

**PROCEEDINGS OF THE  
ATLANTIC STATES MARINE FISHERIES COMMISSION  
HORSESHOE CRAB MANAGEMENT BOARD**

**The Westin Crystal City  
Arlington, Virginia  
Hybrid Meeting**

**April 30, 2024**

**Approved October 21, 2024**

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1. **Move to approve Agenda** by consent (Page 1).
2. **Move to approve Proceedings of October 16, 2023** by consent (Page 1).
3. **Move to accept the 2024 Horseshoe Crab Assessment Update for management use** (Page 10). Motion by Shanna Madsen; second by Conor McManus. Motion passes by unanimous consent (Page 10).
4. **Motion to adjourn** by consent (Page 18).

**ATTENDANCE**

**Board Members**

|  |   |
|--|---|
| Dan McKiernan, MA (AA)                                   | Roy Miller, DE (GA)                             |
| Raymond Kane, MA (GA)                                    | Craig Pugh, DE, proxy for Rep. Carson (LA)      |
| Sarah Ferrara, MA, proxy for Rep. Peake (LA)             | Mike Luisi, MD, proxy for L. Fegley (AA Acting) |
| Conor McManus, RI, proxy for J. McNamee (AA)             | Russell Dize, MD (GA)                           |
| Eric Reid, RI, proxy for Sen. Sosnowski (LA)             | Shanna Madsen, VA, proxy for J. Green (AA)      |
| Justin Davis, CT (AA)                                    | Chris Batsavage, NC, proxy for K. Rawls (AA)    |
| Bill Hyatt, CT (GA)                                      | Chad Thomas, NC, proxy for Rep. Wray (LA)       |
| Marty Gary, NY (AA)                                      | Ben Dyar, SC, proxy for B. Keppler (AA)         |
| Scott Curatolo-Wagemann, NY, proxy for E. Hasbrouck (GA) | Doug Haymans, GA (AA)                           |
| Jesse Hornstein, NY, proxy for Sen. Kaminsky (LA)        | Spud Woodward, GA (GA)                          |
| Joe Cimino, NJ (AA)                                      | Jeffrey Renchen, FL, proxy for J. McCawley (AA) |
| Jeff Kaelin, NJ (GA)                                     | Gary Jennings, FL (GA)                          |
| Adam Nowalsky, NY, proxy for Sen. Gopal (LA)             | Ron Owens, PRFC                                 |
| John Clark, DE (AA)                                      | Chris Wright, NMFS                              |
|  | Rick Jacobson, US FWS                           |

**(AA = Administrative Appointee; GA = Governor Appointee; LA = Legislative Appointee)**

**Ex-Officio Members**

|   |                                    |
|---|------------------------------------|
| Brett Hoffmeister, Advisory Panel Chair | John Sweka, ARM Subcommittee Chair |
|---|------------------------------------|

**Staff**

|                  |               |                 |
|------------------|---------------|-----------------|
| Bob Beal         | Katie Drew    | Caitlin Stark   |
| Toni Kerns       | Jeff Kipp     | Chelsea Tuohy   |
| Tina Berger      | Jainita Patel | Emilie Franke   |
| Madeline Musante | Tracey Bauer  | Trevor Scheffel |
| Kristen Anstead  | James Boyle   |                 |

**Guests**

|  |                                 |   |
|--|---------------------------------|---|
| Thad Altman, Florida House of Representatives    | Jeff Brunson, SC DNR            | Tanya Darden, SC DNR MRR                                |
| Mike Armstrong, MA DMF                           | Jeffrey Brust, NJ DFW           | Conor Davis, NJ DEP                                     |
| Pat Augustine                                    | Darlene Carpenter               | Steve Doctor, MD DNR                                    |
| Linda Barry, NJ DEP                              | Nicole Caudell, MD DNR          | Danielle Dyson, NJ DEP                                  |
| Kendra Beaver, Save The Bay                      | Michael Celestino, NJ DEP       | Julie Evans, East Hampton Town Fisheries Advisory Cmte. |
| Mel Bell   | Haley Clinton, NC DEQ           | Delaney Farrell, FL FWC                                 |
| John Bello, Virginia Saltwater Sportfishing Assn | Margaret Conroy, DE DNREC       | Wenley Ferguson, Save The Bay                           |
| Colleen Bouffard, CT DEEP                        | Danielle Contrada, FL FWC       | Anthony Friedrich, ASGA                                 |
| Michael Bowen, Cornell University                | James Cooper                    | Matthew Gates   |
|  | Claire Crowley McIntyre, FL FWC | Lewis Gillingham, VMRC                                  |
|  | Caitlyn Czajkowski              | Angela Giuliano, MD DNR                                 |

### Guests (Continued)

Laura Graziano, Jenkinson's  
Aquarium

Berlyna Heres, FL FWC

Harry Hornick, MD DNR

Derrek Hughes, NY DEC

Todd Janeski, VCU

Rachel Kalisperis, South  
Carolina Aquarium

TJ Karbowski, Rock & Roll  
Charters

Amy Karlnoski, NYS Assembly

Blaik Keppler, SC (AA)

Kris Kuhn

Robert LaCava, MD DNR

Jennifer Lander, NYS DEC

Christina Lecker, Fujifilm Wako  
Chemicals USA

Ben Levitan, Earthjustice

Susan Linder

John Maniscalco, NYS DEC

Victoria Melendez, FL FWC

Nichola Meserve, MA DMF

David Meservey

Steve Meyers

Chris Moore, Chesapeake Bay  
Foundation

Thomas Newman, North

Carolina Fisheries Assn.

Scott Olszewski, RI DEM

Marina Owens, FL FWC

Danielle Palmer, NOAA

Cheri Patterson, NH (AA)

Derek Perry, MA DMF

Jill Ramsey, VMRC

Allen Reneau, Fujifilm Wako  
Chemicals USA

Sefatia Romeo Theken, MA DFG

James Rosato

Daniel Sasson, SC DNR

Chris Scott, NYS DEC

Ethan Simpson, VMRC

Somers Smott, VMRC

Renee St. Amand, CT DEEP

Benjie Swan

Yoshihiro Takasuga, Fujifilm  
Wako Chemicals USA

Kristen Thiebault, MA DMF

Laura Tomlinson, MA DMF

Kelly Whitmore, MA DMR

Kristoffer Whitney

Angel Willey, MD DNR

Travis Williams, NC DEQ

Steven Witthuhn, NY MRAC

Daniel Zapf, NC DEQ

Jordan Zimmerman, DE DNREC

Renee Zobel, NH FGD

The Horseshoe Crab Management Board of the Atlantic States Marine Fisheries Commission convened in the Jefferson Ballroom of the Westin Crystal City Hotel, Arlington, Virginia, a hybrid meeting, in-person and webinar; Tuesday, April 30, 2024, and was called to order at 3:00 p.m. by Chair Justin Davis.

### CALL TO ORDER

CHAIR JUSTIN DAVIS: I'm going to go ahead and call to order this meeting of the Horseshoe Crab Management Board. My name is Justin Davis; I'm the Administrative Commissioner from Connecticut, and I have the pleasure of taking over as the Chair of this Board starting at this meeting. First order of business, I'll thank our outgoing chair, John Clark, for his excellent leadership of this Board over the last couple years, I think everyone would agree was pretty eventful for this Board.

I thank John for taking care of all that, so that we'll have relative peace and quiet for the next few years.

### APPROVAL OF AGENDA

CHAIR DAVIS: As our first item on the agenda today, Approval of the Agenda. Does anyone have any additions or suggested changes to the agenda? Caitlin is reminding me that I have a change to the agenda that I'm supposed to tell everybody about.

We will not be electing a Vice-Chair today at today's Board meeting. That last item on the agenda is no longer on the agenda. Any other changes to the agenda? Okay, not seeing any, we'll consider the agenda approved by consent with that one change.

### APPROVAL OF PROCEEDINGS

CHAIR DAVIS: Next item on the agenda is Approval of the Proceedings from the last meeting of this Board in October, 2023. Any suggested changes, additions, omissions from those meeting minutes? Okay, not seeing any hands, we'll consider the proceedings from the October, 2023 meeting approved by consent.

### PUBLIC COMMENT

CHAIR DAVIS: Moving right along, next item on the agenda, Public Comment. As a reminder, this would be public comment on any items that are not on the agenda for today's Board meeting. Okay, I'm being told we didn't have anybody signed up for public comment. I see one hand in the back of the room. Sir, if you would like to go ahead and come up to the public microphone there on the corner.

MR. BRETT HOFFMEISTER: Great, thank you very much. My name is Brett Hoffmeister, I am the LAL Production Manager at Associates of Cape Cod. I just wanted to thank you for allowing me to comment today. It was in 1816 that Sir Walter Scott penned the phrase, "It is not the fish you are buying, but it's men's lives."

