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ATLANTIC STATES MARINE FISHERIES COMMISSION

HORSESHOE CRAB MANAGEMENT BOARD

Webinar
January 26, 2022

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Proceedings of the Horseshoe Crab Management Board
January 2022

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2.   **Move to approve proceedings of October 21, 2021** by Consent (Page 1).

3.   **Move to accept the Revised ARM Framework and Peer Review for management use** (Page 20). Motion by Emerson Hasbrouck; second by Dan McKiernan. Motion carried (Page 21).

4.   **Move to initiate an addendum to consider implementing changes to the ARM Framework as recommended by the ARM subcommittee and Peer Review Panel** (Page 21). Motion by John Clark; second by Mike Luisi. Motion carried (Page 23).

5.   **Motion to adjourn** by Consent (Page 24).

ATTENDANCE
Board Members

Dan McKiernan, MA (AA)

Raymond Kane, MA (GA)

Sarah Ferrara, MA, proxy for Rep. Peake (LA)

Conor McManus, RI, proxy for J. McNamee (AA)

David Borden, RI (GA)

Eric Reid, RI, proxy for Sen. Sosnowski (LA)

Matt Gates, CT, proxy for J. Davis (AA)

Rob LaFrance, CT, proxy for B. Hyatt (GA)

John Maniscalco, NY, proxy for J. Gilmore (AA)

Emerson Hasbrouck, NY (GA)

John McMurray, NY, proxy for Sen. Kaminsky (LA)

Joe Cimino, NJ (AA)

Peter Clarke, NJ, proxy for T. Fote (GA)

John Clark, DE (AA)

Roy Miller, DE (GA)

Craig Pugh, DE, proxy for Rep. Carson (LA)

Mike Luisi, MD, Administrative proxy

Russell Dize, MD (GA)

David Sikorski, MD, proxy for Del. Stein (LA)

Pat Geer, VA, Administrative proxy

Bryan Plumlee, VA, (AA)

Shanna Madsen, VA, proxy for Sen. Mason (LA)

Chris Batsavage, NC, proxy for K. Rawls (AA)

Jerry Mannen, NC (GA)

Bill Gorham, NC, proxy for Rep. Steinburg (LA)

Mel Bell, SC (AA)

Doug Haymans, GA (AA)

Spud Woodward, GA (GA)

Erika Burgess, FL, proxy for J. McCawley (AA)

Marty Gary, PRFC

Chris Wright, NMFS

Lowell Whitney, USFWS

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

Ex-Officio Members

Jeff Brunson, Technical Committee Chair

Brett Hoffmeister, Advisory Panel Chair

John Sweka, ARM Subcommittee Chair

Staff

Robert Beal

Toni Kerns

Laura Leach

Lisa Carty

Maya Drzewicki

Tina Berger

Pat Campfield

Kristen Anstead

James Boyle

Emilie Franke

Lisa Havel

Chris Jacobs

Jeff Kipp

Justin Colson Leaning

Adam Lee

Kirby Rootes-Murdy

Sarah Murray

Caitlin Starks

Anna-Mai Svajdlenka

Deke Tompkins

Geoff White

Guests

Max Appelman, NOAA

Mike Armstrong, MA DMF

Pat Augustine, Coram, NY

Jason Avila, Avila Global

Megan Barrow, NYS DEC

Linda Barry, NJ DEP

Alan Bianchi, NC DENR

Nora Blair, CRL

Kurt Blanchard, RI DEM

John Born

Mark Botton, Fordham Univ

Jeff Brust, NJ DEP

Allen Burgenson, Lonza

Laura Chamberlin, Manomet

Margaret Conroy, DE DFW

Yong Chen, Stonybrook

Margaret Conroy, DE DFW

Heather Corbett, NJ DEP

Stephen Cottrell

Nick Couch, DE DFW

Nathan Cowen, FL

Deborah Cramer

Jessica Daher, NJ DEP

Jamie Darrow, NJ DEP

Guests (continued)

Steve Doctor, MD DNR
Paul Eidman
Catherine Fede, NYS DEC
Lynn Fegley, MD DNR
Cynthia Ferrio, NOAA
Brad Floyd, SC DNR
Brendan Harrison, NJ DEP
Hannah Hart, FL FWC
Helen Takade-Heumacher, EDF
Jessie Hornstein, NYS DEC
Christian Hunt
James Jewkes
Carrie Kennedy, MD DMR
Adam Kenyon, VMRC
Marguerite Koehler, TMS Waterfront
Wilson Laney
Nils Larson

Benjamin Levitan, EarthJustice
Susan Linder
Carl LoBue, TNC
Dee Lupton, NC DENR
Samantha MacQuesten, NJ DEP
Kim McKown, NYS DEC
Jason McNamee, RI (AA)
Steve Meyers
Mike Millard, US FWS
Allison Murphy, NOAA
Brian Neilan, NJ DEP
Bryan Nuse
Christian Olla
Derek Orner, NOAA
Derek Perry, MA DMF
Zachary Pryor
Kathy Rawls, NC (AA)

Zoe Read, WHYY Radio
Paul Risi, KBCC, NY
Daniel Sasson, SC DNR
Dave Smith, USGS
Sommers Smott, VMRC
Joel Stoehr, Newschool, NYC
David Stormer, DE DFW
George Sylvestre
Craig Weedon, MD DNR
Peter Wenczel
Kristoffer Whitney, RIT
Angel Willey, MD DNR
Logan Williams
Wes Wolfe, *The Newsleader*
Harvey Yenkinson
Jordan Zimmerman, DE DFW
Erik Zlokovitz, MD DNR

The Horseshoe Crab Management Board of the Atlantic States Marine Fisheries Commission convened via webinar; Wednesday, January 26, 2022, and was called to order at 9:45 a.m. by Chair Joe Cimino.

CALL TO ORDER

CHAIR JOE CIMINO: Okay, good morning, everyone. We're here for the Horseshoe Crab Management Board. We've got some important items to discuss on our agenda today. I'll set a few ground rules for us. We'll go through our agenda, as is typical with the ASMFC process. During the Board meetings we allow for public comment on items not on the agenda, which I will be taking up soon.

If I do see a considerable show of hands, then we'll allow a certain amount of time for public comment. If you have public comment on an agenda item. As many people are aware, there is an item up for possible action regarding a Revised ARM Model. Then I will allow public comment on that agenda item later in the meeting, assuming we have a motion for a possible action.

Keep that in mind please, if you raise your hand for public comment on where it would be most appropriate. Another agenda item, or some ground rules I would like to cover is, we are going to have a presentation from Dr. John Sweka regarding the revisions to the ARM model, and we're going to follow that with a presentation by the Peer Review, which is going to be presented by Dr. Yong Chen of Stony Brook.

I want to have both of those presentations go in order, then we'll turn it over to questions from the Board. Just to staff and to Dr. Sweka and Chen. As that goes forward and you get questions, to make things a little easier, instead of having me as an intermediate. When the questions are directed to you, please just feel free to answer as they come in when we get there.

APPROVAL OF AGENDA

CHAIR CIMINO: With that I'll move on to the two Board consent items that we have on the agenda. The first is Approval of the Agenda. I hope I kind of laid that out for us. If there are any concerns or additions that someone feels are needed to the agenda, anyone on the Board, raise your hand now.

MS. TONI KERNS: I have no hands, Joe.

CHAIR CIMINO: We'll consider the agenda approved by consent.

APPROVAL OF PROCEEDINGS

CHAIR CIMINO: Also, we have in the package Approval of the Proceedings for the October, 2021 meeting, which you all should have had a chance to look at. Is there any concerns or edits that you feel are needed to the proceedings from the October meeting?

MS. KERNS: I have no hands, Joe.

CHAIR CIMINO: Very good, thanks.

PUBLIC COMMENT

CHAIR CIMINO: As I mentioned, this is a time where we will allow public comment on any items not on the agenda. If there are members of the public and you're able to raise your hand, please do so.

MS. KERNS: I don't have any hands, Joe.

CHAIR CIMINO: Okay. Well, with that we do have two important presentations, as I have mentioned. Caitlin, I don't know if you want to give an intro before we get started, and then as I said, I would like to go through both presentations before we take questions.

CONSIDER ADAPTIVE RESOURCE MANAGEMENT (ARM) REVISION AND PEER REVIEW REPORT

MS. CAITLIN STARKS: Sure. John Sweka will be presenting the revised ARM, and then following John's presentation, Yong Chen will be providing

the Peer Review Report. I think they'll give a pretty good background, so I will just let them go for that if that's all right.

