total level of allowed harvest by Maryland and Virginia to provide protection to non-Delaware Bay-origin crabs. The cap is based on Addendum VI quota levels for Maryland and Virginia; the Maryland cap is 170,653 crabs, and the Virginia cap is 60,998 crabs. These caps apply except when the ARM Framework recommends a package that prohibits harvest of female horseshoe crabs. When female harvest is prohibited, a second provision allows for a 2:1 offset of males:females for Maryland and Virginia, which allows the total male harvest of Maryland and Virginia to rise above the cap level. Note again that Virginia's quota only refers to the number of crabs that can be harvested east of the COLREGS line.

3.0 Management Options

Draft Addendum VIII considers two management options:

- Option A: No action
- Option B: Implement the ARM Revision for setting bait harvest specifications for Delaware Bay-origin horseshoe crabs

Option B includes additional sub-options to specify how annual harvest recommendations will be made based on the output of the ARM model.

Option A: No Action
Because the ARM Framework adopted under Addendum VII can no longer be updated due to its obsolete software, under this option, the management program would revert back to the provisions implemented under Addendum VI. These include the following harvest quotas and limitations for New Jersey, Delaware, Maryland, and Virginia.

Addendum VI prohibits directed 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 harvest to 100,000 horseshoe crabs per state per year.

Addendum VI prohibits directed harvest and landing of horseshoe crabs in Maryland from January 1 through June 7 for two years, from October 1, 2006 to September 30, 2008. It also prohibits the landing of horseshoe crabs in Virginia from federal waters from January 1 through June 7.

Addendum VI mandates that 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 must be comprised of a minimum male to female ratio of 2:1.

Table 2. Commercial horseshoe crab bait harvest quotas for the Delaware Bay states under Addendum VI.

Jurisdiction	Addendum VI ASMFC Quota
NJ*	100,000
DE*	100,000
MD	170,653
VA**	152,495
DELAWARE BAY TOTAL	523,148

*Male-only harvest
**No more than 40% of Virginia's annual quota may be harvested east of the COLREGS line in ocean waters. Horseshoe crabs harvested east of the COLREGS line and landed in Virginia must be comprised of a minimum male to female ratio of 2:1.

Option B: Implement the ARM Revision for setting bait harvest specifications for Delaware Bay-origin horseshoe crabs

This option would adopt the updates to the ARM Framework recommended in the 2021 Revision and incorporate them into the process for setting specifications for bait harvest of Delaware Bay-origin horseshoe crabs. Changes to the ARM Framework are described in detail in the 2021 Revision to the Adaptive Resource Management Framework and Peer Review Report, and include:

- Catch multiple survey analysis (CMSA) to estimate male and female horseshoe crab population estimates using all quantifiable sources of mortality (i.e., natural mortality, bait harvest, coastwide biomedical mortality, and commercial dead discards) and several abundance indices from the Delaware Bay Region
- Integrated population model (IPM) to quantify the effects of horseshoe crab abundance on red knot survival and recruitment based on data collected in the Delaware Bay
- Transition to new modeling approach which can be implemented through readily available R software and incorporates uncertainty on all life history parameters for both horseshoe crabs and red knots
- Harvest recommendations based on a continuous scale rather than discrete harvest packages as in the previous Framework
- Female harvest decoupled from the harvest of males

Harvest Recommendations

Harvest recommendations under the ARM Revision are based on a continuous scale rather than the discrete harvest packages in the previous Framework. Therefore, any harvest number between zero and the maximum allowable harvest could be recommended, not just the fixed harvest packages. Harvest of females is decoupled from the harvest of males so that each are determined separately. The maximum possible harvest for both females and males are maintained as in Addendum VII at 210,000 and 500,000, respectively.

Although harvest is treated as continuous in the new ARM Framework, if the continuous harvest recommendations were made public, it would be possible to back-calculate the biomedical mortality input, which is confidential. Therefore, it is necessary to round the continuous sex-specific harvest outputs to obscure the confidential biomedical data, unless the maximum sex-specific harvest is recommended. There are two sub-options for rounding the harvest output from the ARM Framework:

- **Sub-option B1:** Round down continuous optimal harvest recommendation to nearest 25,000 horseshoe crabs. For example, if the continuous optimal harvest recommendation is 135,000 males and 96,000 females, these values would be rounded down to 125,000 males and 75,000 females.