He couldn't have known just how relevant that statement would be over 200 years later. I cannot imagine he would have thought it relevant to the humble horseshoe crab either. But here we are. Human lives are now intertwined with those of the horseshoe crab on which we depend on for endotoxin testing. Testing that is so critical to our healthcare that is required by law in the U.S., 2024 marks 50 years of Associates of Cape Cod doing business. Our founder was the first to license LAL with the USFDA. Since then, LAL has functionally replaced the rabbit pyrogen test, it was viewed as the gold standard around the world for endotoxin testing.

We provide products, support, services to pharmaceutical and medical device manufacturers globally. We also provide clinical testing products and testing services for patients from or who are at risk of invasive fungal infections. This vital assay is used millions of times annually across the globe, to help ensure the safety of life saving, life enhancing medical devices, implants, hardware, IV fluid, drugs, vaccines and antibiotics.

This assay is so critical to our healthcare system that it is pretty safe to say that nearly every human being that you will meet in your entire life benefited from the products and services that this industry

provides. The LAL test will be needed for many years to come, even as new technologies enter the market.

There are only four companies in the U.S. that are licensed to make LAL. Our facilities are scattered along the east coast of the U.S. We work closely with state and coastal fisheries managers, fishers, dealers, and regulatory agencies to provide the products and services so critical to an industry that not only extends human life, but helps to maintain and increase the quality of life for countless people around the world.

Our medical use of these animals is a low impact activity that is essential to our global healthcare system. It is amazing that LAL has a hundred percent safety record. It has never failed us when used correctly. It is within that context I would like to comment on the recent efforts to limit or prohibit collection of horseshoe crabs that defers business of LAL manufacturing.

While Associates of Cape Cod shares the concerns of many regarding conservation of these remarkable animals, it is vital to recognize the role they play in human health. Conservation measures are working and data demonstrates the horseshoe crab populations are robust and healthy. Overall, fisheries related mortality over the past 15 or 20 years has been on a steady decline, and in many areas, populations appear to be growing substantially.

The well-meaning for many efforts to list the horseshoe crabs as endangered or other means that will limit access to these animals, is reckless, and potentially dangerous, as it could limit the ability of the LAL industry to supply this essential assay to the companies that are required to test for endotoxins. This could have far-reaching and longstanding impacts on the healthcare system.

Alternative assays have been available for many years, and new products have recently been brought to market. Without a doubt they will have a role to play in the future. But allowing proper vetting takes time. Calls to ban fishing for crabs and

force the use of alternatives are misconstrued and flawed approach that needlessly places at risk the people who are in need of medical intervention.

Simply put, there are no shortcuts around the barriers of the regulatory landscape, and this exists solely to protect human life. The political purses surrounding this fishery ignores the efforts of scientists and fisheries managers who have been tasked with managing our fisheries. Similarly, efforts are producing hundreds and in some cases thousands of electronically filled out letters and petitions to sway decision makers and adopting an agenda potentially undermines the system's that are put in place and been developed to allow experts, like you, to make decisions based on fact, science and data.

It is my hope and expectation that we can allow experts in a particular field to do their job and manage, regulate, or otherwise utilize the authority we have placed on their shoulders, unencumbered by misinformation, agendas and group sourcing. This goes for wildlife managers, fisheries managers, regulators, and those who contribute to human healthcare, management and safety. The impact of the decisions and the work that you do cannot be taken lightly, for indeed, it is not just fish you are selling.

CHAIR DAVIS: Brett, can I just ask that you wrap it up. We're over the three minutes.

MR. HOFFMEISTER: I'm done, thank you very much.

CHAIR DAVIS: Thank you for your comment. Any other public comment before we move on?

#### **CONSIDER 2024 HORSESHOE CRAB STOCK ASSESSMENT UPDATE**

CHAIR DAVIS: Okay, we're going to go ahead and move on to our next item on the agenda, which will be a presentation of the 2024 Horseshoe Crab Stock Assessment Update by Katie Rodrigue.

MS. KATHERINE RODRIGUE: To begin, I just want to go over the stock assessment schedule for

horseshoe crab. The last coastwide assessment was the 2019 Benchmark Assessment, and the Peer Review Panel recommended a benchmark every 10 years with an update every 5, so now in 2024 we've completed the 5-year update assessment.

The next coastwide assessment will be the benchmark in 2029. There was also a revision the Delaware Bay ARM framework in 2022. The stock assessment update was developed by the SAS and approved by the TC, and it is a product of both committees. Here you can see that membership. There was no TC Chair or Vice-Chair for this update.

But going forward, we'll have Ethan Simpson from VMRC as Chair, and Ingrid Braun from PRFC as Vice-Chair. First, I'll go through the fishery dependent data. This is bait harvest coastwide from 1998 to 2022. The gray line on this figure is the coastwide bait harvest, and then the stacked bar charts underneath is showing the breakdown by sex.

The dotted orange line represents the coastwide quota. Since the 2019 benchmark, coastwide landings decrease in 2020 due to the COVID 19 pandemic, but then increased again in 2021 and 2022, the level similar to the recent year's preceding 2020. Landings have remained well below the coastwide quota since the implementation in 2000.

This is bait landings by management regions, so stock status is determined by four management regions for horseshoe crabs, there is the northeast region, the New York Region, Delaware Bay Region and the Southeast. These are based on tagging and genetic studies management and data availability. The assessment does recognize that there may be embayment specific populations or other nuances to these groupings. The majority of bait landings are harvested from the Delaware Bay region and are predominantly males, due to the harvest restrictions in the ARM framework. Historically the New York Region has had the next highest bait landings, but in recent years that has been the Northeast Region. Since 2004 ASMFC has required states to monitor the biomedical use of horseshoe crabs, and that is to determine the source of the

crabs, track their total harvest, characterize pre and post bleeding mortality. In recent years sex data is also being provided.

The black line on this figure is showing the total number of crabs that are collected for the biomedical industry, and then the gray line is the number of crabs that were actually bled. The stacked bar chart below shows the breakdown of bled crabs by sex, and from a metanalysis of bleeding studies in the benchmark assessment, a mortality rate of 15 percent is applied to the number of bled crabs, to estimate the bleeding mortality.

That is added to the number of crabs that are actually observed during the biomedical process, to estimate total mortality from the biomed industry. That is shown on the orange line in this figure. The estimated mortality from the biomedical industry in 2022 was just under 146,000 crabs, which is the highest in the time series.

Dead discards are also provided from the Northeast Fisheries Science Center's Northeast Fisheries Observer Program. For horseshoe crab those discard estimates come specifically from Delaware Bay Region only, and that is due to the limited data on horseshoe crabs in the Observer Program, and also for its use in the Catch Survey Model.

While the methods used are the same from the benchmark, there was some improved data filtering from the 2022 ARM Revision, and so this is representing that update and analysis. The estimated number of dead horseshoe crabs is variable through time, with the highest values in 2016 and 2021, and the lowest in 2022.

Next, I'll move on to the fishery independent data and our indices of relative abundance. During the 2019 benchmark the SAS explored both nominal and standardized indices, and due to the high number of zeros in the data, used the Delta Distribution for the mean and variance for all indices. But in 2022, the Peer Review noted that fixed station surveys should be standardized, and so for this update any fixed station surveys, those



indices were standardized, while the others used the delta mean.

I'll just briefly go through indices for each region from north to south. Here are the Northeast Region indices, on the upper left is the Massachusetts Trawl Survey north of Cape Cod. On the upper right the Massachusetts Trawl south of Cape Cod, and then on the bottom is the Rhode Island Trawl survey. For many surveys there are some data gaps due to reduced sampling during COVID, and this was the case in 2020 for the Massachusetts indices.

Spearman rank correlation coefficients were estimated between the indices within each region to see how these surveys are correlated with each other, and in the Northeast the Rhode Island index is negatively correlated with both Massachusetts indices, but the comparisons were not significant. Now moving on to the New York Region. Their indices are derived from five surveys. On the top left is the Connecticut/Long Island Sound Trawl Survey, on the upper right the New York/Peconic Trawl Survey, and on the bottom the Western Long Island Sound Seine Survey, with Jamaica Bay on the left and the Little Neck and Manhasset Bay is on the right. Again, there are some data gaps in these surveys in 2020 due to COVID. Then finally, the last survey for the New York Region is the New York Region of the NEAMAP Survey.

Again, we looked at correlation comparisons between the surveys. For the New York Region, all were positively correlated with 4 of the 10 being significant, and those are circled in red. Next on the left is the Delaware Bay Region. There are 14 indices for this region. First is the Delaware Bay Region of the NEAMAP Survey on the left, and Maryland Coastal Bay Survey on the right.

The New Jersey Ocean Trawl Survey has four different indices from the survey. On the top is the spring, with females on the left and males on the right, and on the bottom the fall survey. Again, females on the left and males on the right. No sampling was conducted in 2020 and 2021.

Next is the Delaware Bay Adult Trawl Survey, which is also separated out by sex and season, again with the spring survey on the top, fall survey on the bottom, and females on the left and males on the right there. Finally, the Virginia Tech Trawl Survey. This is separated out by sex and maturity stage. On the top here we have the newly mature crabs with females on the left and males on the right.