CHAIR CIMINO: Sounds great, thank you.

PRESENTATION OF ARM REVISION REPORT

DR. JOHN SWEKA: Thank you, Mr. Chair, thank you, Caitlin for the introduction. This has been a work in progress for the past couple years, a lot of effort by a lot of different people on the ARM Subcommittee. First a little management history and assessment history. In 1998 the fisheries management plan for horseshoe crab was approved. In 2007, an effort began to develop a multispecies management approach for horseshoe crabs and red knots.

Then in 2009, the original version of the Adaptive Resource Management or ARM framework was peer reviewed. By 2012, Addendum VII was approved by the Board, and the ARM was instituted for management of horseshoe crab harvesting among the Delaware Bay states. By 2013, we did another coastwide stock assessment update, and then in 2019, we had another coastwide benchmark stock assessment. That was when we began this revision of the ARM framework.

Within the original ARM framework, the problem statement which guides our work, was to manage harvest of horseshoe crabs in the Delaware Bay to maximize harvest, but also maintain ecosystem integrity and provide adequate stopover habitat for migrating shore birds. Within the original ARM framework there were three possible red knot population dynamics models, with differing model weights, based on expert opinion, and our belief in each one of these three models.

There was a no effect horseshoe crab model, horseshoe crabs' effect red knot fecundity, and then horseshoe crabs' effect red knot survival and fecundity. On the horseshoe crab side of things, we had a model that was based largely on literature values. It started off as an age-structured model that we published years ago, and it was then converted to a stage-structured model. Originally, we had a possible selection of five harvest packages of optimal harvest, depending on the abundance of horseshoe crabs and red knots. These packages ranged from a complete moratorium for Package 1 to a 420,000 male and 210,000 female harvests under Package 5. Since the ARM has been implemented, each year we've always selected Package Number 3, which is 500,000 males and 0 females.

Why should we revise the ARM at this time? Well, basically it's time to. This is an effort to address critiques from the original peer review. We have a decade more of data for both species. The previously used software, known as Adaptive Stochastic Dynamic Programming is now obsolete. This reflects an evolution of our modeling techniques and expertise in adaptive management.

Also, the management board requested to include biomedical data in our ARM management, you know something that was largely ignored in the original ARM framework. Also, we have a problem with the previous knife edge utility functions, in that they tend to act as an all or nothing harvest control rule.

We've known this is a problem for years, and this was our opportunity to take a look at that and remedy some of the problems that occur because of the utility function. Our revised problem statement basically had the first part, which is exactly what the original problem statement was. But we added this text in red.

That was, and to ensure that the abundance of horseshoe crabs is not limiting the red knot stopover population or slowing recovery. This was an effort to acknowledge the fact that the red knots are now listed under the Endangered Species Act as threatened, and to highlight the close link between the species.

Just a quick overview of all of the changes, and I'll go into much more detail on these throughout the

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rest of the presentation. We revised the horseshoe crab and red knot population dynamics models. We revised the reward function. As I mentioned, ASDP software is now obsolete, so we abandoned that in lieu of a new approach called Approximate Dynamic Programming for the optimization. This ADP approach can actually be run in readily available software, such as R.

Also, harvest recommendations would now be on a continuous scale, and one of the major advantages of the ARM revision is that it will lead to easier model updating with the collection of routine data that we collect each year. One thing to note is that the conceptual model of horseshoe crab abundance having an influence on red knot survival and reproduction remains intact, with the underlying intent in ensuring that it's not limiting population growth of red knots.

One of the terms of references that we've had were to reexamine our definition of Delaware Bay origin crab. We still define Delaware Bay origin crab as crabs that spawn at least once in Delaware Bay. Genetics data indicate that crabs everywhere from Cape Cod to Cape Hatteras are related, and tagging data indicates that there is movement of crabs along the coast.

Recent genetic evidence from Dr. Erick Hallerman at Virginia Tech, was used to estimate the proportion of the state's landings, discards and biomedical harvest that were of Delaware Bay origin. Given this new information, we updated the values from our previous assessments such that 100 percent of Delaware crab, 100 percent of New Jersey collect crabs are Delaware Bay origin. For Maryland it's 45 percent, and for Virginia it's now 20 percent. Moving on just conceptual diagram of how the revised ARM framework works. As you know we have a horseshoe crab component and a red knot component.

Within the horseshoe crab component our information and data from trawl surveys and harvest gets input into what's known as a catch multiple survey analysis. The results from this catch survey analysis are then also used in the red knot assessment model, which is known as an integrated population model.

Along with estimates of crab abundance, we account for spawning survey information, in particular the proportion of crabs that spawn during May, artic snow cover during the breeding of red knots, mark/recapture resight data, and then aerial counts and ground counts. The catch model and survey analysis in the integrated population model are then used to create forward projecting simulation models of both species.

These forward projecting models are then brought together in the approximate dynamic programming part of the model, and this is where the optimization for optimal harvest packages or harvest recommendations is made. First, I'll go into detail on the catch survey analysis. This was approved during the 2019 benchmark stock assessment for use as the best estimate of horseshoe crab abundance in the Delaware Bay area.

We've shown this equation before. Essentially our number of multiparous crabs is a function of the number of multiparous plus primiparous crabs in previous year decremented by mortality and catch. The catch in this case includes everything from bait, biomedical and dead discard estimates. The biomedical and dead discard estimates are a huge step forward over the previous ARM framework.

Also, we have natural mortality, which is estimated at 0.3. This was based off new analysis of tagging data, and we also found that there were no differences in natural mortality between the sexes. Some of the other inputs, obviously catch. The Delaware Bay origin bait landings, this is just a graph showing trends through time in those.

These are landings that come from Delaware, New Jersey, Virginia and Maryland, and takes into account that proportion of Virginia and Maryland's crabs that are of Delaware Bay origin. As you can

see in more recent years the very low landings of female horseshoe crabs, because of the ARM management that has been implemented for years.

Biomedical mortality, we have six facilities coastwide, and four within Delaware Bay. For the development of the ARM revision and the results that I'm presenting today, we used the coastwide estimates in this report, rather than Delaware Bay specific. This is to avoid data confidentiality issues.

If this new framework is approved for management, Delaware Bay specific biomedical mortality would be used when actually setting harvest recommendations on an annual basis. Our dead discards came from the Northeast Fishery Observer Program data, and we revised our methods from our 2019 benchmark stock assessment to have what we figure are better estimates of gear-specific mortality. Then there are just graphs of the total discards and then the proportion that actually die after being discarded for males and female horseshoe crabs. Our fishery independent surveys that go into the model include the New Jersey Ocean Trawl Survey, which samples waters along the coast of New Jersey.

There are the population trends, in terms of mean catch per tow we see during the spring of the survey. We also have the Delaware Adult Finfish Trawl Survey, which samples fixed stations throughout Delaware Bay, and here are the corresponding trends in the data that we see from that survey for males and females.

Then we also have the big one, you know that we really rely upon, and that's the Virginia Tech Trawl Survey. The area shown in the map here that boxes out the Delaware Bay area. That's the area that we used in this assessment. Here are the trends in estimates coming from the Virginia Tech Trawl Survey, in terms of partitioning the crabs out into newly mature females, which are primiparous, mature

females, which are multiparous animals, and then the same for males.

When we put all of these data into our CMSA model, here are a quick view of the results that we get. Through time we can see a general increase in the number of multiparous animals. The primiparous animals fluctuate quite a bit, and those really crazy looking years between 2013 and 2016, those were the years in which the Virginia Tech Trawl Survey lost its funding, and we didn't have data from Virginia Tech during those years.

Our terminal year for this assessment, in 2019 we estimated that there were 9.3 million females within the Delaware Bay area. Here are the same results for males. Again, the years between 2013 and 2016, when the trawl survey went away. We have some pretty highly variable estimates of abundance for primiparous animals. But again also, the multiparous animals had increased over the past several years. The terminal estimate was 21.9 million total males in 2019.

We also conducted several sensitivity analyses of the CMSA model. These included varying discard mortality rates, natural mortality, survey weights of the three fishery independent trawl surveys that go into the model, and looking at coastwide biomedical mortality either included or excluded.

All of these sensitivity analyses showed that the CMSA output, in terms of total population size was very robust. You know female deviations from the base model range from plus or minus or plus 7 percent, and deviations for males range from minus 12 to plus 4 percent. Moving on to the red knots integrated population model, or IPM.

This model is used to estimate annual apparent survival of red knots, recruitment rates, and the influence of horseshoe crab on both of those. There are three components to the IPM, a mark/resight model, which is an open robust design model that estimates the survival probability and sight use while accounting for imperfect detection.