- **Sub-option B2:** Round down continuous optimal harvest recommendation to nearest 50,000 horseshoe crabs. For example, if the continuous optimal harvest recommendation is 135,000 males and 96,000 females, these values would be rounded down to 100,000 males and 50,000 females.

The Board is seeking public input on the level of rounding of the optimal harvest recommendation. Sub-option B2 would be more conservative, but sub-option B1 would yield harvest levels closer to the optimal harvest.

Adaptive management cycle

Under this option the adaptive management cycle would include three tiers of short and longer term management, update, and revision processes for the ARM Framework, as follows:

1. **Annual management process:** The annual specification of harvest will occur at the ASMFC annual meeting in calendar year *t* for the harvest to be implemented the following season (year *t*+1). The CMSA requires multiple indices of abundance and removals from multiple sources. Because the necessary data take time to be finalized, and final data for a given year would not be available by the time of the annual meeting, the results of a run of the CMSA in year *t* will be based on data obtained from the previous two years. Inputs to the CMSA will include the Virginia Tech trawl survey that is conducted in the fall of year *t*-2; Delaware and New Jersey trawl surveys from year *t*-1; and removals from year *t*-1. To match the abundance estimates of horseshoe crabs with red knot mark-resight population estimates, horseshoe crab abundance estimates from year *t*-1 and red knot population estimates from year *t*-1 will be used as input to the ARM Revision harvest policy functions in year *t*. Optimal harvest recommendations can then be implemented in year *t*+1. The two year time lag between data availability and implementation of optimal harvest was incorporated in the ARM Revision modeling when determining what the optimal harvest would be based on horseshoe crab and red knot abundance.

   Each annual step is identified in the timeline below:
   - April - July (year *t*) – The ARM workgroup compiles monitoring data to run the CMSA (Virginia Tech trawl survey data from year *t*-2, New Jersey and Delaware survey data from year *t*-1, removal data from year *t*-1). The ARM workgroup estimates red knot stopover population size from the mark-resight analysis in year *t*-1.
   - August (year *t*) – The ARM workgroup inputs horseshoe crab and red knot population estimates to the ARM Revision harvest policy functions and calculates the optimal harvest.
   - September (year *t*) – The Delaware Bay Ecosystem Technical Committee reviews the ARM Revision results and optimal harvest recommendations.
   - ASMFC Annual Meeting (year *t*) – The Management Board reviews the optimal harvest recommendations from the ARM workgroup and decides on the harvest to be implemented in year *t*+1.

2. **Interim update process:** Every three years, an update process would occur in which the model parameters (e.g., red knot survival and recruitment, horseshoe crab stock-recruitment relationship) are updated based on the annual routine data collected in the region.
3. **Revision process:** every 9 or 10 years (or sooner if desired by the Board), the ARM Framework should undergo a revision process similar to what occurred for the 2021 ARM Revision. This amount of time is appropriate given it allows for two updates to occur, and encompasses one generation for horseshoe crabs. This should incorporate the following components:
    - 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 management process
        - In August, ARM Subcommittee runs models/optimization
        - At the ASMFC Annual Meeting, the Board revisits harvest decision

If Option B is selected, implementation of the ARM Framework Revision would likely occur for the 2023 fishing season, with Board review and decision-making likely to occur at the Board's 2022 annual meeting.

Allocation of the Delaware Bay-origin harvest recommendation

Under this option, the allocation methodology established in Addendum VII would be modified to update state lambda values as recommended in the 2021 Revision based on more recent genetic data analysis. Lambda indicates how much of a state's harvest is of Delaware Bay-origin (i.e., has spawned at least once in Delaware Bay). Lambda shall be assumed to be 1.00 for New Jersey and Delaware and based upon the recent genetics data and analysis (ASMFC 2021), 0.45 for Maryland, and 0.20 for Virginia.

State	Lambda, λ
NJ	1.00
DE	1.00
MD	0.45
VA	0.20

Allocation values will be calculated using the same formula as Addendum VII. Lambda will be multiplied by the state's Addendum VI quota. The resulting value will be divided by the sum of values for all four states to provide the percent of the Delaware Bay harvest recommendation that will be allocated to each state. 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).

State	Allocation of Delaware Bay Harvest (%)
NJ	34.6%
DE	34.6%
MD	26.6%
VA	4.2%

Harvest cap for Maryland and Virginia

Under this option the harvest cap for Maryland and Virginia established under Addendum VII will be maintained. 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 is based on Addendum VI quota levels for Maryland and Virginia. 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

These caps 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 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.