Then the bottom mature individuals, females on the left, males on the right. The data gap in the middle of the time series is due to a lack of funding for the survey during that time. For Delaware Bay there are 28 of the 91 comparisons were significant and positively correlated, and this is mostly between the Delaware Adult Trawl Survey, the New Jersey Ocean Trawl and the Virginia Tech Trawl Surveys, all of which are used in the Catch Survey Analysis and the ARM Framework.

Just those indices from the ARM framework were subset, and of those 28 comparisons 12 were significant and positively correlated. Lastly, the Southeast Region. On the upper left we've got the North Carolina Estuary and Gillnet Survey, on the upper right the South Carolina Crustacean Research and Monitoring Survey, which has since then renamed to the Estuarine Trawl Survey, but we're maintaining the old name here to be consistent with the benchmark, and that will be changed in the next assessment.

On the bottom left is the South Carolina Trammel Net Survey, and the bottom right the South Carolina section of the NEAMAP Survey. Both of these are marked with red stars, and that is to indicate that these surveys underwent changes in their sampling design in recent years. Trends post 2019 should be interpreted with caution, because we don't know if those trends are representing true trends in abundance, or it it's more of an artifact of the change in the sampling design.

Typically, we would stop a time series if survey methods changed, so this is something that the SAS will revisit in the next benchmark assessment. Then the Georgia/Florida Region of the SEAMAP Survey on the left, again also subject to the sampling

design changes, and then finally on the right is the Georgia Trawl Survey. For the Southeast, 4 of the 15 comparisons were significant. Most were positive, but one was negative, and that was between the Georgia/Florida Region of the SEAMAP Survey and the South Carolina Crustacean Research and Monitoring Survey. Next, I'll go through the tagging analysis. This data comes from the U.S. Fish and Wildlife Service's Horseshoe Crab tagging database, which also provides regional recapture rates.

This allows for mark-recapture analysis to derive survival estimates for each region. I do just want to note that the tagging analysis regions are slightly different from the management region, so you can see those on the screen. In this table, shows the survival estimates from that model, both with the 2019 benchmark and the 2024 update.

The highest survival rates were in Delaware Bay, and the lowest in the Southeast Region. All regions saw a decline in survival since the benchmark, with the exception of the Coastal New York/New Jersey Region. But though there was a decrease in survival for most regions, the error rate also increased quite a bit.

You can see the really wide confidence intervals in the 2024 update. This decrease in survival may be due to reduced tagging efforts in recent years, which I will show in more detail in a little bit. Then just to visually show between a benchmark and the update assessment estimates, those super wide confidence intervals.

With the exception of the Southeast, the update and benchmark confidence intervals full overlap. Just to illustrate the change in tagging effort. On the top table here is the number of tag releases, and the bottom the number of recaptures. The last three columns are how they deviate from the average within the last three years of the assessment.

You can see there was a decrease in both releases and recaptures in 2020, with some regions still remaining below average tagging effort in 2021 and

2022. Again, New York/New Jersey had the smallest reduction in tagging effort during COVID, and they are also the only region that did not see a decrease in their survival rate.

Just to kind of recap, the reduction of crabs in 2020 coupled with reductions in recapture reports in 2020 and 2021, would likely cause a tagging model to underestimate survival rates. This is because the tagging models rely on consistent reporting rates to produce reliable estimates, and the model will account for these missing tag-recaptures as mortalities or emigrants from the population, which will in turn reduce survival estimates.

From the tagging analysis, the survival rate from Delaware Bay is used to estimate natural mortality for the Catch Survey Model, and in 2019 in the benchmark assessment, that rate was 0.274, and the 2022 ARM revision it was 0.3, and for this update 0.4. I also just want to note that the calculation from survival to mortality may be more appropriately characterized as total mortality, rather than natural mortality. That will be reconsidered in the next benchmark.

Next, I'll talk about the Catch Multiple Survey Analysis. This is updated annually, as part of the ARM framework, to support harvest specification setting in the Delaware Bay Region. Use of quantifiable sources of mortality to estimate male and female horseshoe crab populations, it was developed for the 2019 benchmark, specifically for female horseshoe crabs, and then updated in the 2022 ARM revision, and the male model is also developed as part of that. Just to note, because of the Delaware Bay specific biomed data is confidential, population estimates for horseshoe crabs were made using the coastwide biomedical data or no biomedical data, to provide those upper and lower bounds.

I won't go through the analysis in too much detail, because this same version through 2022 was already presented to the Board in detail during the October 2023 meeting, as part of the ARM framework. As a reminder, there is no management action from the coastwide assessment

that was based on this Catch Multiple Survey Analysis.

This is only used for management in the ARM framework. In 2022, the model estimated 16.1 to 16.2 million mature female horseshoe crabs in the Delaware Bay Region, and approximately 40.3 million mature male horseshoe crabs in 2022. Because of those data caveats that I spoke about with the tagging model for the 2024 update, the base run of the catch multiple survey analysis used the M of 0.3 from the 2022 ARM revision.

That is the gray line in these two figures here. But we did do a sensitivity run using the revised M of 0.4, and that is shown in the black line. Ultimately, the population estimates from each run varied pretty minimally, but in the sensitivity run, did result in slightly higher terminal year population estimates.

Next, I'll go over the ARIMAS, the Auto Regressive Integrated Moving Average Models. These are fit to the time series of horseshoe crab abundance indices that were shown before, and they estimate the probability that the terminal year in each index is less than certain reference points with 80 percent confidence intervals.

Those reference points are the lower quartile of the fitted index values, and also the 1998 for the index value. That year representing when harvest restrictions were implemented. Now I'll go through the results. Just to kind of orient you to this table here, the first column is the survey which the indices was derived from, and then I want to draw your attention to the columns with the percentages.

This fourth column here being the probability that the terminal year is below the 1998 reference point, and then in the third column from the right here, that is the probability that the terminal year was below the lower quartile reference point. Then the last two columns are the results of Mann-Kendall Test to detect trends in the data. That is since 2017, being the terminal year of the benchmark assessment, and also since 2012, which was the terminal year on the last update assessment. For

the Northeast Region, there are mixed ARIMA model results.

For the Massachusetts Trawl Surveys they showed increasing of stable trends, with low probabilities of being less than either of those reference points, whereas the index from the Rhode Island Trawl Survey is showing a continued decrease, and has a high probability of being below both of those reference points. The New York Region has generally continued to show declining trends, which has been evident since the 2009 benchmark assessment. The Jamaica Bay, Little Neck and Manhasset Bay and Peconic Bay surveys all have high probabilities of the terminal year indices being below their 1998 reference points. But the Connecticut/Long Island Sound Survey has showed increasing trends since 2012, and the NEAMAP and the New York Peconic Trawl Surveys increased over the last 10 years.

The Delaware Bay Surveys generally all show increase in trends, and low probabilities of the terminal year being less than either or both reference points. This is the Virginia Tech Trawl Survey ARIMA results, and the only exception here is that the trawl survey for newly mature females has shown low abundance since 2019, and this has been discussed in the update report and also during previous Board meetings.

There are three possible hypotheses that have been discussed between SAS and TC members. The first being that there is a recruitment failure in recent years. But this seems the least likely hypothesis, because mature females have continued to increase, and there has not been a concurrent decrease in the newly mature male population.

The second hypothesis is a change the spatial distribution of newly mature females, which is resulting in lower catchability in the surveys or three, these individuals are being misclassified as mature individuals rather than newly mature. Both immature males and females are declining according to the Mann-Kendall Test, but have low probabilities of the terminal year value being less than the lower quartile reference point.

Finally for the Southeast, previous assessments have generally showed increasing or stable trends in abundance. But this update does indicate that there may now be some decline occurring. The South Carolina Trammel Net, Georgia Trawl and the Georgia/Florida portion of the SEAMAP Surveys showed declining trends in recent years, though the probabilities of being less than either the lower quartile in 1998 reference points are still low.

Then again, as previously stated, the trends in the Trammel Net Survey and the SEAMAP Survey should be interpreted with caution, due to the decreased sampling since 2020. As in the 2019 benchmark, stock status is based on the percentage of surveys having a greater than 50 percent probability of the terminal year fitted value being less than the 1998 reference point.

That is within each region and coastwide. Again, this 1998 reference point represents the point in time in which horseshoe crabs became actively managed by the ASMFC, and so status relative to this gives us some indication of the effects of management on the population. A region had poor status if greater than 66 percent of the surveys met these criteria, good if less than 33 percent of surveys met this, and then neutral if the status was between 34 and 65 percent of the surveys.

Here is the stock status over the last several assessments. The regional determinations effort that this update remains the same as in the 2019 benchmark, with the exception of the Delaware Bay Region, which improved from neutral to good status. The Northeast Region remains neutral, and New York remains poor, except for the 2019 benchmark, and the two hypotheses before then for the New York status is either one, that bait harvest remains at a level that is not sustainable in the New York Region, or the habitat has changed and simply cannot support the number of horseshoe crabs that it once did. Then again, although the status of the Southeast Region was determined to be good, this should be viewed with some caution, because it is only based on two surveys that extend back to 1998, one of which has showed recent declining trends, that being the

South Carolina Trammel Net Survey, but again also subject to the sampling design changes.