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The data used here was from 2005 to 2018. A Count Model or state-space model, which estimates change in population size among years and the aerial count data, and then a life-cycle model, which describes the underlying population dynamics that link survival and recruitment to a change in population size. This is just a schematic of what the integrated population model looks like, and you can see the boxes around each one of these component models and where they share information.

For example, the Mark/Resight model shares information with the Count Model, in terms of the proportion of birds that are present in Delaware Bay each year. The Life Cycle Model shares information with the Count Model, in terms of change in population size from one year to the next.

Moving on to the results from the IPM. Here we have a graph depicting the apparent survival probability over years from 2005 through 2017. You can see it's fluctuated anywhere from greater than 95 percent to somewhat between 85 and 90 percent. The recruitment of red knots, the recruitment is in terms of a per capita recruitment rate, so how many new birds do we get two years from now for every bird that we have this year.

Recruitment is rather low throughout all of the time series. The black dots represent the mean, and the blue dots represent the median. Within the IPM, as I mentioned, we can examine the effects of covariate on these life history parameters of red knots. We included in the model the effects of the proportion of horseshoe crab spawning that occurs in May, and what effect it would have on survival, and the interaction term as we grab abundance and the proportion spawned in May.

Just the horseshoe crab abundance alone, Artic snow cover, how that may affect survival, and then finally how horseshoe crab abundance effects annual recruitment. Of these covariates that were examined, it was only the horseshoe

crab effect on survival showed a significant effect. You can see the dots on this graph represent point estimates of the regression coefficient and the lines and whiskers represent the error about that.

It was just the abundance of horseshoe crabs and its effect on survival is the only parameters that did not overlap zero. It is a significant effect of horseshoe crabs on survival. This just shows a graph of how survival and recruitment are a function of horseshoe crab abundance. The top graph shows survival, and you can see over the range of horseshoe crab estimates that we have, you know there is a slight increasing trend in red knot survival.

But overall, the change in survival over the range of horseshoe crab estimates that we have, is only our expected survival only varies by about 2 percent. The overall mean annual survival of red knots is 0.93, and the overall mean recruitment for red knots was 0.063, and no effect of crab abundance on recruitment.

Moving on, we take these estimation models and then turn them into projection models. For horseshoe crabs it's based on the catch multiple survey analysis, but we also have to generate recruits in that model to turn it into a projection model. We use the mean recruitment of 1.7 million primiparous females and 2.2 million primiparous males. These were based on the entire time series of our estimates of primiparous animals, coming from the CMSA. Recruitment does decrease when total females are less than 3.75 million. We chose that number because that seemed to be about the lowest total females that we've estimated throughout the time series with the CMSA. The red knot projection model was based on the IPM, and we used MCMC output to link all those parameters in the IPM in the forward projecting model. The models were then linked and simulated together for the optimization, in order to find hard policy functions within the approximate dynamic programming.

I'll go into more detail about what a harvest policy function is. If we look at a reward function, this is

what we want to maximize in our optimization. The annual reward is a function of the utility of horseshoe crab, the utility of red knot and their product. Though we sum them in, also add in the multiplication of the two.

If we think of an ideal situation, this is when harvest would be near the maximum allowed, and red knot abundance would be above a threshold that we had maintained since previous ARM of 81,900 birds. If that's the case then everybody is happy. Harvest a lot of crabs, we have a high abundance of red knots.

Value to those utilities can range from 0 to 1, so that they're scaled so that red knots and horseshoe crabs are on an equal playing field. Ultimately, the total reward that you can get within a given year would range from 0 to 3. As an example, if we're able to harvest a lot of horseshoe crabs, red knot abundance is still high plus their product, we get a reward score of 3.

The advantage of this formulation of a reward function is that it prevents getting all of the reward from horseshoe crab harvest alone, and it accounts for, we include red knot abundance in this, because red knots do have inherent value to us as well. What the optimization does is try to move us from a situation where we have low utility on both species, or high utility on both species.

It's trying to push us from that upper left corner down to that lower right corner, so from 0 to 3. We want to maximize the average total reward over some long-time horizon, for example a hundred years. Getting into specifically now what is inside of those utility functions. Here for red knots, the utility on red knots is a value-based decision.

What we've come up with, you know it's very similar to what was in the previous ARM, is that there is new utility for red knots, unless they get up to that threshold value of 81,900. In the revised ARM red knots start to have utility once

you're at 90 percent of that threshold value, and then once you hit that threshold value, utility of red knots is equal to 1.

For horseshoe crab utility it's a little more straightforward, and it really boils down to economic decision, and that is the proportion of maximum economic value or maximum harvest. We've long considered that the value of a female horseshoe crab is twice that of a male horseshoe crab. What we can do is in any given year, two times the number of harvested female crabs plus the number of harvested male crabs, divided by twice the maximum allowable harvest of females and the maximum allowable harvest of males. That gets your utility.

The question is, okay how many crabs can you harvest to determine that horseshoe crab utility? Well, that is the function of what are termed the harvest policy function. We have three harvest policy functions, which are based on the abundance of female horseshoe crabs, the abundance of male crabs and the abundance of red knots. These functions are each defined by separate logistic functions, that is the equation up at the top. Within each one of these logistic functions, you have an alpha parameter and a beta parameter.

The beta parameter signifies the inflection point of these curves, and the alpha parameter signifies the slope at the inflection point. The alpha and beta parameter for each one of these curves is really what is optimized in the revised ARM framework. What comes out of these are a harvest factor ranging from 0 to 1, which then you modify by the maximum allowable harvest for each sex of horseshoe crab, to get how many crabs you can harvest in a particular year.

For males this is very straightforward, we just modify the harvest factor by 500,000, and that's our number. For females, we take into account both the harvest policy function for female horseshoe crabs, as well as the harvest policy function for red knots. We sum them and then subtract their product and multiply that by the maximum allowable female harvest.

The way the optimization proceeds is that we in a simulation environment, is that we randomly selected an alpha and beta parameter for each harvest policy function, and then in that simulation we apply the recommended harvest specified by that suite of alpha and beta parameters for a given level of horseshoe crabs and red knot abundance.

The reward is calculated for that year, and then the population is projected forward for an iteration. We then repeat this process over and over, based on that same suite of alpha and beta parameters. At the end of the simulation run, say 100 years, then some yearly rewards over that timed horizon. We have an algorithm in there that searches for the alpha and beta parameters from each of the three harvest policy functions that maximizes the average total reward over 10,000 simulations.

It's fairly computer intensive, but it still runs faster than what the previous ARM model did when it's optimizing. The results in the output from the optimization. Here we have the harvest policy function for male horseshoe crabs. We see this curve that increases and then levels off at 500,000 as a function of male horseshoe crab abundance.

The blue area indicates the areas where we currently are, and where we expect to be over the next hundred years. Relatively high abundance, which also corresponds into relatively high allowable harvest of male horseshoe crabs, near 100,000. For females the picture is a little more complicated, because you have to look along two different axes. The X axis represents adult red knot abundance in thousands, and the Y axis represents adult female horseshoe crab abundance in millions.

We have these curves across a range of male, a range of female crab abundance and red knot abundance. What you can do is for example you would look at these curves. If we had 50,000 red knots out there and 10 million female horseshoe crabs, you know where they

intersect on this graph. That band of color kind of tells you how many female horseshoe crabs can be harvested. With 50,000 red knots and 10 million horseshoe crabs, we would be just under 150,000 for an allowable harvest of female horseshoe crabs. The green dots on this graph represent the projected population of both species over the next ten years. You can see this is the range in which we might fall. This next series of graphs shows the predicted population sizes of red knots and male and female horseshoe crabs if the ARM were implemented and moving forward with our Optimal Harvest Policy function.

We can see the red knots on average the black line in this graph represents the median projected population size. They should increase gently and then asymptote at around 100,000 birds. The dark gray area represents the 25th and 75th percentile, and the light gray area represents the 2.75 percent and 97.5 percentile.

For horseshoe crab, we see that the female would likely asymptote at 7.3 million and the males at 14.9 million. Now you might look at this and think we are going to expect a decrease, but keep in mind there is a lot of uncertainty in these population projections, but based on the wide confidence intervals we would predict that currently we were probably at the upper end of the projected distributions here.

There is a chance that horseshoe crab abundance could decline, and not just because of ARM recommended harvest. Another question one might naturally ask, is okay well what effect does the ARM implementation have on our projections of red knot abundance? Well, this graph shows an overlay of two scenarios.