2:1 Male:female offset for female crabs below the Addendum VI levels

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

Fallback option if ARM Framework cannot be used

As part of the 2021 ARM Framework Revision, 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
- Horseshoe crab relative abundance indices from Delaware and New Jersey fishery-independent surveys
- Total horseshoe crab removals (bait harvest, biomedical mortality, and estimated commercial discards)

- Horseshoe crab spawning beach sex ratio from the Delaware Bay Horseshoe Crab Spawning Survey
- Red knot abundance estimates, including stopover counts and re-sightings

The absence of these annually-collected data sets could inhibit the use of the ARM Framework depending on which data sets were missing. If model results were not available for the fall 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 by one of the following methods:

- 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. Harvest could be more conservative than the previous year's ARM Framework harvest level and allocation for New Jersey, Delaware, and Maryland, and Virginia coastal waters.

4.0 Compliance

TBD

5.0 Literature Cited

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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 A. Example Allocation of Delaware Bay Horseshoe Crab Harvest

Table 1. Horseshoe crab and red knot population estimates and resulting harvest recommendation for 2017-2019 based on the 2021 ARM Revision. Coastwide biomedical mortality was used for model development, so actual Delaware-Bay specific values will result in slightly lower population estimates. Source: Supplemental Report for ARM Revision, Table 11.

Year	CMSA Estimates		Red knots	Optimal HSC Harvest (revised ARM)	
	Female HSC	Male HSC		Female	Male
2017	10,967,100	31,664,430	49,405	154,483	500,000
2018	9,735,690	24,715,290	45,221	146,792	500,000
2019	9,357,400	21,897,920	45,133	144,803	500,000

Table 2. Example allocation of the Delaware Bay optimal horseshoe crab harvest using the 2019 Optimal HSC Harvest (see Table 1). Top: Example allocation under Option B, sub-option B1. Bottom: Example allocation under sub-option B2. Total quota includes crabs of non-Delaware Bay Origin.

State	DE Bay Origin Quota			Total Quota		
	Sexes Combined	Male	Female	Sexes Combined	Male	Female
DE	216,268	173,014	43,254	216,268	173,014	43,254
NJ	216,268	173,014	43,254	216,268	173,014	43,254
MD	166,080	132,864	33,216	170,653	136,522	34,131
VA	26,384	21,107	5,277	60,998	48,798	12,200
Total	**625,000**	**500,000**	**125,000**	**664,187**	**531,349**	**132,837**

State	DE Bay Origin Quota			Total Quota		
	Sexes Combined	Male	Female	Sexes Combined	Male	Female
DE	207,617	173,014	34,603	207,617	173,014	34,603
NJ	207,617	173,014	34,603	207,617	173,014	34,603
MD	159,437	132,864	26,573	170,653	142,211	28,442
VA	25,328	21,107	4,221	60,998	50,832	10,166
Total	**600,000**	**500,000**	**100,000**	**646,885**	**539,071**	**107,814**

Atlantic States Marine Fisheries Commission

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MEMORANDUM

TO: **Horseshoe Crab Plan Development Team**

FROM: **Horseshoe Crab Advisory Panel**

DATE: **July 22, 2022**

SUBJECT: **Advisory Panel Input on Biomedical Mortality and Best Management Practices**

Background

In October 2021, the Board assigned the Plan Development Team (PDT) with the following task: review the threshold for biomedical mortality to develop biological based options for the threshold and to develop options for action when the threshold is exceeded; also, review the best management practices (BMPs) for handling biomedical catch and suggest options for updating and implementing BMPs. The PDT requested that the Horseshoe Crab Advisory Panel (AP) meet to discuss this task and provide input to the PDT regarding the biomedical mortality threshold and BMPs.

The AP met on July 11, 2022 to review the task and provide comments to the PDT. A summary of the AP's discussion and is summarized below. These comments represent the opinions of individual advisors and do not represent a consensus opinion.