Then the other surveys in the Southeast I would not use as part of stock status determination for the region, have shown some decreasing trends since 2012. But regardless, none of these surveys showed a high probability of the terminal year value being less than the reference points. Then lastly, the update assessment noted several research recommendations from the benchmark that have been either addressed or initiated.

That included collecting more information on horseshoe crab ecology and movement, as well as studies related to the biomedical industry. Then the use of the Catch Multiple Survey Analysis in the ARM Framework, and some additional recommendations from the 2024 update are addressing that reduced sampling in the Southern surveys.

Maintaining pre-pandemic levels of tagging effort, evaluating the use of Z instead of M, in the Catch Multiple Survey Analysis, and then reexamine the stock structure with more years of genetic and tagging data. With that I will be happy to take any questions.

CHAIR DAVIS: Okay, thank you, Katie, for that excellent presentation. I will look to the Board to see if there are any questions on the presentation on the stock assessment update. Mike Luisi.

MR. MICHAEL LUISI: Thank you, Katie, for the presentation. I wonder if you can clear something up for me. During your presentation you mentioned it a couple times, and you used the little red stars as a way to highlight areas to be, just taken with some caution. The first slide you mentioned that the surveys had changed.

Then I think later on you referred to, I believe it was in the Southeast, there just being low numbers of crabs being caught. Were they the same surveys where the methodologies have changed, and they're just catching low numbers? Just want to make sure I'm clear as to where that focus should

be on that area of concern, or at least where to focus on, as far as being cautious about the results.

MS. RODRIGUE: Sure, so I believe that is true for the South Carolina Trammel Net Survey, and so that underlined the sampling design changes that lowered the number of samples that are conducted, and also saw declining trends. The other surveys that I spoke on that are showing declining trend, I don't believe they were part of the surveys that underwent those changes. But they are also not included in the stock status determination, because they don't go back to 1998. I would have to look back at specifically those surveys to let you know.

MS. LUISI: Just a quick follow up, Mr. Chairman. If the SAS takes a look at those surveys. Right now, it's kind of like apples to oranges, maybe. Would we anticipate that they would be brought together in some way to cut through a recalibration? Just trying to understand kind of where it went askew. I realize that if the state wasn't able to conduct the number of surveys and the methodology has changed slightly. I don't have any problem with that. It is just that at some point we will have to figure out how to compare one time series with the other. Just looking, I have another interest in why this would be something outside of horseshoe crabs. But I'm just trying to get your thoughts on, how do you bring those two things in line, if that's the objective of the SAS?

MS. RODRIGUE: I think that standardization could help to an extent, but it may be that the change is too drastic for that to help. I think that typically a time series would not be used if nothing has changed so drastically. But I might look to Kristen if she has any other input on that.

DR. KRISTEN ANSTEAD: Yes, you're correct, Katie, and I'll just add that this was the case. There was a New Jersey Surf Clam Survey, and we have it now as just a shortened time series that we had in the benchmark, and then stopped using it. In the case of the SEAMAP or the trammel, we might either consider that now two indices, because I'm not clear on if there is going to be a calibration to correct the later time series. It might end up being

broken or stopped at a terminal year, but it's still used, only through 2019.

CHAIR DAVIS: Okay, next I have Bill Hyatt.

MR. WILLIAM HYATT: In the 2019 assessment, in this assessment then in your presentation today. You referred to the poor condition of the New York area Region population, and speculated that either bait harvest is excessive, or habitat carrying capacity has declined. I was just wondering if you've had any conversations amongst your group, if you were able to speculate as to what type of habitat conditions might contribute to such a decline with horseshoe crabs.

I'm asking that sort of from the perspective of recognizing that within at least the Long Island Sound Portion of their range, the crab population that has made it through some pretty harsh environmental conditions and habitat changes in the past just fine. I'm just kind of at a loss as to what habitat changes might have occurred in the last 15 to 20 years that might be driving this.

MS. RODRIGUE: I don't know that I have an answer for you specifically. I can try and get back to you about it, or if anybody else has comments that might help.

MR. HYATT: No, I would appreciate that, and understand, I'm just looking for some thoughts and speculation. I'm sure there isn't anything concrete or it would have been in the report, so thank you.

CHAIR DAVIS: Next I have Shanna Madsen.

MS. SHANNA MADSEN: My comments are related to Mike Luisi's. First of all, thank you, Katie for a wonderful presentation. I think my question is probably going to be more directed at ASMFC staff, but I find it concerning that the South Carolina Trammel Net Survey portion of SEAMAP has reduced sampling. I'm wondering if that is a permanent change, and if it is a permanent change, why that is happening and what other species might be affected by this, because it is the first time I'm kind of seeing it come up. Thank you.

DR ANSTEAD: Yes, so there were a couple of things going on with the SEAMAP Survey, one was, one of the years there were some storms, and so that was a legitimate not being able to sample during the times they normally. It's also my understanding that SEAMAP has changed their seasons from three seasons to two seasons. I believe that is a permanent change from the previous three seasons, now two that kind of straddle the three. That is one reason why we're not going to be able to go back in time and make these consistent time series. I believe that is permanent.

CHAIR DAVIS: Next I have Conor McManus.

DR. CONOR McMANUS: Really nice presentation, Katie. I know that it is an update assessment, and TOR 1 specific to updating last assessments entities. I'm just kind of curious for food for thought on future assessments, if the group discussed other surveys that exist that are not currently used for individual regions that may also provide insight into relative abundance trends for horseshoe crab.

Just kind of curious if in your meetings there was discussions about other state surveys from other gear types or other seasons that might be of use, particularly in some of the stock units where there may be two, three indices currently being used. It's okay if the answer is, we didn't talk about it. But just kind of curious.

MS. RODRIGUE: Yes, and unfortunately that might be my answer, Conor. But yes, I don't know if Kristen again has anything to add to that.

DR. ANSTEAD: Yes, we didn't re-pole the states for like new data, because it's an update. But certainly, that is something we will do for the next benchmark, and I'm hopeful that there will be some other datasets that play out, especially in those regions that we have fewer.

CHAIR DAVIS: Next I have Ben Dyar.

MR. BEN DYAR: Yes, just to kind of give a little more clarification on some of those sampling methods and changes in South Carolina. The Trammel Net

Survey went from monthly sampling down to two months out of every three months for each quarter, and that is just due to logistics. All the methods are the same, the methodologies did not change.

Gear, everything, it's still a random stratified sampling design, so it's just a change in those. Then the SEAMAP is unfortunately, due to funding. But with a new vessel coming online soon, hopefully they will still be standardized methodologies as well with the new gear type for the new vessel.

CHAIR DAVIS: Next on the list I have Dan McKiernan.

MR. DANIEL MCKIERNAN: Yes, Katie, great presentation, and I'm not sure you're the person to ask this question, but I need to bring it to the Policy Board. Given the last couple of slides about recommended future studies. Do you folks ponder like where we could find some of that money, because the public interest in the species is just enormous, and yet you can't go to S-K for it or it's not a federally managed species.

It tends to be the poor child among our advantaged species. You don't even have to answer it, but I guess to my colleagues on the Board. I wonder if we can put our heads together to find funding sources for a lot of these questions that you've identified that will help us manage going forward.

MS. RODRIGUE: Thank you, and I will just say, at least in Rhode Island we do take advantage of the State Wildlife Grant for species like horseshoe crab that aren't covered by say the Sport Fish Restoration Fund. But in terms of all their funding sources, I'm not really sure.

DR. DAVIS: John, go ahead, John Clark.

MR. JOHN CLARK: Thank you for the presentation, Katie. Just curious, I know the issue with the primiparous and the Virginia Tech Trawl was kind of an oddity there. I know this went through 2022, the assessment. Did you get 2023 data? Did that still continue where they are still not seeing primiparous females in the Virginia Tech Trawl for last year?

MS. RODRIGUE: I have not seen the 2023 data, so I'm not sure about that.

DR. ANSTEAD: John, we did hear from Virginia Tech after the 2023 season, and they did see primiparous this past year. We won't get that data for a couple more months, and I have just queried for all of the data to support the ARM that you will see in the fall. But there were primiparous again.

CHAIR DAVIS: Okay, I don't have anybody else on the list. Last call here for questions on the presentation. Any hands online? Okay, I think at this point, as a next step, we would want a motion to approve the stock assessment for management use. I'll look to the Board to see if anybody is inclined to make that motion. Shanna Madsen.

MS. MADSEN: **Move to accept the 2024 Horseshoe Crab Assessment Update for management use.**

CHAIR DAVIS: I'll look for a second. Conor McManus. Shanna, would you like to provide some rationale for the motion? Okay, you're going to pass, Conor, as the seconder of the motion?