One, in green, where we implement ARM recommendations, so we have bait harvest plus our background harvest that we have no control over, and that's the biomedical mortality and also the dead discards. The blue area is background harvest only, so no bait harvest allowed. We see for red knots that the projected distributions overlap nearly 100 percent.

In fact, there is only about a 1 percent chance that under ARM management we would result in fewer red knots than under no bait harvest at all. ARM management actually has a slightly bigger effect on horseshoe crab abundances, and you can see where the equilibrium levels of males and females horseshoe crabs are slightly less if we implement ARM management.

As an example of harvest recommendations, if we look at the years 2017, 2018 and 2019. The top part of this table shows recommended harvest under the old ARM framework. We see that there are the abundances of male and female crabs and red knots during this time period. The previous ARM obviously recommended 0 female harvest and 500,000 male only harvest.

If the revised ARM were implemented, and we had the same data from 2017 to 2019, we would now recommend roughly 150,000 female harvest across those years, and still 500,000 male harvest across those years. Moving on, one of the sections to report is stock status and conclusions. For the Delaware Bay population, you know there are no overfished or overfishing definitions as in a traditional stock assessment.

Our problem here is more of an optimal harvest, given the states of horseshoe crabs and red knots. This is dependent upon the underlying population dynamics of both species, as was shown. One thing we want to point out is that the major source of uncertainty in both species is the recruitment. You know you can change the values of recruitment and that has the greatest effect on population projections and recommended harvest. But the uncertainty on this should resolve as we collect more routine data. Some of the advantages of the ARM revision is the models for both species are based on empirical data from Delaware Bay, and it also incorporates additional horseshoe crab mortality sources.

The previous ARM model was based largely on literature values, and was more theoretical in approach. Model updating will be easily conducted with our routine monitoring data, and we could even update everything in these models on a yearly basis. There are not capacity limitations for ADP.

We don't have the same capacity limitations in ADP as we did in ASMP, and all uncertainty gets carried throughout the optimization. In ASCP our former software, we were limited on the amount of stochasticity on life history parameters we could include. The reward posting also now values both horseshoe crab harvest and red knot abundance, and you can't get full reward from one of those two only.

Another nice thing is that we can make harvest recommendations on a continuous scale. These could be truncated to maintain yearly consistency in management. For example, if the recommended harvest from the ARM revision was 130,000 females, you could round that down to 100,000 males, and that should allow some stability and avoid rapidly changing quotas from one year to the next.

For research recommendations, I'm not going to go through every single one that are outlined in the report. The complete list is in the supplemental report, which represents both research recommendations developed by the ARM Subcommittee and additional ones that were recommended by the Peer Review Panel.

We have them grouped based on future research, such as implications of climate change, observed egg density versus horseshoe crab abundance, you know something to further examine. Also, data collection, there are some more analyses that we could do with the Virginia Tech Trawl Survey, you know look into sex and stage information from Delaware/New Jersey trawls. I know both of them plan to start sexing and staging all crabs, and additional tagging efforts for both species, you know crabs and birds.

Other research recommendations pertain to data analysis and modeling, such as additional tagging analysis, regular model updating, and use of

evaluation of perfect information, in making management decisions. Now in all assessments we always strive to reach consensus among committee members, but unfortunately in some cases we can't reach consensus. We did have two minority opinions filed as part of our report, one by Larry Niles from New Jersey, and one by Wendy Walsh with Fish and Wildlife Service.

Just to briefly touch on those minority opinions. The key issues from Larry Niles were an apparent lack of trend and egg density data, and apparent lack of trend in the Virginia Tech Trawl Survey, and inclusion of New Jersey and Delaware Trawls in the Catch Multiple Survey Analysis. In the report we had detailed responses to their minority opinions. But just to summarize, you know for the first one from Larry Niles, we removed egg density data from consideration early on in the ARM process, even back in the original ARM. We have a direct link between horseshoe crab abundance and estimates of red knot survival that we can use, and also, I want to say that direct comparison to the early egg density estimates from Botton et al (1994) is inappropriate, because of differences in spatial and temporal sampling designs between what New Jersey does now compared to what Botton did back in the early nineties.

The lack of trend in Virginia Tech Trawl, I mean we do see an increasing trend in the swept area population estimates that are used as input into the catch multiple survey analysis. Also, including New Jersey and Delaware trawls in our assessment, you know they have both been long used as an index of abundance for horseshoe crab, and they were included in 2004, 2009, '13, and 2019 stock assessment for updates.

Also, it is very common to include multiple fishery independent surveys in a given stock assessment model for any species. Moving on to the Walsh minority opinion. She focused her opinion on the utility functions, stakeholder input, the survey weights going into the CSMA, and model uncertainty.

As far as utility functions, the previous utility functions were technically flawed, as I discussed, and resulted in an all or nothing harvest. The main problem with those was, if we would happen to hit that 11.2 million female horseshoe crab threshold, we would automatically bounce to the maximum allowable harvest under the old ARM.

We've known that was problematic for a long time. In recent years we have gotten close, based on Virginia Tech swept area. As far as stakeholder input, we do have a diversity of expertise on the ARM Subcommittee, Delaware Bay TC and the Advisory Panel, and also there will be a comment period on any draft addendum process that may stem from this ARM revision.

There is more opportunity for other stakeholders to weigh in. As far as the catch survey weights. We were never clear on what the appropriate weighting should be. This was a question that we had during the 2019 benchmark stock assessment. That Peer Review Panel then recommended that we have equal weighting, so that's what we went with in this ARM revision.

We also reached consensus early on in the ARM revision process to go with equal weighting, and this was also ultimately supported by the Peer Review Panel this time around. As far as model uncertainty, yes, our models are uncertain. You saw the population projections of each species, and there is a lot of uncertainty on those. But this is exactly why we do adaptive management modeling. I'll stop there, and I guess we'll hold the questions until Dr. Chen has given his report from the Peer Review Panel.

CHAIR CIMINO: Great, thank you, John. I hope that we can go forward in that manner. I think that might be helpful, especially if that presentation helps answer some of the questions that might be coming up. I always appreciate your background summaries. You know we went through the peer review for horseshoe crab, and we've come a long

way, and a lot of work has gone into this. I appreciate that presentation, and happy to turn it over for the Peer Review Report.

**PRESENTATION OF
PEER REVIEW PANEL REPORT**

DR. YONG CHEN: Thank you, Mr. Chair. My name is Yong Chen, I am a Professor at Stony Brook University, and I'm Chair of this Peer Review Panel. We have a Scientific Review Workshop that was held on November 16 to 18 last year, to review the ARM Revision, developed by the Horseshoe Crab Technical Committee and Subcommittee, and the ARM Subcommittee.

The Scientific Review focuses on models, input data quality and quantity and modeling outputs sensitivities and overall quality of the new ARM framework. Scientific review report, you can find the scientific report online. The Peer Review Panel consists of four members, including Dr. Erica Nol from Trent University in Canada, and Dr. Kelly Robinson and Dr. Justin Bopp from Michigan State, and myself from Stony Brook.

Collectively the Panel has expertise in horseshoe crab and migratory shore bird ecology, population dynamics and statistics, stock assessment, and adaptive resource management and structured decision making. The ARM Work Group developed models to project sex-specific horseshoe crab abundance, with inputs from horseshoe crab stock assessment model.

The Work Group also developed an integrated population models for red knot population dynamics and change reward function, and shifted to Approximate Dynamic Programming, which removed some constraints associated with the previous ARM framework, and I think John gave an excellent talk about the work.

Overall, the Review Panel concludes that the Workshop completed your Term of Reference,

and the ARM division is significantly improved over the previous ARM framework, and that the ARM revision represents best available science, and is appropriate for providing management advice. That is the overall conclusion from the Review Panel.

We're giving a list of Term of References, so I will go one by one, and for the first Term of Reference the Panel concluded that proposed Catch Model and Survey Analysis model and a new projection model developed for Horseshoe Crab are appropriate for use in ARMs and the Panel also agrees that the CMSA estimated Delaware Bay horseshoe crab stock dynamics is robust, and appropriate for use in ARM.

The Panel recommends that Delaware Bay horseshoe crab stock be better defined, as some new genetic studies and some tracking studies indicated that the stock can be better defined. The full time series of recruitment estimates be used in the projection model to count for all possibilities. For the second Term of Reference, the Panel concluded that the proposed Integrated Population Model for red knot is a significant improvement over the previous model.