Advisory Panel Attendance: Brett Hoffmeister (ACC), Allen Bergeson (Lonza), George Topping (commercial for biomed Lonza), Christina Lecker (Fuji Wako), Benjie Swan, Walker Golder (Audubon, Coastal Land Trust), Nora Blair (CRL), David Meservey (Fisherman Dealer)

Public: Ben Levitan (Earth Justice), Kristoffer Whitney (RIT, NSF research)

AP Comments on Biomedical Mortality

Regarding the current estimates of biomedical mortality, Allen commented that the 15% mortality rate that is assumed for crabs that are bled was originally based on studies that used practices that are completely different from the true practices of the industry. He believes the mortality associated with the biomedical process is actually much lower, closer to 5%. He also noted that during the last assessment the data showed that the biomedical crabs had better survival rates than crabs not processed by the biomedical industry; this is because the biomedical labs take care not to bleed crabs that are unhealthy. A paper by Dave Smith (2020) estimates better mortality for bled crabs than control crabs. Regarding the 57,500 crab mortality threshold, Allen said this number was arbitrary when it was established. Efforts have replenished HSC in last few years.

Nora Blair echoed the statements related to the biomedical mortality rate and feels 15% is an overestimate. She also agreed with the TC in their decision to not recommend a biologically-based mortality threshold.

Walker Golder commented that the claims that biomedical mortality is lower than currently estimated do not address or explain why egg density in the Delaware Bay is low compared to what it was years ago. It used to be that egg density was 50,000 per square meter on the beaches in May. He is concerned that there are no signs of increasing egg density in the Bay regardless of the trawl survey trends, noting

that the shorebirds need eggs to survive, and other species need them too. In addition, he has concerns about the post-handling mortality and impacts of bleeding on horseshoe crabs. He would also like to see more research on the impact of post-spawning capture, because spawning is energetically intensive; post-spawning capture at a time when crabs may be trying to replenish energy supplies and body condition could be contributing to mortality. Similarly, there seems to be minimal information on physiological effects on the adult crabs that are bled. He is also concerned about the release of the crabs after bleeding, specifically about whether the crabs are displaced from their habitat and spawning areas, and not being released close enough to where they are collected.

Allen Burgenson responded to these concerns, first stating that he believes the timing of the shorebirds and the peak egg density of horseshoe crabs are out of sync. Regarding replacement of crabs collected for Lonza, the collection location coordinates are taken and recorded, and also the release coordinates, which allows them to return the crabs within a small area near where they were collected.

AP Comments on Biomedical Best Management Practices

The AP members discussed and provided some thoughts on the BMPs, as well as current practices in the biomedical industry. They also reviewed each of the BMPs from the 2011 document, and provided a few suggested changes.

Walker Golder noted concerns that in general, the language in the BMPs is too vague, and that the BMPs should be coastwide mandates instead of recommendations or state requirements. He would like to see BMPs that are more prescriptive and take into consideration the geographic variability and other variables from capture to release, because the current language leaves it open to interpretation of the individual. For example he asked if a specific tow time for trawls could be required rather than recommended.

The AP members representing the biomedical companies agreed that the BMPs were written this way because of the variation in the environment, collection methods, and facilities along the coast. Because there are different fishing practices in different states, for example hand harvest versus trawling, some of the BMPs would not be practicable in some areas and therefore could not be mandates. Similarly, they discussed that language like “appropriate” or “suitable” were used to describe issues like temperature and number of crabs in transport containers because these factors depend on the conditions specific to an area (e.g. the water temperature in South Carolina is different from that in Massachusetts). Therefore they agreed that broad restrictions or requirements across states would not make sense.

Brett Hoffmeister reminded the group that states have their own specific regulations to protect the spawning population of horseshoe crabs, like lunar closures. For example, in Maryland they do not collect crabs until after they spawn, after the second week of June. Walker Golder said all harvest and biomedical collections should be prohibited during the spawning period and during the period that horseshoe crabs are staging for spawning, including hand harvest.

In general, the biomedical representatives on the AP agreed that the industry is following the best management practices as if they are required (and in some states they are requirements) and making an effort to minimize mortality and stress of the crabs. It is in their best interest to keep mortality as low as possible. For Lonza, the BMPs are included in a contract with the fishermen and in their collection permit, and Maryland audits them for compliance with the BMPs.

Several AP members spoke favorably about the dual use of horseshoe crabs (bait crabs being used for biomedical before being returned to the bait market), saying it is an efficient use of the resource. Others said that it would not be possible in their state because there is no bait fishery.