DR. McMANUS: Just nice work and thank you, really good stuff.

CHAIR DAVIS: Okay, any discussion on the motion? Let's see if we can do this the easy way. **Are there any objections to the motion? Any abstentions for the record? Okay, seeing no hands the motion passes by unanimous consent.** I believe that concludes that item on the agenda. I'll look to Caitlin to see if I'm forgetting anything.

#### **DISCUSS HORSESHOE CRAB BAIT DEMAND**

CHAIR DAVIS: We're good, all right, so we'll move on to our next item on the agenda, which is a Discussion of Horseshoe Crab Bait Demand, and we're going to have a presentation from Caitlin Starks.

MS. CAITLIN STARKS: At the last Horseshoe Crab Board meeting there was a brief discussion about differences in state regulations concerning

horseshoe crab bait harvest along the coast and how restrictions in some states might impact other states.

#### **POSSIBLE IMPACT OF STATE HARVEST REGULATIONS ON BAIT DEMAND**

MS. STARKS: The Board requested that staff gather some information from the states with horseshoe crab bait fisheries, as well as states with fisheries that use horseshoe crab as bait, to better understand these dynamics.

Some questions were sent out to the State Administrative Commissioners, and these were, what commercial pot fisheries in your state are using horseshoe crab as bait? Has a survey been conducted of the trap or pot fishermen in your state that use horseshoe crab as bait about their use and alternative bait, and are data for these fisheries collected that could reveal trends and effort? For example, number of active permits or traps fished or trap hauls.

If those data are being collected, what are the trends that are being seen? Then if the state bans or severely restricts the bait harvest of horseshoe crab, has it also considered restrictions on the use of horseshoe crab as bait by pot fishermen? Then lastly, does the state collect any data that would allow us to quantify the origin of horseshoe crab imported from other states, and how much?

I'll just go over the summary of responses that I received. First, the two pot fisheries that were identified as using horseshoe crab as bait are eel and whelk or conch. Most states have at least one of these fisheries, and as you can see at the bottom, there were some blanks where I'm missing some information.

Then as for the state survey, none of the states indicated that they've conducted their own surveys of the pot or trap fishermen in their states about their bait use. The only survey that has been conducted relevant to this topic was the ASMFC survey on eel fishing practices in 2017, and that

survey found that about 22 percent of the eelers that responded used horseshoe crab as bait.

Then some but not all of the states have data that can show trends in effort in the eel and whelk fisheries. Generally, the states have landings data as well as permit data, or number of participants. Then there are a few states like Connecticut, Delaware and Virginia that do have trip level effort data for eel and whelk.

Then in terms of the trends that these states have been seeing. Massachusetts reported that effort and landing in the whelk fishery have been declining. Connecticut indicated there has been low but steady effort for eel, while the whelk there show effort decline from the mid-2000s to mid-2010s, and then has stabilized at a lower level.

New York data don't show significant trends for eel, but for whelk the pot landings trips and number of fishers reporting landings have all increased since 2014. The number of permits also increased from 2000 to 2023 by 24 percent, but it has been declining since 2009. Then New Jersey indicated they have seen increases in the last couple years for both of these fisheries. Maryland has seen declines in both the number of eel potters and landings since 2012, but for whelk the number of potters decreased, while the whelk landing increased. Then in Delaware there has been a significant decrease in eel effort since the female horseshoe crab harvest ban. Then for whelk the number of participants has decreased, but soak days and landings have increased.

Then lastly, Virginia data show that there has been declining effort for the eel fishery, but a shift in the effort trends for whelk, where it increased and then was followed by a decrease in the more recent years of the time series. Regarding the question on whether states with bans or significantly restrictive regs for horseshoe crab harvest have also implemented restrictions on bait use; the answer is generally no.

None of the states have implemented or considered such measures at this point. Then the last question that was asked is whether the states collect any

data that would show the quantity and origin of horseshoe crabs imported from other states. Again, the answer across the board here was generally that the states so not collect any such data. I know that was a quick summary, but I'm happy to take any questions.

CHAIR DAVIS: Thank you, Caitlin, I'll look to the Board to see if there are any questions. Dan McKiernan.

MR. MCKIERNAN: Thank you, Caitlin, for compiling that. I know I brought that up at the last meeting, and I really appreciate you compiling all that information.

CHAIR DAVIS: Thank you, Dan. Any other members of the Board with questions or comments? Do we have any hands online? Okay, no hands online. Okay, if there are no further comments, we'll move along to our next item on the agenda.

#### **ADAPTIVE RESOURCE MANAGEMENT SUBCOMMITTEE (ARM) REPORT**

CHAIR DAVIS: Okay, so the next item on our agenda is a report from the Adaptive Resource Management Subcommittee. John Sweka.

DR. JOHN SWEKA: Just a little history about how we got here and the source of this presentation. The original Adaptive Resource Management Framework was adopted for management use back in 2012, and it began setting harvest levels for horseshoe crabs in the Delaware Bay region beginning in 2013.

From 2013 through 2022, the ARM Framework consistently recommended 500,000 males and 0 female harvest. The ARM Revision then was ultimately adopted in 2022, had many changes to the modeling. This was because we gained much, much, more data in the Delaware Bay specific both to horseshoe crabs and red knots, and our methodologies for modeling both species greatly improved.



However, with the new ARM Revision there was potential for female harvest, and this created a lot of controversy among various stakeholder groups, and resulted in extensive public comment prior to the October 2022 and 2023 Board meetings. The Board decided then to still set female harvest at 0 after both of those meetings.

#### **TECHNICAL RESPONSE TO EXTERNAL REVIEW OF ARM FRAMEWORK REVISION**

DR. SWEKA: Earthjustice contracted outside experts to review the ARM Revision Report, and they supplied public comments in September, 2022, which contained the views and critique by Dr. Kevin Shoemaker of the University of Nevada, Reno, and Dr. Romauld Lipcius from VIMS. Then again in September, 2023, Earthjustice supplied more public comment, which contained an additional review and analyses by Dr. Shoemaker. During the Board meetings last October, the Board tasked the ARM Subcommittee with responding to the 2023 review by Dr. Shoemaker.

What I'll present today here are responses to six major topical criticisms by Dr. Shoemaker, from his 2023 review of the ARM Framework, and then also provide some brief responses to additional items that were contained in his 2022 review, as well as those from Dr. Lipcius from VIMS.

A much greater detail on my response is provided in the report, the ARM Subcommittee generated report. Jumping into it. Criticism 1, the major topic here was that estimates of red knot survival used in the ARM appear to be artificially inflated, resulting in falsely optimistic estimates of population resilience.

Well, there is high survival and long lifespan, which is commonly known for red knots and other shorebirds of similar size and similar life histories. Our estimates of survival are not out of the realm of possibility, and are similar to others. The survival rates that were used in the ARM are calculated from tagging data for red knots in the Delaware Bay, and are comparable to other public studies.

We critically reviewed the tagging information to represent the best available data and all of those caveats were addressed in the data in our survival estimates, and they are provided in our 2022 report. The analysis of the tagging data and its use in modeling was commended also by the Peer Review Panel.

One of the more specific claims in Dr. Shoemaker's review was that survival estimates are biased by individual misidentification of or flagged misreads. While the Delaware Bay misread error is probably between 0.38 percent and 4.5 percent. The way we figure this is there were records of 702 impossible flag observations. These are data entry errors, or data recording errors in the field, where a flag number was written down, but it never occurred when you go back to the historic data. That particular number was never actually applied to a bird.

Also, there was approximately 8,500 single observations of birds. In a given year, there always is a possibility that you misidentify the flag on a bird. We looked at those data and you can remove single observations of a bird within a season. Obviously, if you see a bird more than once, you are more confident that that flag reading is right.

However, some additional modeling by Anna Tucker showed that this level of possible error would have very minimal impact on our survival estimates. I'm moving on to Criticism 2, and that was the trawl-based indices of horseshoe crab abundance are inadequate for modeling the biotic interaction between red knots and horseshoe crabs.

While the inclusion of trawl surveys as indices of horseshoe crab abundance may be imperfect, but it is the best available science that we have, and it has been used for horseshoe crab stock assessment for a long time, and has gone through several independent peer reviews. Most of the criticisms that we received on the trawl surveys would also apply to egg densities or bird count data. All surveys suffer from the same sorts of catchability problem.

There is also consensus among all the trawl surveys for an increasing trend in horseshoe crab abundance since 2010. It's not like we only have one survey that shows an increase, all of them are showing an increase. Ultimately, trawl surveys are the standard method of sampling for bottom dwelling organisms such as horseshoe crabs, and are used for many other species as well.

Within this criticism, we were criticized for not using a general linear model or a general additive model in calculating indices of abundance for horseshoe crab. While the Delaware Trawl Survey actually does use a GLM approach, and this is because it is fixed station survey, and this was pointed out during the peer review of the ARM Revision.