Analysis for the red knot population dynamics is appropriate for use in the ARM. The Panel recommends that the Work Group continue exploring the multi-state model that was used in the previous version of ARM, but it has some issues this time. The Panel also recommends that the red knot model parameters be updated frequently, particularly in the short term, to reduce uncertainties in the model and the decision for the horseshoe crab harvest. For the third Term of Reference the Panel concluded that data that was used are adequate for ARM revision to provide a horseshoe crab management recommendation. The Panel recommended the research be conducted to evaluate how changes in the environment and sampling time may influence horseshoe crab survey catchability. The Panel also suggested to evaluate an apparent lack of relationship between horseshoe crab egg densities by beach surveys and the red knot survival. To

update the assessment models with the new data when they become available for both species on an annual basis in the near future.

For a research recommendation, like John mentioned, there is a long mix there, but I kind of included four of them here. We think it's important. The Panel made a research recommendation for improving assessment methodology and data collection, and including revisiting ARM framework to evaluate the performance every 5 to 10 years.

Continuing funding the Virginia Tech Horseshoe Crab Survey Program, evaluating the new utility and harvest function, to make sure the broad representation of stakeholder's values, and using the expected value of perfect information to evaluate the effects of uncertainties in red knot and horseshoe crab dynamics on harvest decision. The Panel also reviewed two minority reports and majority responses in the report, and the Panel agreed with the majority responses in survey effectiveness.

The Panel also agreed with majority responses in reformulating utility and harvest functions for fast updates to reduce uncertainty. The Panel recommends that a mismatch between egg sampling and horseshoe crab spawning abundance be evaluated. The Panel also recommends considering uncertainties in horseshoe crab management, and ensuring current functions to adequately represent stakeholder concerns. Thank you, and I will be happy to answer questions.

CHAIR CIMINO: Great, thanks, Yong. Hopefully as we go through with the questions, if individuals want a slide pulled up that staff will be able to do that for us. With that, Toni, if you could help me out. I would like to see hands from the Board on questions regarding either presentation.

MS. KERNS: Yes, will do. I have no hands raised right now, Joe.

CHAIR CIMINO: Oh, you guys are good.

MS. KERNS: Now Joe, I have three hands, John Maniscalco, David Borden, Conor McManus and Rob LaFrance.

CHAIR CIMINO: Okay, we might need you to go one more time, Toni, but as I mentioned, Dr. Chen and Sweka, or if a question ends up going to staff. Please don't wait for me to relay, allowing you to speak. If a question is addressed to you, please feel free to answer. We'll start with John Maniscalco, go ahead, John.

MR. JOHN MANISCALCO: This question is for Dr. Sweka. First, thank you both for the presentations. You made a reference to some recent genetic work by Dr. Hallerman, and there was a comment I believe in maybe one of the minority opinions towards that 44 percent of your bait harvest was of Delaware Bay origins, and referencing personal communication from Erick Hallerman. The last tagging table I saw associated with the assessment said that there was less than 2 percent tag returns from New York and Delaware Bay or vice versa, and I am just wondering what the basis for that 44 percent comment was, and if you have any more information about the genetics connect policies that Dr. Hallerman is undertaking, thank you.

DR. SWEKA: Yes, Dr. Hallerman's analysis was samples were taken from landed horseshoe crabs. Certainly, a lot of them in the New York area originated from Delaware Bay or could be traced back to Delaware Bay. But for our tagging information, as you mentioned, what we see is, although a relatively large portion of New York's harvest might be from crabs that originated in Delaware Bay.

From the tagging information we don't see a large net movement to New York and then back to Delaware Bay. If you think in terms of metapopulation dynamics, what we have, what it kind of looks like is the Delaware Bay is a source population, and New York would be a sink population. You have a net movement of crabs from Delaware Bay up to New York.

Those crabs in Delaware Bay that move to New York are unlikely to ever move back to Delaware Bay. Essentially those represent almost the same as, you know just a natural loss of crabs from Delaware Bay as they move out. You know it represents near permanent immigration for those crabs. I don't know that we would want to make a leap, and it certainly merits further analysis that harvest in New York would be impacting the crabs that would eventually spawn in Delaware Bay.

MR. MANISCALCO: Thank you.

DR. CHEN: If I may add, and the Review Panel recommended further study to better define Delaware Bay horseshoe crab stock structure.

CHAIR CIMINO: John Sweka, if I may follow up. I think it has been a while before this type of genetic composition was used to update the proportional harvest. I am curious, is there a standing research recommendation or is there guidance on how often that should be updated? Maybe even as Dr. Chen suggested, looking into that, like maybe the number and timing of samples that were used for the current work and exploration of that.

DR. SWEKA: Well, we certainly have research recommendations to continue looking into that. As far as specific timing or how frequently that should occur, Joe, we haven't got into the whole detail on that research recommendation.

CHAIR CIMINO: Thank you, and my apologies to David Borden and the others who are ready in the queue there for jumping in with my own question. I believe David Borden is next.

MR. DAVID V. BORDEN: Two quick questions. I was just wondering whether or not there is any evidence that the center of abundance on horseshoe crabs has shifted along the coast. There are a number of other species where we documented that. If I could get an answer to that, and then the other question is, is there any evidence that natural mortality rates have

changed over time, so those two questions, thank you?

DR. SWEKA: Okay, to your first question about the center of abundance. We haven't looked specifically at that, but I would say that it doesn't appear that there have been. If we look at the New Jersey Ocean Trawl Survey and the distribution of their catches, we see that throughout the time series that we have available to us.

The majority of their catches occur close to the mouth of the Delaware Bay, and the farther away you move the lower their catches are. That seems fairly consistent, so I guess that would lend some support that the center of biomass of horseshoe crabs hasn't shifted. To the second question. Could you repeat that again, please?

MR. BORDEN: Second question was whether or not there is any evidence that natural mortality rates have changed over time.

DR. SWEKA: Right now, we don't have any evidence of that, but the available tagging data doesn't go back in time really all that long. You know to come up with our current estimates of natural mortality, we focused on those years of data since the state of New Jersey put their moratorium in place.

You know feeling that that was most representative of recent years, and would also eliminate the most potential for confounding impacts of any bait harvest going on out there. At this point in time, I don't think we have strong indication of any trends in natural mortality, or at least the data that we have available isn't amendable to actually looking at that.

CHAIR CIMINO: Thank you, David. Go ahead.

DR. CHEN: I just want to mention that during the review, actually the Panel requested a part of positive tows in the survey for horseshoe crab, and we didn't see any temperature on that, so that is probably an indication that this issue has not been changed. I just want to add it.

CHAIR CIMINO: Thank you for the addition. Toni, please correct me if I'm wrong. I had Conor McManus and then Rob LaFrance next.

MS. KERNS: That's correct, and just to let you know, Roy Miller put himself in the queue as well.

CHAIR CIMINO: All right, very good. Conor, go ahead, please.

DR. CONOR McMANUS: I just want to first commend the technical group here for all the work that they've done, a symbol of a lot of new advancements that I think (faded) proved to be appreciative of that. Two questions from me. The first is regarding the weighting for the surveys.

Maybe for John. If you could remind me what the impact of the weightings were on our imprints for crab abundance by sex, just the magnitude higher or lower, and maybe could you speak to other tools that were evaluated to understand the weighting or infer weighting, or incorporate catchability of the surveys to the weighting? Just a little bit more for the confidence of the minorities report.

DR. SWEKA: Sure. In the 2019 benchmark stock assessment we applied a weighting system that was based on a hierarchal model that took all three of these surveys, and it was the inverse of their standard deviation in that model. How much variance was explained by each of those surveys in that combined hierarchal index, we used that originally as a weighting system, which it gave the Virginia Tech Trawl Survey the highest weight, and less weight to Delaware/New Jersey Trawls.

During the peer review in 2019, the Peer Review Panel had a question about, if we use that weight, which is based on a variance, and then we also had CVs of each individual survey in the CMSA model, are we basically double counting the variance of each survey?

There was a lot of discussion about that during the 2019 benchmark stock assessment, and we came around to consensus between the Stock Assessment Subcommittee and the Peer Review Panel that it's probably most appropriate not to weight either one, or have any weighting for each individual survey.

We carry that through to this new ARM revision, and we've reached consensus among the Subcommittee early on that we shouldn't weight one versus the other. In the end in the minority opinion, yes there was a desire to then put weights back in. We actually tested the sensitivity of model results to that. We used the original weights from the 2019 benchmark stock assessment, which would be completely inappropriate to put back in now.

We also did a sensitivity analysis on the, one suggestion by the current Peer Review Panel was perhaps weighting based upon the amount of area sampled by each survey, so we did that. The area weighting method almost put Virginia Tech Survey and New Jersey Ocean Trawl Survey on equal footing, because although the distributions of their sampling area don't overlap completely, in terms of area they were about the same.