The AP members suggested some specific changes to the BMPs, as follows:

- Under *Collection*, combine these two redundant bullets: "Sort out and return to the water individuals that do not appear to be healthy (damaged, slow movement, dull shell/old)" and "When possible, release juveniles or unhealthy individuals immediately and do not transport to the facility."
- Under *Transport to Facility,* change "Maintain temperature between approximately ambient water temperature at time of collection and 10ºF below ambient-water temperature" to "Maintain appropriate temperature to prevent temperature shock." This addresses variation in temperatures along the coast and identifies the purpose of the practice.
- Under *Holding at Facility/Preparation for bleeding/Bleeding*, substitute the term "cell collection" for bleeding, and "collection" for harvest.
- Edit "Continue ~~30-year~~ policy of not attempting to suction additional blood from the horseshoe crabs"
- Edit "Return to the water as soon as possible. If not being returned to the area of capture, ensure that conditions ~~(salinity, water temperature, etc.)~~ are similar to those found at the collection site"
    - Walker Golder raised a concern about the statement "If not being returned to the area of capture" because the BMPs indicate that the horseshoe crabs must be returned to the waters they were collected from.
- Under *Return to Sea*, clarify that it is a <u>requirement</u> to return the crabs to the sea.
    - The AP discussed whether it could be more specific how close they must be released to collection site. Walker Golder suggested the following language: "All crabs should be returned as close as possible to site of capture, in the same body of water, at a site with suitable local habitat and conditions, and not more than one mile from the site of capture"
    - A commercial harvesters noted that sometimes the state wants them to release the crabs some distance away from where they were collected to reduce the chance that recently released crabs would be picked up in another trawl.

General Comments

George Topping noted that he also works on the Virginia Tech Trawl Survey, and has seen a huge increase in the horseshoe crab population during the survey for crabs of all sizes. He commented that they now have to stay in shallower areas to avoid too many small crabs. To get a good number of mature crabs 15-20 years ago they had to tow for much longer than they do now. Everything that management has been doing has worked and it would not be fair to mess with something that is working. He suggests continuing the surveys and current management. Habitat in the Delaware Bay has changed with increased human population growth and land development, and that is a lot of the reason why crabs are not coming up on beaches anymore. He also said that the Board needs to study the impact on horseshoe crabs before building windmills in the horseshoe crab sanctuary.

Atlantic States Marine Fisheries Commission

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MEMORANDUM

TO: **Horseshoe Crab Plan Development Team**

FROM: **Horseshoe Crab Technical Committee**

DATE: **July 25, 2022**

SUBJECT: **Technical Committee Recommendations to PDT on Best Management Practices for Handing Biomedical Collections**

Background

In October 2021, the Board assigned the following task to the Plan Development Team (PDT): review the threshold for biomedical mortality to develop biological based options for the threshold and to develop options for action when the threshold is exceeded; also, review the best management practices (BMPs) for handling biomedical catch and suggest options for updating and implementing BMPs. The PDT tasked the Technical Committee (TC) with reviewing available information to address this task and recommending potential methods for developing biologically based options for the biomedical mortality threshold. They also requested the TC review the BMPs and recommend any updates.

The TC met in July to continue their discussion on the second part of the task relating to the BMPs. At this time, the TC agrees that more information would be needed to make any recommendations for updating the BMPs or potential requirements for biomedical collection practices. **If the Board wishes to pursue modifying the BMPs or considering new requirements, the TC recommends forming a Work Group to collect additional information and develop recommendations.**

Technical Committee Discussion on Biomedical BMPs

At the TC's June meeting, state representatives were requested to provide information on how their state incorporates the BMPs into their permitting process for biomedical collections and facilities. For each of the BMPs listed in the 2011 document, the state TC representatives indicated whether the practice was required by their state, practiced by the industry but not required, not required nor practiced, not applicable, or unknown. The responses varied widely across the states, with some states requiring few if any of the BMPs and others requiring many of them. However, it was noted by many states that the practices in each state vary greatly, and consequently so does the applicability of some of the BMPs. For example, some states do not allow trawling as a biomedical collection method while others do; to address these differences the TC thinks the BMPs could be further grouped by collection method or other relevant categories. Other issues the TC would like to discuss further are BMPs specific to horseshoe crab holding pens and seasonality of biomedical collections.

The TC agreed that a much more in-depth process is needed to review biomedical practices and permitting in each state. The TC recommends the following next steps:

- Form a Work Group comprised of TC representatives from each of the states that permit biomedical collections and/or facilities, as well as Advisory Panel representatives from the biomedical industry.