We went back and changed it and recalculated that index. Also, the Virginia Tech Trawl Survey follows a stratified sampling design, and those sorts of things that would affect trawl catchability are taken into account by the sampling strata. Also, the New Jersey Trawl Survey, we had attempted to do a GLM standardization in the 2019 benchmark stock assessment, and found that it didn't really improve the data or the error on the data very much.

There has also been a lot of criticism for a lack of correlation between the trawl surveys. Well, it depends on what sort of correlation analysis you do, and at the end of the day each trawl survey still shows an increasing trend. It's the consensus among these trends that is important, not exactly how closely they match one another.

There is always going to be some mismatch, you know a trawl being in the right place at the right time gets crabs. I'll have more on this correlation criticism in the next point. Criticism 3 was that red knot survival is strongly sensitive to horseshoe crab egg density, indicating that persistent degradation of the horseshoe crab resource could have dire consequences for the red knot population.

Well, we've been criticized for not using egg density data. The egg density data were requested by the ARM Subcommittee, but they were never provided.

Therefore, we couldn't consider them as a data input to the models. When we look at the egg density data, which was finally supplied in a publication by Smith et al in 2022, after we had finished up the ARM Revision.

We look at the trends in egg density data, and lo and behold they are correlated with other data inputs from the years included in the ARM Model. Thus, we think even if we would have had the egg density data ahead of time, it's unlikely that they would result in any meaningful difference from current ARM Framework, in terms of harvest recommendations, because they showed similar trends.

Again, the Smith et al paper that documented the egg densities in recent years, showed general increasing trend in horseshoe crab eggs. They were very similar to the horseshoe crab abundance, and consistent with the findings of the ARM revision. Here we have the correlations of the egg density data that was extracted from Smith et al. The population estimates from the Catch Multiple Survey Analysis, the New Jersey Trawl, Delaware Trawl, and Virginia Tech Trawl, and here we have a correlation coefficient, and those that are circled are statistically significant at the 0.05 or 0.10 level. Also on this graph, we just compare our catch multiple survey analysis estimates of female horseshoe crab abundance with egg density data that we digitized from Figure 2 in Smith et al, 2022.

As you can see, both of them show interannual variations, some ups and downs, which could be due to sampling effects, or just random sampling error. But overall, there is an increasing trend over both time periods for the egg density data, as well as female crab abundance from the Catch Multiple Survey Analysis. Dr. Shoemaker also reanalyzed the egg density data from Smit et al, to try to account for differences in survey methodologies through time.

Once he reanalyzed those data, contrary to Smith et al, he found no increasing trend. Well, there is not a whole lot we can say about this, because again, we weren't provided the egg density data. But it is interesting that Dr. Shoemaker reanalyzed their

data to account for differences in survey methodology, which was one of the reasons why we've always been reluctant to use egg density data, because of the consistently changing survey methodologies through the years.

Dr. Shoemaker also conducted an analysis then to determine the effect of egg density on red knot survival, and he found that survival was positively correlated with egg density. But the methods that he described in his report weren't documented in great detail, and only included the New Jersey side of the Bay, so egg density and also bird data just from the New Jersey side.

It is somewhat questionable whether that analysis is applicable to the entire Bay. If Dr. Shoemaker's analyses are correct, we would have a positive relationship between egg density and red knot survival, but no trend in egg density. But all of our analyses and our Catch Multiple Survey Analysis shows an increasing trend in female abundance.

It begs the question, how do we then link harvest, which affects crab abundance, which then obviously crab abundance should affect egg density, not only red knot survival. How do we then model each one of those steps in the entire process? Unfortunately, Dr. Shoemaker in his criticisms and review doesn't propose a parameterized model to do so.

Moving on to Criticism 4, the ARM exaggerates evidence for an increasing trend in the number of females horseshoe crabs in the Delaware Bay. Well, the analyses that were provided in Dr. Shoemaker's report had some errors, including the use of incorrect data sub-setting for some of the indices that he was provided data, and applications of an analysis that we feel is inappropriate for the data. The trawl-based indices were early considered by the ARM modelers. Katie just presented them to you here today as part of our stock assessment update.

They represent the best available science for tracking horseshoe crab abundance, been through several peer reviews by this point. The goal of the ARM modelers is not to find an increasing trend,

but to develop the data in the most statistically sound way possible, regardless of what the answer may be. When Dr. Shoemaker was provided the data, he reanalyzed the New Jersey Ocean Trawl Survey using a GLM approach. The ARM Subcommittee, we have no issue at all with using a GLM approach, and like I said, we attempted this during the 2019 benchmark assessment, but found that it didn't really improve the data much. As we collect more data, perhaps we can better derive the effect of covariates upon catchability, and a GLM would be more useful. As I said, however, Dr. Shoemaker subset the data in an inappropriate manner, and this was discovered in an initial review of his report by staff at New Jersey.

Dr. Shoemaker made a questionable analytical choice when conducting a trend analysis. Here on these figures the two figures on the left are from Dr. Shoemaker's trend analysis approach, where he fit a linear model to both his raw and also adjusted index values, adjusted using the general linear model.

Well, Dr. Shoemaker ran this trend analysis on the entire time series of the data, and obviously early on we did have a decrease in horseshoe crab abundance. You know the Delaware Trawl Survey went back to 1990, and there was a decline in abundance, and a decline up through 2000, and this was part of the reason it spurred on the development of the fisheries management plan for horseshoe crab.

What we have here is a time series of data from the three trawl surveys that shows a U shape. Well, if you fit a linear model to U-shaped time series, of course the slope is going to be close to zero over that entire time series. What should be done is either, you know you can see clearly in the surveys here that around 2010 is when we seem to hit a low point in abundance from all the surveys.

If we looked at just the information in the time series coming from 2010 with just a simple linear model from that point to the present. You know we have a significant increase in female crab. Another possible approach, if you wanted to look at the

entire time series, would have been to use a segmented regression approach, and that would show you a decreasing trend, and then again even with the segmented regression approach, it turns out that around 2010 we have a change in the slope, where it changed from decreasing to an increasing trend.

Looking at Criticism 5, this focused on our red knot model, and it's the integrated population model used for estimating red knot population parameters is overparameterized and likely yields spurious results. Dr. Shoemaker's criticism of the red knot model is really unsubstantiated, and misrepresents the models used in the ARM Framework.

Much like the trawl surveys, I mean red knot data are imperfect, but they are the best available data that we have. They are also subject to catchability issues or detection error from one year to the next or from one trip to another to another out in the field. Dr. Shoemaker assumes that too many parameters will produce incorrect results, when the relationship between overparameterization and bias models is really more nuance than that.

I would like to remind everybody, the Integrated Population Model that was used for red knots is actually three different models all put together, and each one of them feed into one another. You know first we have a life cycle model; this is your typical stage structured model that advances juveniles to recruits to adults, and those adults then produce these juveniles. Typical sort of model used in all population biology. We also have the open robust model, which is used to estimate survival from the tagging data on the bird, and a state space model, which accounts for the observed counts and those aerial surveys and ground count surveys of birds from one year to the next. If all three of these models are essentially ran simultaneously, and they feed into one another in the estimation of those vital parameters, such as survival and recruitment for red knot. This is something I think Dr. Shoemaker failed to recognize is that structural linkage between the sub models. His claims for overparameterization may be valid for traditional

applications of singular models, but it is much more nuanced for an integrated population model.

At least at this point in time there is no hard and fast rules as to what overparameterization may be. One thing you always keep in mind is that overparameterization does not necessarily mean biased results. Under-parameterization can too. The next criticism is that the Integrated Population Model exhibits poor fit to the available data.

In this critique, Dr. Shoemaker provided some conflicting arguments from the use of goodness and fit test to the red knot model. Goodness and fit test applied to the red knot model indicated poor fit in one model component, but the proportion of the model including the survival probability did not fail that goodness of fit test.

There are certainly some more details than that in the report if you would like to read them. Moving on to Criticism 7 through 11. These were a few major topical things that we as the ARM Subcommittee thought we should bring forward to the Board, and these are from the 2020 reviews by Dr. Shoemaker and Dr. Lipcius, and some additional items from a supplemental section in Dr. Shoemaker's 2023 report.

On Criticism Number 7, this is a big one in the first comments we got from Dr. Shoemaker and Earthjustice. This is the estimate of mean horseshoe crab recruitment and propagation of error within the horseshoe crab population dynamics model is inappropriate. Do you remember, we had those years of Virginia Tech Survey when it did not operate. Admittedly, those years of our estimates of recruitment coming from our Catch Multiple Survey Analysis, those are poor years.

But the estimate of mean horseshoe crab recruitment used by our Subcommittee is still really the most biologically realistic. If mean recruitment were lower, as Dr. Shoemaker suggests, then as we project our population forward, the current population estimate of horseshoe crabs will be well, well above any predicted "carrying capacity" of the

Delaware Bay, and certainly we expect the crab population to decline due to that carrying capacity.