In the end, it really doesn't make that much difference. As I said in the summary of the results of the sensitivity analyses, the female horseshoe crabs over everything that we did, you know we might range, our final terminal year abundance estimates of female crabs might vary plus or minus 7 percent at most.

Also, I can certainly understand the desire to more heavily weight the Virginia Tech Trawl Survey, because that survey was typically designed to capture horseshoe crabs. The gear is designed to more effectively sample horseshoe crabs. You can see that in the raw data. The average catch per tow from Virginia Tech Survey is greater than that of the other two surveys.

If a crab is encountered, Virginia Tech is more likely to catch it. Now having said that, I mean all of the

surveys suffer from the same problem, in terms of interannual variation. In all of them we can get these extreme up and downs, you know from one year to the next. Basically, it boils down to being in the right place at the right time to catch crabs. All the surveys suffer from that. Some years you catch quite a few, you hit the hot spots, some years you don't. In terms of reflecting the population, all of our surveys, our underlying assumption is that whatever your catch per tow is, you know your index of abundance. Whatever that is, it's proportional to the total population size. At this point in time, and the results of the surveys are correlated with one another, especially since approximately 2010.

We've seen an increase in abundance in all the surveys. The current Peer Review Panel agreed, you know we had a lot of discussions about weighting systems, and eventually the current Peer Review Panel made the suggestion, and recommended in their report that as long as we still have this correlation, the equal weighting that we ultimately used is appropriate at this time.

DR. McMANUS: Thanks, John, I really appreciate that. Very thorough and helpful. I guess my other question is, you cite that some of the greatest uncertainty perhaps in the results that tie to recruitment. I guess I was just curious, similar to some of the red knot kind of model covariate work you were doing.

Have you looked at other indicators in the environment or from outside of maybe regular population dynamic models that could help inform recruitment in your model? Do you see trends in some of the other things that would be driving recruitment external to red knots that may be used to inform the model?

DR. SWEKA: Yes, you know a while ago we did use the Virginia Tech Trawl Survey data and apply to general linear model to account for covariate, thinking that perhaps fluctuations in catches might be due to the environmental

effects, and maybe those differ between primiparous and multiparous crabs.

We attempted that. The results of it didn't really change much. Yes, I think there is more that we could do, and some of the research recommendations from this Peer Review Panel, in terms of the spatial distribution and habitat suitability modeling for horseshoe crab could come into play in the future.

For red knots we have those covariates that we evaluated in the IPM of the effect of crabs on red knot recruitment. Also, Artic snow cover and so on. We still retain those in the model. We didn't just completely drop those. I mean right now they're not informative, because there is no effect of them.

But they are still retained in the model, if as we collect more data into the future, we start to see that those effects become evident. It could just be still a matter of data limitation that we can't discern those effects right now. But they are contained within the model, and as we collect more routine data and update our models. If those start to show some sort of effect on red knot recruitment, we should be able to tell that.

DR. McMANUS: Great, thanks.

CHAIR CIMINO: Great questions, Conor, thank you for that. I especially appreciate, you almost got someone named Dr. John to say, right place but the wrong time. I think next is Rob LaFrance.

DR. ROB LaFRANCE: Thank you for the presentation today. My question was very similar to what was just asked about the trawls and the weighting. In the minority report there was a weighting suggested. I just want to know whether that model was run. I think Wendy Walsh recommended 0.59 percent, 0.16, and then 0.25. Did you guys actually run those scenarios? Then I have a follow up question on something different.

DR. SWEKA: Yes, that was exactly one of the scenarios that we ran in the sensitivity analyses, and there is a table in the report and in the

supplemental report of the results of that. That weighting scheme came from the original weighting that was sent to the Peer Review Panel for the benchmark stock assessment in 2019, which ultimately, they suggested we don't weight using those.

DR. ROB LaFRANCE: That's in the supplemental report, thank you. My larger, sort of bigger question is this issue of the egg masses. It seems to me that for a number of reasons they are not really being included in the overall analysis and modeling. I'm just wondering if you could take a little time and explain what some of the problems with that approach are, and I think I see recommendations that you would like to do more with that going forward. I'm just trying to get a little better understanding of that, thank you so much.

DR. SWEKA: The egg density data, you know they are highly variable and subject to not only the abundance of spawning horseshoe crabs, but also the spatial and temporal variation that we see in the effects of wind and wave action on the beaches, and also the timing of spawning. The timing of peak spawning is when egg surveys are conducted.

A lot of things can influence your major egg abundance. The use of egg density data as a predictor of red knot survival was abandoned, even in the original ARM framework, just because of the high variability of egg density data, and we also found a direct link between female crab abundance and red knot survival.

That relationship still exists in this ARM revision. Another point is that our management of horseshoe crabs directly effects crab numbers not egg density, which are subject to a host of all those other factors. Oftentimes you see the comparison to those early numbers by Mark Botton, back in the early nineties, but there are differences between how egg density data is collected now versus the sampling design that was implemented in Botton's study in the 1990s.

A direct comparison between the two is probably not appropriate. As you said, we do make recommendations. Eggs certainly are the direct input for the red knots, you know that is what they're actually using. We do have research recommendations to continue to look at the egg density data, see if we can come up with any sort of predictable models between crab abundance, spawning beach surveys, and that egg density, and red knots.

Now, if you think about that, that is a lot of steps and a lot more sources of uncertainty. Perhaps we could do that into the future, as we gather more data and examine that closer. But right now, the most efficient way to see what's the impact of horseshoe crab on red knots is that direct jump from crab abundance to red knot survival, which we do see a significant relationship with.

DR. LaFRANCE: I just would add that maybe taking a closer look at standardizing how you actually analyze big masses might be helpful as well, just because I think if there was a standard approach as to how to do it, you might be able to get rid of some uncertainty, just a thought.

CHAIR CIMINO: Thank you, Rob, appreciate that. That's kind of what put us on this journey, is making sure that there were more eggs available on the beaches, so it's an important question, and something we need to continue to look at. Roy Miller, you're next.

MR. ROY W. MILLER: Dr. LaFrance's question answered the very thing that I was going to ask about as well, so thank you.

MS. KERNS: You have Mike Millard, Shanna Madsen, and I think Conor's hand is left over from before, but I'm just double checking.

DR. McMANUS: That's correct, thanks, Toni.

CHAIR CIMINO: Okay, go ahead, Mike.

MR. MIKE MILLARD: A quick question for John. John, about half way through your presentation you

put up an analysis, that regression analysis that suggested red knot survival was significantly related to horseshoe crab abundance. Then later you showed those projections of the red knot population with horseshoe crab harvest and without horseshoe crab harvest, and they were essentially 100 percent concurrent. I can see where those two conclusions, a lot of people in the public and some of us around the table might find those two conclusions inconsistent. Can you unpack that a little bit, and tell us how that can be?

DR. SWEKA: Sure, Mike. In the strictest sense if you have a decrease in horseshoe crab abundance you would have a decrease in red knot survival. But at the same time there is a lot of variation about that relationship. Over the range of female horseshoe crabs that we have observed, or estimated by the CMSA, the effect on survival is rather weak.

It is statistically significant, but there is not a big effect. Going from 4 million to 12 million crab causes a 2 percent difference in the annual survival, with quite a bit of uncertainty about that. When you have the uncertainty about the relationship between crabs and red knot survival, you also have uncertainty and variation in natural mortality of horseshoe crab. You have uncertainty in the recruitment of both horseshoe crabs and red knots.

Taking all of that together, the amount of uncertainty due to other factors really dwarfs the relationship between crabs and birds, in terms of survival. Within the simulations that go into the ARM optimization, the expected distribution of red knot population growth under the ARM is really indistinguishable from distribution under a no-bait harvest scenario. I don't know, hopefully that answered the question, or at least puts it in perspective more.

MR. MILLARD: Yes, that helps, thank you.

CHAIR CIMINO: We have Shanna Madsen next.

MS. SHANNA MADSEN: I thank you very much, Dr. Sweka for this presentation. It was really informative, and thank the whole assessment team for doing all the work on this. I think Mike asked a similar question to the one that I was going to ask. I'm asking about the second graph that he was referencing, which I think was on a predictive population size slide.

On that slide he showed those predicted populations for red knots and both male and female horseshoe crabs on, and then the differences when you allow bait harvest as well as the biomedical harvest. I guess I was questioning, what is that bait harvest? What is the value for that bait harvest that you were using in those graphs? Is that the maximum allowed harvest by the model?