- The Work Group should expand on the information collected thus far by the TC. Specifically, it should identify the following:
    - Differences in biomedical practices across the states (from collection to return to sea)
    - Which BMPs are incorporated into practices or not (and why)
    - Which if any of the BMPs are required by the state
    - Enforceability of the BMPs
    - In text references or documents encompassing state permits or agreements with biomedical facilities and/or collectors.
- The Work Group should compile this information into a report including recommendations for potential actions the Board could consider (e.g., recommended changes to the BMPs, recommended coastwide requirements).

The TC believes this process would be beneficial for improving existing BMPs to inform management of the collection of horseshoe crabs for biomedical use by states through permitting or other mechanisms. It could also help identify areas in which mortality and sub-lethal impacts on horseshoe crabs collected for the biomedical industry could be reduced.

Atlantic States Marine Fisheries Commission

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MEMORANDUM

July 22, 2022

To: **Horseshoe Crab Management Board**

From: **Tina Berger, Director of Communications**

RE: **Advisory Panel Nomination**

Please find attached nominations to the Horseshoe Crab Advisory Panel for Delaware – Jordan Giuttari, a dealer/processor, and Matt Sarver, a conservationist . Please review this nomination for action at the next Board meeting.

If you have any questions, please feel free to contact me at (703) 842-0749 or tberger@asmfc.org.

Enc.

cc: Caitlin Starks

ATLANTIC STATES MARINE FISHERIES COMMISSION

Advisory Panel Nomination Form

This form is designed to help nominate Advisors to the Commission's Species Advisory Panels. The information on the returned form will be provided to the Commission's relevant species management board or section. Please answer the questions in the categories (All Nominees, Commercial Fisherman, Charter/Headboat Captain, Recreational Fisherman, Dealer/Processor, or Other Interested Parties) that pertain to the nominee's experience. If the nominee fits into more than one category, answer the questions for all categories that fit the situation. **Also, please fill in the sections which pertain to All Nominees (pages 1 and 2). In addition, nominee signatures are required to verify the provided information (page 4), and Commissioner signatures are requested to verify Commissioner consensus (page 4). Please print and use a black pen.**

Form submitted by: John H. Clark (your name) State: Delaware

Name of Nominee: Jordan Giuttari

Address: 3337 Main St

City, State, Zip: Bowers Beach, DE 19946

Please provide the appropriate numbers where the nominee can be reached:

Phone (day): 302-233-4694 Phone (evening): 302-233-4694

FAX: _____ Email: DelBaySeafood@gmail.com

. . . . . .

FOR ALL NOMINEES:

1. Please list, in order of preference, the Advisory Panel for which you are nominating the above person.
   1. Horseshoe Crabs
   2. _____
   3. _____
   4. _____
2. Has the nominee been found in violation of criminal or civil federal fishery law or regulation or convicted of any felony or crime over the last three years?

   yes _____ no ✓
3. Is the nominee a member of any fishermen's organizations or clubs?

   yes ✓ no _____

   If "yes," please list them below by name.

Delaware Shellfish Advisory

4. What kinds (species) of fish and/or shellfish has the nominee fished for during the past year?

Blue Crabs
Conchs
Horseshoe crabs
Oysters
Rockfish

5. What kinds (species) of fish and/or shellfish has the nominee fished for in the past?

Blue Crabs
Conchs
Horseshoe crabs
Oysters
Rockfish

FOR COMMERCIAL FISHERMEN:

1. How many years has the nominee been the commercial fishing business? 15 years
2. Is the nominee employed only in commercial fishing? yes _____ no ✓
3. What is the predominant gear type used by the nominee? Crab pots
4. What is the predominant geographic area fished by the nominee (i.e., inshore, offshore)? DE Bay

FOR CHARTER/HEADBOAT CAPTAINS:

1. How long has the nominee been employed in the charter/headboat business? _____ years
2. Is the nominee employed only in the charter/headboat industry? yes _____ no _____

   If "no," please list other type(s)of business(es) and/occupation(s): _____

3. How many years has the nominee lived in the home port community? _____ years

   If less than five years, please indicate the nominee's previous home port community.

FOR RECREATIONAL FISHERMEN:

1. How long has the nominee engaged in recreational fishing? _____ years

2. Is the nominee working, or has the nominee ever worked in any area related to the fishing industry? yes _____ no _____

   If "yes," please explain.