Now Dr Shoemaker's proposed method for air propagation is something that is worth considering by the ARM Subcommittee in the next revision of the ARM. But when we make some comparisons between his population projections and those of our current models, they are nearly identical, and this was shown in this slide.

The graphs on the left are from Dr. Shoemaker's 2020 review, where he recalculated the Catch Multiple Survey Analysis, used his method for air propagation, and it's more of a Bayesian model and predicted that forward. Then on the right are predictions from our current ARM model for horseshoe crab. The top graphs are under a situation of no female harvest ever, and also a 210,000 female harvest, you know the maximum allowable. If you just did that and held that constant each year. As you can see, I tried to scale these graphs as best I could, so that the scales match up, and essentially, for all of the concern over our air propagation and mean recruitment, in the end the projections from both Dr. Shoemaker's model and that of the ARM Subcommittee are essentially the same, you know the same number of multiparous and primiparous crabs, so the N and the R.

The next criticism was that the ARM model would not predict a decline in red knot under a total collapse of the horseshoe crab population, and that is evidence that the model is fatally flawed. Well, Dr. Shoemaker is incorrect that the ARM model would not predict a decline in red knot if the horseshoe crab population collapsed.

His assertion that red knots would continue to increase in the absence of horseshoe crabs is just mathematically impossible in the model. Red knot survival in our model is a function of the log of female crab abundance. Obviously as survival declines to zero as crab abundance decreases. Also, we should keep in mind that a complete collapse of a horseshoe crab population is a sensationalized and extreme scenario.

If that should happen, nobody would argue either at the ARM Subcommittee level, the TC level or this management board, that if our abundance of horseshoe crabs would dip to low levels that are lower than what we've seen or used to build our models, you know we wouldn't advocate for additional harvest of horseshoe crabs.

You know certainly, we're trying to make predictions on a model based on data that is well outside the range of a model. Criticism 9 deals with demographic data that indicate a declining horseshoe crab population. These comments came from Dr. Lipcius with VIMS in the 2022 comment.

During his comment, one of the things he looked at was this declining size of mature horseshoe crabs in the Virginia Tech Trawl Survey. That decline started in 2008. He used that as an argument that it could indicate overfishing is occurring. Now we certainly agree that in a typical finfish fishery, if you have declining mean size at age, that is indicative of overfishing, because a fishery will select for faster growing individuals, and those faster growing individuals are plucked out of the fishery the sooner, and then therefore your mean length at age would decline.

However, application of that rule of thumb to horseshoe crabs is a bit uncertain, because horseshoe crabs will grow, have a terminal molt, and then stop growing afterwards. It's pretty uncertain whether you can apply that same general rule of overfishing to the species like horseshoe crabs.

Now along with that declining size at age, the smaller the horseshoe crab size the fewer eggs you would expect to be laid by that crab. Dr. Lipcius assumed that we would also have declining recruitment or egg deposition in recruitment. But assuming the natural mortality is not changed, and we've seen the increase in abundance of horseshoe crab, abundance of horseshoe crabs could not have increased if egg deposition and hatch also had not increased over that same time period.

Recent low estimates of the other thing is recent low estimates of female newly mature crabs, as seen in the Virginia Tech Survey. We've discussed this problem over the past few Board meetings, Katie mentioned it earlier. Again, male newly mature crabs did not decrease over the same time period. Although it really doesn't seem that overfishing is occurring with horseshoe crabs in the Delaware Bay, and we have no evidence to suggest that. Criticism 10 was specific to the bird population model again, and that is that there is an incorrect specification of the "pi" parameter in the red knot IPM model.

The "pi" parameter is the probability of being present in Delaware Bay in the occasion  $t$  of year  $j$ . Is the bird present or not as the Integrated Population Model is looking at, you know different time periods within a year, could the birds be present or not in Delaware Bay? This is a criticism that does warrant some further consideration by the ARM Workgroup.

We should look into this a bit further, and our folks that were experts in bird modeling are considering this in any future revisions. Finally, the last criticism is that there is an overrepresentation of Mispillion Harbor in red knot resighting data. While use of data from Mispillion Harbor does not result in bias inferences, it is very true that the bulk of red knots are seen in Mispillion Harbor.

But when we start to look at the number of birds and the proportion of birds that are seen just in Mispillion versus other sites, this really is not like it's overwhelming or the overwhelming amount of data comes solely from Mispillion Harbor. As we can see here, this is the proportion of birds that are seen in Mispillion Harbor only, other non-Mispillion Harbor sights and then sighted at both Mispillion and other sights.

You can see they are almost the same across the board, and it varies a bit from year to year. It's not like data from one site is overwhelming the model. Just to conclude our rebuttal to a lot of the comments we've received. You know continued scientific review is always welcome. That is how

science progresses, so we welcome that. The ARM Revision really represented some great advances in our understanding of population dynamics for both species, and methods to optimize the harvest.

The ARM Subcommittee, we are left wondering, with all the advances we made in our modeling, why was the original ARM not criticized nearly as much, and we can't help but ask, is the real problem with the final answer and not necessarily the data methods or the process? The benefit of the ARM Framework is the ability to make decisions with imperfect data. That is why we went down the Adaptive Management Route from the beginning, way back in 2008.

We strived to design a modeling framework with routine monitoring to allow rapid learning. This is a critical feature that wasn't addressed by Dr. Shoemaker in his reviews. You know our models are based on the data that we get from routine modeling. Easily updated, and easily changed from year to year as more data is added.

A lot of the criticisms really stem from the belief that there had to be a strong relationship between horseshoe crab, egg density, horseshoe crab abundance, and red knot survival. Dr. Shoemaker postulated that the collection of additional data may show the relationship between horseshoe crab abundance and red knot survival could either disappear or become negative with a collection as we move forward. He states in his '22 review, this outcome would pose an existential problem for the ARM Framework, decoupling the two-species framework and rendering the red knot model unusable in the context of management. Our question then is, well, would we not expect the relationship between horseshoe crab abundance and red knot survival to disappear if horseshoe crab abundance were high enough, such that it did not limit red knot survival.

That is something we should expect would happen. There is no question that Dr. Shoemaker is very knowledgeable in quantitative ecology, however, his criticisms focused on specific model components of why each might be wrong. He doesn't provide any recommendations for how to then take all of

these individual pieces that he added comments to, and put them back into place and bring them all together again in one unifying decision-making framework.

He also failed to recognize how uncertainty is handled in the optimization, the approximate dynamic programming. We found it very interesting that throughout all of the comments we received that there were no criticisms about the approximate dynamic programming, no criticism about the utility functions for horseshoe crabs or red knots, and no criticisms about ultimately the Harvest Policy Function that are solved for, and that is really what tells you how many crabs you can harvest, given the number of birds or horseshoe crabs.

There will always be some room for improvement in the ARM Framework, and it is designed to do exactly that through the double-loop learning process. Every few years we add more data. We go back, we rerun our models, rerun the optimization, tweak our models as need be. The critique by Dr. Shoemaker and Earthjustice failed to really make any real recommendations for improvement on that front.

The ARM Subcommittee stands firm in our belief that our work currently provides the best approach to addressing the problem statement, if that problem statement is still valid today. At this point I certainly, myself and the ARM Subcommittee, we really thank the Board for allowing us this opportunity to respond publicly to a lot of the criticism that we received. Thank you.

CHAIR DAVIS: Thank you, John for that excellent presentation, and on behalf of the Board I want to thank the ARM Subcommittee for putting together such a thorough and thoughtful response to the external criticisms of the ARM Revision. It is obvious a tremendous amount of work went into that report, but certainly a worthwhile effort. At this point, I'll look to the Board to see if there are any questions or comments on John's presentation or the report. Bill Hyatt.

MR. HYATT: John, thank you, and I'll echo what Justin just said that to you and all your team that was a tremendous amount of work, tremendous report, and I think it's going to be useful to us as Board members on many fronts. I have a question, and I hope it is not an eye roller. I hope I didn't miss something.

But in the report, itself, I believe there is a research recommendation in the text to examine the horseshoe crab abundance egg density estimates, to begin to establish that longer chain that you were talking about. I guess I'm wondering, is the data that is being collected currently, provided you have access to all the data. Is the data that is being collected currently sufficient to begin that process, or is there additional data that needs to be collected and additional work that needs to be done, just to get it started?

DR. SWEKA: That is a difficult one to answer. I think the egg collection data has gotten better in New Jersey through the years, you know at least with what we have been given in the final report for publication. I mean it does sound better than it was. If you remember back in 2013, that was when Delaware was questioning whether or not they needed to collect egg density data anymore.

You know at that point in time it seemed, you know the methodologies seemed to constantly be changing, and when asked whether or not they should collect it, the TC and the SAS, that no, we don't need to, because the methodologies are constantly changing. Since then, I think it has improved. Is it adequate enough? Well, I guess we would have to see it to really know.

CHAIR DAVIS: John Clark.