DR. SWEKA: That would be the harvest as recommended at any point in time, based on the harvest policy. If during the course of one of those simulations the crab population or bird population declined, harvest at that point in time would also decline. What those represent is the implementation of those harvest policies, not a specific harvest number.

Really, it's simulating the management system and how harvest changes on an annual basis, depending upon the abundance of crabs, birds and both sexes of crabs. But overall, yes, the absolute maximum you could harvest at any given point in time would still be 210,000 females and 500,000 males. We haven't changed that maximum allowable harvest from the previous ARM framework.

MS. MADSEN: Thanks, John, that clears that up, thank you.

MS. KERNS: That is the queue, Joe.

CONSIDER MANAGEMENT RESPONSE TO ARM REVISION AND PEER REVIEW REPORT

CHAIR CIMINO: Got you, okay. Well, that's a great discussion. Two very well thought out presentations to start us off with, and then a round of very important questions, I think. We do have an

agenda item for considering management response. I'll turn it over to Caitlin, I know she has some slides for that.

MS. STARKS: I guess I will make one note before I put up the slides for management response. Typical to our normal consideration of stock assessments, I think procedurally for this we would want the Board to consider accepting the ARM revision for management use, and then subsequent to that consider a management response. I just wanted to make that note before I put these slides up here for you.

This is going to be very quick. I just wanted to give the Board a couple of things to guide the discussion here. For the management response for this ARM revision. The first thing to note is that the current ARM framework that we use for the Delaware Bay management was implemented through an addendum, Addendum VII to the FMP in 2012.

Therefore, in order to revise the framework and make the improvements that were recommended by the ARM Subcommittee and the Peer Review, we would need to approve a new addendum. If that is the desire of the Board, the Board can consider initiating an addendum today to consider implementing changes to the ARM framework, as recommended by the ARM Subcommittee and Peer Review. Then as John presented and we discussed earlier, these are the main changes that were made to the ARM framework in the revision, and what should be included in the addendum, so that the definition of the double-loop process, the definition of harvest packages, the lander values, which are the percent of each state's harvest that comes from the Delaware Bay stock.

State allocations of the total Delaware Bay harvest, and then adaptive management recommendations for allowing future changes to the ARM framework to occur outside the addendum process, and then as always, if

desired the Board could consider other issues through the addendum as well. I just wanted to quickly give that as a context for considering a management action. That's all I have. But like I said, I think the first step would be to accept the ARM revision for management use.

CHAIR CIMINO: I think that now is the appropriate time to do that, but I do want to speak to it for a few moments. I think all the Board members are well aware of the ASMFC process that we're dealing with here. As I said, we had two great presentations on all the hard work that was done to improve this model, and a peer review that accepted those terms of reference in this model for being appropriate for management use.

There has been a considerable amount of media. We had one or two written comments that made it in time for our materials, but since then we've had a few others that expressed, in particular a concern that we would be taking action today to allow harvest of female crabs in the Delaware Bay.

I think it's important to note that that is not the decision before the Board today. But whether or not this model represents the best available science, and if it's the most appropriate for use. It's a significant enough change to our management process that it's going to require another addendum to the FMP. That of course will kick off an entirely separate chance for the public to comment on this model for management use.

What Caitlin is laying out before us is, as we start this addendum, are there other items that we want to add, which could be important? I would say that with so much that we're deciding on today, it may be difficult to fully flesh out that decision. For just a second, I'll take off my Board Chair hat, and put on my Vice-Chair hat for the Commission and say, there were discussions during our Executive Committee this morning.

ASMFC staff are going to be very tasked with a great number of possible addendum and amendments that are moving forward for management plans that will require a tremendous amount of public

hearings, or could between now and May. I would say that although I would like to have a vote on whether or not to accept this model, you know to fully flesh out and kick off the Board's needs for this addendum, may not need to happen today.

We might be able to suggest that, or a motion that starts that process, but the Board may have time to gather their thoughts and have another discussion at a future meeting on all the things we would like to see a plan development team include into this. That is something I haven't talked a great deal about with staff, but I think is something that we should consider as we have this discussion, and entertain a motion. Let's open this up for discussion. Thoughts on where we are, interest in moving forward with accepting the Peer Review and potentially starting a new addendum.

MS. KERNS: I have John Clark.

CHAIR CIMINO: Okay, John, let's start us off.

MR. JOHN CLARK: Joe, we've just had a presentation on the phenomenal work of science here done by the ARM Panel, the Peer Review. It's clearly the best available science, and I fully agree we need to accept this for management use. But as you said, the actual management part, what we would actually put in the addendum is a lot of thought has to go into that too. I am in full agreement with you that today is the time for us to approve this for management use, but as far as the addendum, give it some more time to think of all the alternatives we want in that.

CHAIR CIMINO: Thank you, John, Toni, other hands?

MS. KERNS: I have Pat Geer.

MR. PAT GEER: I agree with what you said and what Mr. Clark said. I think we need to approve this ARM Revision today. I think they did a

great job on it, and it's the best available science. But I agree with you, I think given what we heard this morning in the Executive Committee, as many as 40 public hearings over the next few months. I think we should take our time and basically come back together in May and have a discussion on what we want this addendum to look like. I agree with what's been said so far.

CHAIR CIMINO: Great, thanks, Pat.

MS. KERNS: You have Rob LaFrance and then Emerson Hasbrouck.

CHAIR CIMINO: Go ahead, Rob.

DR. LaFRANCE: I guess I just have a question on what we, by accepting this for management purposes, that just means we accept that the work has been done and we're going to consider it moving forward, but nothing of substance would happen with it, until such time as we passed another addendum? Is that the correct understanding?

CHAIR CIMINO: Yes, this is one that I think I'll start. I would appreciate staff helping me out, especially if I misspeak on where I start. We would be accepting that this is the best model available to produce estimates of what we're trying to get at here. The ARM model is something that has been in place for several years now.

We're looking at that utility function with trying to achieve a harvest package that allows or suggests the safest harvest levels for horseshoe crab that don't inhibit red knot survival. We need something there. We have a peer review that suggests that this model is the best available to spit out a harvest package. As this moves forward, that will continue to get a range of options for the harvest packages, and that is something that will go into the addendum for us to look at. Toni or Caitlin, anything I missed or that could be covered better?

MS. STARKS: You did a good job, Joe, and I think the main takeaway to the question is that yes, we

would have to approve an addendum in order to implement the ARM Revision.

DR. LaFRANCE: Toni, just a follow up then. Basically, what we're saying is if we accept this today, we're saying that because of the work that's done, and because of the Peer Review, we accept it as the best available science on this particular issue. However, in terms of moving forward on management, for example, whether the Board thinks that the numbers are correct, and whether we want to get a greater detail understanding of the risk associated with different packages. That still has to work through an addendum process, is that right?

MS. KERNS: Rob, I wouldn't couch it as we think the numbers are correct, because I think by accepting the assessment for management use you are saying it is the best available science, so in that sense that you are agreeing with the information that is in the ARM review. How you utilize that for management then, is a decision that you all are going to need to make through the management process.

DR. LaFRANCE: That's the clarification I was looking for, basically, the difference between accepting. I don't like what happened in menhaden, where they accepted some information, and then we had to figure out what our risk analysis, our risk tolerance was going to be, before we decided on certain management choices. I see this following that same process, is that fair to say?

MS. KERNS: Correct, yes.

CHAIR CIMINO: Yes, it's a good point. You know these are the only two species that we've attempted to tackle at a multi-species modeling level, and there were recommendations from the Peer Review on the TORs regarding stakeholder values. Moving forward we have to remember that that is not only part of the management decision, it's actually part of the model.

It's important to consider that, that this isn't just the model said that it's safe to harvest some female crabs, and therefore you have to harvest female crabs. It's an important distinction that this is a more complicated process than that, for sure.

MS. KERNS: Joe, just to get your queue back, you have next Emerson Hasbrouck, then Dan McKiernan, followed by Pat Geer and then Chris Wright.

CHAIR CIMINO: Go ahead, Emerson.

MR. EMERSON C. HASBROUCK: Based on your response to the previous couple of questions, are you ready for a motion then to approve the ARM revision for management use at this time? If not, you can come back to me, if you want to have some more discussion.

CHAIR CIMINO: Yes, we have a few hands in the queue, and we're doing pretty good on time, so let me clear the hands that we have, Emerson, and then I'll come back to you. Dan, go ahead, please.