_____

_____

_____

FOR SEAFOOD PROCESSORS & DEALERS:

1. How long has the nominee been employed in the business of seafood processing/dealing? 4 years

2. Is the nominee employed only in the business of seafood processing/dealing?

   yes _____ no ✓ If "no," please list other type(s) of business(es) and/or occupation(s):

   Commercial fishermen

   DE Bay + River Pilots Association

   _____

3. How many years has the nominee lived in the home port community? 34 years

   If less than five years, please indicate the nominee's previous home port community.

_____

FOR OTHER INTERESTED PARTIES:

1. How long has the nominee been interested in fishing and/or fisheries management? _____ years

2. Is the nominee employed in the fishing business or the field of fisheries management? yes _____ no _____

   If "no," please list other type(s) of business(es) and/or occupation(s):

_____

_____

_____

FOR ALL NOMINEES:

In the space provided below, please provide the Commission with any additional information which you feel would assist us in making choosing new Advisors. You may use as many pages as needed.

Nominee Signature: _____ Date: 7/21/22

Name: Jordan Giuttari
(please print)

COMMISSIONERS SIGN-OFF (not required for non-traditional stakeholders)

John H. Clark
State Director

State Legislator

Governor's Appointee

ATLANTIC STATES MARINE FISHERIES COMMISSION

Advisory Panel Nomination Form

This form is designed to help nominate Advisors to the Commission's Species Advisory Panels. The information on the returned form will be provided to the Commission's relevant species management board or section. Please answer the questions in the categories (All Nominees, Commercial Fisherman, Charter/Headboat Captain, Recreational Fisherman, Dealer/Processor, or Other Interested Parties) that pertain to the nominee's experience. If the nominee fits into more than one category, answer the questions for all categories that fit the situation. **Also, please fill in the sections which pertain to All Nominees (pages 1 and 2). In addition, nominee signatures are required to verify the provided information (page 4), and Commissioner signatures are requested to verify Commissioner consensus (page 4). Please print and use a black pen.**

Form submitted by: John H. Clark (your name) State: Delaware

Name of Nominee: Matthew Sarver

Address: 6 Walnut Ridge Rd

City, State, Zip: Wilmington, DE 19807

Please provide the appropriate numbers where the nominee can be reached:

Phone (day): 724-689-5845 Phone (evening): same

FAX: _____ Email: matt@sarverecological.com

FOR ALL NOMINEES:

1. Please list, in order of preference, the Advisory Panel for which you are nominating the above person.
   1. Horseshoe Crab
   2. _____
   3. _____
   4. _____

2. Has the nominee been found in violation of criminal or civil federal fishery law or regulation or convicted of any felony or crime over the last three years?

   yes _____ no X

3. Is the nominee a member of any fishermen's organizations or clubs?

   yes _____ no X

   If "yes," please list them below by name.

4. What kinds (species) of fish and/or shellfish has the nominee fished for during the past year?
N/A

5. What kinds (species) of fish and/or shellfish has the nominee fished for in the past?
N/A

FOR COMMERCIAL FISHERMEN:

1. How many years has the nominee been the commercial fishing business? _____ years

2. Is the nominee employed only in commercial fishing? yes_____ no X_____

3. What is the predominant gear type used by the nominee?_____

4. What is the predominant geographic area fished by the nominee (i.e., inshore, offshore)?_____

FOR CHARTER/HEADBOAT CAPTAINS:

1. How long has the nominee been employed in the charter/headboat business? _____ years

2. Is the nominee employed only in the charter/headboat industry? yes _____ no X_____

If "no," please list other type(s)of business(es) and/occupation(s):_____

3. How many years has the nominee lived in the home port community? _____ years

If less than five years, please indicate the nominee's previous home port community.

FOR RECREATIONAL FISHERMEN:

1. How long has the nominee engaged in recreational fishing? _____ years

2. Is the nominee working, or has the nominee ever worked in any area related to the fishing industry? yes _____ no X

   If "yes," please explain.

_____

_____

_____

FOR SEAFOOD PROCESSORS & DEALERS:

1. How long has the nominee been employed in the business of seafood processing/dealing? _____years

2. Is the nominee employed only in the business of seafood processing/dealing?

   yes _____ no X_____ If "no," please list other type(s) of business(es) and/or occupation(s):

_____

_____

_____

3. How many years has the nominee lived in the home port community? _____ years

   If less than five years, please indicate the nominee's previous home port community.