MR. CLARK: Thank you, John, and the Committee. This is phenomenal. It is great that it is out, and of course the problem is that the damage was done over a year ago, when all this came out and I still see the Shoemaker criticisms in newspaper articles and of course we're still seeing a lot of push from some of the more extreme groups to ban horseshoe crab harvesting total. I still don't understand the

connection between male horseshoe crabs and eggs on the beach.

One of the criticisms, I mean Bill brought up the egg density, and that keeps coming up, and yet we have this great data showing that as the population of females is increased, obviously it is not a limitation here. I don't see how they cannot make the connection between the horseshoe crabs and greater egg density out there.

It just seems to be something that just keeps coming up. As you said, the egg density study was terminated on the Delaware side, and it is not something we look forward to, but that question just stays out there. We've heard from some NGOs that are asking us for permits to do their own egg density work and all.

It's obviously a concern, I mean there just doesn't seem to be, when people that have agendas out there want to do this work, it's just a little off-putting to us. Phenomenal work, but don't know if it is really going to cure the problem. But I hope this does get the type of publicity it should get from the many criticisms that we've seen about the ARM since the ARM came out.

CHAIR DAVIS: I have Mike Luisi next on the list.

MR. LUISI: Thank you, John, for your presentation. I just wanted to make a general comment. As someone who has dedicated the past 25 years in a natural resource management career, I find a lot of comfort in what just happened between the report, the work to develop a response in a very articulate way, in a professional way, to confront the critics that we often get to the survey work that we do, the results that we put forth, the modeling exercises that we go through. I'm often challenged, as well as my colleagues in Maryland about when the results are what the stakeholders are looking for, they are often challenging the work that we do. I was actually, I wanted more. I wanted there to be more criticisms. It was the first time in a while I've been disappointed that one of his presentations wasn't getting to wrapping up. But I thought you did an excellent job, and I think that the work that, I

would love to give you credit, Mr. Chairman, but I think maybe this might have been John's work as a former Chair, working to allow the ARM Subcommittee to put forth this report in the way that they did.

I hope we can use this as a process in the future, not just for horseshoe crabs but for other species, when we as a management board are criticized about the work we're doing. We have some of the world's greatest scientists working right with us every day, and I just found it refreshing, and I hope that we can take this in and consider using this type of process down the road when we have other hurdles that we have to get over. Thank you.

CHAIR DAVIS: Next I have Rick Jacobson.

MR. RICK JACOBSON: John, I want to echo what everyone else said, fantastic work on your part and on the work of the entire Subcommittee. The ARM Model is really a remarkable step forward, so thank you for that. I actually have two questions, and the first question hearkens back to your response to Criticism Number 4.

If I understood your description correctly, there is actually a recognition of a changing trend in horseshoe crab abundance based on the survey data that that occurs before 2010, and that that occurs after 2010, a shift from declining abundance to increasing abundance. I wonder if there is anything in particular you can point to that would suggest that inflection point, and where there was a change.

What was forcing that change or causing that change? Then the second question builds on Mr. Hyatt's question earlier about egg abundance data. If we were to start anew. You know we make substantial investments today in the various survey techniques for adults and immature horseshoe crabs.

If we were to reinvest those dollars in some way, with a very structured and thoughtful approach to egg abundance surveys, where we had confidence in the data that was being collected. Is there any



reason to think that we would be further ahead reinvesting in that direction, or would we be further ahead staying with our investments, looking at immature and mature horseshoe crabs?

DR. SWEKA: Thanks, Rick. To your first question, why the change in 2010. You know it really makes sense when you think about the life history of horseshoe crab. They don't mature until they are 9. 1-0 years old, and the first FMP came online in 1998, you know by the time the harvest was curtailed greatly after that.

It would really take a good decade, and we said this all along, even from early on in the horseshoe crab management. It's going to take a while to see an effect. After 10 years, you started to get all of the age classes that were protected and had less fishing pressure on them, they all matured. It made perfect sense that around 2010 is why we would see the increase. You know I think the Commission should be proud, you know this is certainly an example where management has worked, you know decreased harvest. We kind of knew as scientists it is going to take a while to see a change, and eventually it did change and we can detect that. As far as the egg abundance, certainly we've never been opposed to using egg density data, it is very difficult to use, because not only do you have year to year variations, you've got day to day, you know beach variation.

Could another survey be developed and consistent methodology be put forth to develop a good egg density survey that we're all confident in? Yes, I think we can. I think it would be expensive, you know take a great deal of effort on people's part, not only collecting the samples, but then processing the samples and enumerating eggs in a core sample of eggs or a core sample of sand.

Is it worth doing? You know that is something I think we could discuss more on the SAS or the ARM Subcommittee. You know we do have the empirical relationship between horseshoe crab abundance and survival now. By adding the step of eggs into our model, I mean it is going to increase some uncertainty.

Even if we could find a good relationship between crab numbers and egg density, that is still one more step and a bit more uncertainty that we add into our model. Those confidence intervals on the population may get bigger. Yes, I'm not sure if it's really, really worth it. I don't know, we might have to do another exercise where we look at what is known as the evaluation of perfect information, you know would it really change a decision if we had that additional step in there, you know an exercise we could do?

CHAIR DAVIS: Next I have Rob Lafrance.

MR. ROBERT LAFRANCE: I think that was a really great explanation of the egg density. That was kind of the way I was going, in terms of the question. One of the things I think happened, when you think about red knots, that is what they are looking at, but that is the egg density issue. I really appreciate what you said, in terms of understanding it.

Is it your sense though that the protocols are actually getting better? Are we getting any better consistency in how we would look at it, or is that still something that needs additional work before we could come up with something that may be used for management?

DR. SWEKA: I think it needs more critical review. Like I said, we see what is in their latest publication, and that sounds good, but we haven't seen the real data. If the generators of the egg density data would conform to typical processes within ASMFC, to provide data when a stock assessment starts, just like every other entity. We get information from the state, from academia, from other federal agencies. You know we would certainly treat them the same with the same critical rigor, but also the same fairness.

CHAIR DAVIS: Shanna Madsen.

MS. MADSEN: Thank you, Dr. Sweka and Dr. Anstead and the rest of the ARM Team. I can see the amount of work that this represents, and I, like Mr. Luisi, think that this was a really important step,

and something that was needed to be done. It's really important when we're criticized scientifically that we are allowed the space to respond scientifically as well. I appreciated seeing that. This isn't really a question, but more of a comment. I think that it would behoove us to have this on the management website for horseshoe crabs, maybe go out as a press release or something along those lines, because again, this sort of information really needs to get out there. These are the legs that we stand on, and I think that needs to be out.

CHAIR DAVIS: Thanks for that, Shanna, and I'm sure there can be some follow-on conversations after the meeting deciding the best way to publicize this report. I agree. I have exhausted the list of hands I have on this topic, and I don't believe we have anybody online, so I'll just issue one last call for questions or comments on this topic before we move on. Not seeing anyone, thank you, John.

#### **UPDATE ON HORSESHOE CRAB MANAGEMENT OBJECTIVES WORKSHOP**

CHAIR DAVIS: We'll move on to our final scheduled bit of business on the agenda today, which is an Update on the Horseshoe Crab Management Objective Workshop from Caitlin.

MS. STARKS: Sorry, I was trying to get out of this. But the first week update where we are with this workshop. We've sent out invitations to a list of participants that cover the stakeholder groups with an interest in horseshoe crab management in the Delaware Bay. We have participants who are shorebird biologists, horseshoe crab biologists, state managers, representatives of environmental organizations, and bird advocacy organizations as well, as well as some biomedical representatives.

I think this will be a really good group to get all of their heads together and have some productive discussion. The workshop has been scheduled for July, mid-July, 15th and 16th. The location is still to be determined, but we are aiming for the Delaware/Maryland coast area, to try to make it more assessable for some of the folks coming from those coastal areas that this fishery takes place in.

That is our next step is to hold that workshop, and then coming out of that workshop we won't have quite enough time to get a report back to the Board in August, so the expectation is that we will have a report, including recommendations from that group, and things for the Board to consider for future management at the October meeting.

In case I didn't mention it previously, we have contracted with Dr. Kristina Weaver, who helped with the Menhaden Workshop in Virginia, and came highly recommended, and so we have full faith in her abilities to help us get at some of these difficult questions about horseshoe carab management.

CHAIR DAVIS: Dan McKiernan.

MR. MCKIERNAN: Quick question, Caitlin. Will there be an opportunity for folks from other states to listen in to the conversation?

MS. TONI KERNS: Dan, we're going to try to. But I'm not going to make a promise just yet.

MS. STARKS: The workshop will be open to the public, if folks want to attend and listen in, in person.

#### **ADJOURNMENT**

CHAIR DAVIS: Okay, any other questions on the Horseshoe Crab Management Objectives Workshop? Okay, not seeing any hands, that brings us to the end of our scheduled agenda today. I'll ask if there is any other business to come before this Board. Not seeing any hands; this Board stands adjourned.

(Whereupon the meeting adjourned at 4:30 p.m. on Tuesday, April 30, 2024.)