_____

FOR OTHER INTERESTED PARTIES:

1. How long has the nominee been interested in fishing and/or fisheries management? 10 years

2. Is the nominee employed in the fishing business or the field of fisheries management? yes _____ no X

   If "no," please list other type(s) of business(es) and/or occupation(s):

Volunteer Conservation committee Chair at Delaware Ornithological Society. Professional ecologist by trade.

FOR ALL NOMINEES:

In the space provided below, please provide the Commission with any additional information which you feel would assist us in making choosing new Advisors. You may use as many pages as needed.

Nominee Signature: _____ Date: 7/18/22

Matthew Sarver

Name: _____
(please print)

COMMISSIONERS SIGN-OFF (not required for non-traditional stakeholders)

_____
State Director

_____
State Legislator

_____
Governor's Appointee

EARTHJUSTICE

July 26, 2022

Atlantic States Marine Fisheries Commission
1050 N. Highland Street, Suite 200 A-N
Arlington, VA 22201
comments@asmfc.org

VIA ELECTRONIC MAIL

Re: Consideration of Draft Addendum VIII on the Implementation of Recommended Changes from 2021 Adaptive Resource Management Revision and Peer Review Report for Public Comment

Dear Commissioners:

I write on behalf of New Jersey Audubon and Defenders of Wildlife regarding the Atlantic States Marine Fisheries Commission ("ASMFC") Horseshoe Crab Management Board's "Consider[ation of] Draft Addendum VIII on the Implementation of Recommended Changes from 2021 Adaptive Resource Management Revision and Peer Review Report for Public Comment," which is scheduled for discussion at the Board's meeting on August 3, 2022.[1] Please include this letter in the supplemental materials for that meeting.

On February 23, 2022, the parties to this letter submitted records requests to ASMFC, the U.S. Geological Survey, and the U.S. Fish & Wildlife Service seeking the model, including inputs, used to generate bait harvest recommendations under the adaptive resource management ("ARM") revision. The purpose of the records requests was to ensure that the public has an opportunity to independently assess the rigor and functionality of the model. To date, the federal agencies have not provided the model or any of the model's components or inputs.[2]

New Jersey Audubon and Defenders of Wildlife strongly urge the Horseshoe Crab Management Board not to initiate public comment on proposed Addendum VIII until all components of, and inputs to, the model are publicly available, and the public has had a reasonable opportunity to analyze them. Specifically, they urge the Board not to take management action to initiate a public comment period at the meeting on August 3. By initiating a comment period, the Board would be asking the public to comment on a model that the public has not yet had an opportunity to review, contravening basic requirements for informed public input.

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[1] ASMFC Horseshoe Crab Management Board, *Draft Agenda (August 3, 2022)*, http://www.asmfc.org/files/Meetings/2022SummerMeeting/HorseshoeCrabBoard.pdf

[2] ASMFC provided certain components of the model on April 29, 2022, but indicated that most of the model's components and inputs were in the possession of federal agencies.

The stakes of the Horseshoe Crab Management Board's decision on proposed Addendum VIII are immense. On January 18, 2022, New Jersey Audubon and Defenders of Wildlife submitted a letter[3] to ASMFC detailing concerns about the ARM revision's likely impact on the horseshoe crab and red knot, a migratory shorebird listed as threated under the Endangered Species Act for which horseshoe crab eggs are an essential food source. The red knot's precarious situation calls for a precautionary approach to facilitate its recovery—and to prevent a potentially irreversible decline.

There is no justification for advancing proposed Addendum VIII through the approval process without meaningful public review of the underlying model. The Board should postpone the initiation of a public comment period until the opportunity for such review has been granted.

Respectfully submitted,

Benjamin Levitan
Senior Attorney, Biodiversity Defense Program
EARTHJUSTICE
48 Wall Street, 15th Floor
New York, NY 10005
(202) 797-4317
blevitan@earthjustice.org

[3] Letter from Benjamin Levitan to ASMFC Commissioners re: Proposed "Revision to the Framework for Adaptive Management of Horseshoe Crab Harvest in the Delaware Bay Inclusive of Red Knot Conservation" (Jan. 18, 2022), *in* Supplemental Materials for the Horseshoe Crab Management Board meeting (Jan. 26, 2022) at p. 37 of PDF, http://www.asmfc.org/files/Meetings/2022WinterMeeting/HorseshoeCrabBoardSupplemental.pdf.