MR. DANIEL McKIERNAN: Emerson kind of stole my thunder. I was wondering if you would be ready for a motion. It seems to me that this was an outstanding piece of work, best available science. I'm just trying to think forward about timing of new proposed management measures, and the seasonality of harvest. If we were to undertake a new addendum, is it expected that we would accomplish it in time for the 2023 harvest seasons, or would it likely extend into 2024, for the first time we would see any modifications of management?

CHAIR CIMINO: I think at an ambitious timeline, we would have been revisiting accepting a new addendum at the October meeting, which is our last meeting of the year, when we're typically setting harvest specifications. I think that slowing that down could certainly result in kind of a status quo methods for setting the specifications for 2023.

But keep in mind, and again that's so important of a consideration for all the individuals who are so concerned that a new model means a changing of

how we're going to manage this species in the Delaware Bay. We could take an ambitious timeline, and have this model in place, but still choose to stay with the status quo harvest package, because of all the uncertainties expressed so far, and that we think that's the best choice.

I think there are some other items that we've talked about. We had a pretty good discussion during the October meeting last year on what should be included in this addendum. We might want to take some time, and kind of really work on that and see where we end up.

MR. McKIERNAN: That sounds like a future horseshoe crab board meeting to kind of set the parameters for that. It would take a few meetings. I think it sounds like at this point you would be looking for a motion to accept the revised ARM, and I would be happy to do that once you clear the queue.

CHAIR CIMINO: To some extent, you know we've had some members speaking in favor of that. I've kind of made it clear that as we move forward, even with just information that we heard this morning, that that is where I'm kind of leaning as Board Chair, but I'm certainly willing to entertaining any motions if folks feel otherwise. With that we'll go to Pat Geer.

MR. GEER: I think Emerson and Dan stole my thunder, as far as a motion is concerned. I was just going to make a motion.

CHAIR CIMINO: Okay, thanks, we have Chris Wright.

MR. CHRIS WRIGHT: Yes, I'm in support of the ARM, but my question was related to some of the earlier questions, in regards to timing, and whether or not we were going to try to get an addendum done before 2023, and that timing, and whether or not we were going to assign anything to the PDT. But I guess we'll just move forward the way we're going right now.

CHAIR CIMINO: I do want to say once again that I certainly showed my hand, but I'm not trying to strong arm the Board here if there was an interest in moving this forward more quickly, then I think we can certainly have that discussion, whether in the form of a motion or a little less formally. But not everyone was privy to the Executive Committee. I know not everyone tunes in, necessarily.

As far as what staff is dealing with, we have menhaden and striped bass amendments that have some pretty big issues in them. We're looking at a Rec Reform Initiative, and potentially we're talking about dozens of public hearings between now and May, without even tackling horseshoe crab. I want to put that out there. Toni, if no one else in the queue, I'm going to go back to Emerson.

MS. KERNS: I don't have anybody else in the queue.

CHAIR CIMINO: Emerson, go ahead.

MR. HASBROUCK: Does staff have a motion prepared to accept the ARM revision for management use? I move to accept the Revised ARM Framework and Peer Review for management use.

CHAIR CIMINO: Thank you, do we have a second?

MS. KERNS: Dan McKiernan.

CHAIR CIMINO: Thanks, Dan, any discussion on the motion?

MS. KERNS: We don't have any hands raised at this time.

CHAIR CIMINO: As I mentioned, if any motions come before the Board on possible actions today, I wanted to also give the public a chance to speak, so I will open it up now to the public, if they have any questions or things that they wanted to comment on regarding the motion.

MS. KERNS: Just giving it a second. I currently don't see any hands raised. Just to make sure, everybody who is not familiar. You click on the hand button,

the little icon that looks like a hand to raise your hand. Still no hands.

CHAIR CIMINO: Okay, thank you, Toni, I appreciate that. Caitlin, with that, is there anything else you need regarding this, or Toni, since we did kind of break this into two elements. Do we need a discussion on when we might pick this up? Is there the possibility of getting on the agenda for the next Commission meeting?

MS. KERNS: Joe, I think there is definitely the possibility of getting this on the next Commission meeting. If it is the intention of the Board to initiate an addendum, and you want the PDT to start to do some work. I don't see an issue with at least making that motion to initiate and have the PDT perhaps start some progress. You know obviously with the time allowed that we will have, depending on all the different management documents that we talked about this morning in Executive Committee. If that is something that the Board does want to do, then after you dispense with this motion here, you could consider a motion to initiate an addendum. Obviously, addendums can have a longer timeframe for development process. It doesn't have to come back to the Board immediately. The PDT could start looking into some things, and the Board could provide additional feedback at the May meeting.

CHAIR CIMINO: Great, okay, and so thank you for reminding me that there is a motion on the board. Let's do that then, let's dispense with that first. Is there any objection to this motion, please raise your hand?

MS. KERNS: I see no hands raised in objection.

CHAIR CIMINO: Okay, great, thank you. Again, you know there was a lot of public interest in this process, and I think some misunderstanding to how we work with this stuff. We don't kind of keep a standing Plan Development Team that works on fishery management plans or their

amendments. Typically, we need to collect a new group of individuals from the states every time we start a new amendment or addendum. A motion here wouldn't necessarily put us back on a fast track, but they would have at least one standing pass.

They know that they need to go back to what we did for inclusion in the FMP for the original ARM model in 2012, and kind of retool that for a new addendum. Then they will be standing by for any other tasks that come from a future board meeting, hopefully at our very next board meeting. Caitlin or Toni, correct me if I'm wrong, but the establishment of the PDT, we will go back, states will nominate members, and through an e-mail process those members would get included, is that correct?

MS. STARKS: Yes.

MS. KERNS: I just wanted to jump in. Joe, can you just say that the motion carries.

CHAIR CIMINO: Keep me honest here, Toni. The motion carries, it was passed by consent. Thank you. Caitlin, I think, confirmed that for us, Toni, and if any members of the Board are interested in allowing a PDT to get formed to start some of this work, I think spreading this out could help alleviate some of staff's task assignments as well. Happy to entertain a motion for that.

MS. KERNS: You have John Clark.

CHAIR CIMINO: Go ahead, John.

MR. CLARK: I would be glad to make that motion. Is there an already made motion? Oh, there we go. Yes, I would like to make the motion to initiate an addendum to consider incorporating the revised ARM Framework for management of the Delaware Bay stock. Does it have to say into an addendum?

MS. KERNS: No.

CHAIR CIMINO: Toni, do we have a hand for a second?

MS. KERNS: We do, Mike Luisi.

CHAIR CIMINO: Thank you, Mike. Any discussion on the motion?

MS. KERNS: We have Rob LaFrance.

CHAIR CIMINO: Go ahead, Rob.

DR. LaFRANCE: I just wanted to make sure I understand this. All we're doing at this juncture is just going around the states and pulling together a PDT. Because I know in other PDTs I worked with, they like to have specific questions that they need to answer, and come back with some specific report. As long as the idea here is just to get something started, I'm fine with that.

I also would be interested, if Caitlin wouldn't mind sharing to all the members of the Board her PowerPoint screen there. I think that was very helpful for folks. Anyway, that's what I just want to get clarification on if I could. Is that all we're doing, just setting it up?

CHAIR CIMINO: Yes, I thought I was clear that that is exactly what I was trying to explain before asking for a motion. We have a motion before the Board, I guess we will have to turn to the maker and seconder of the motion if that's also their intent.

MS. KERNS: Joe, are you saying that you all don't. Once the PDT is formed, you all do not want them to do any work on the addendum between now and May? I think there is a list of things that Caitlin had provided in her PowerPoint that they could at least start to explore, and bring perhaps comments back to the Board at that time, just to at least, as you said before, spread out the work a little.

CHAIR CIMINO: Yes, well, Toni, they certainly have the assignment of adapting or changing the wording of where we are for management using Revised ARM Framework. I guess, if there are other assignments related to the ARM, then I would think that would be included in this task. I was thinking other elements that were listed by Caitlin.

If they have time between now and then, I don't think it's harmful. I think the biggest concern was, are we moving too quickly with a new model? I guess again, that might be up to the maker and seconder of the motion, are there other tasks included, and if so, we may need to revise this motion.

MS. STARKS: If I could add something, Mr. Chair.

CHAIR CIMINO: Yes, please, Caitlin. Go ahead.

MS. STARKS: I just want to kind of give everyone my perspective on what this would look like if this motion were to pass. As discussed, we would form a PDT. I think we have a pretty solid foundation for getting the addendum started, given that the ARM Revision is complete. We have recommendations from the ARM Committee and Peer Review for what is the best available science, and what should be modified from the old ARM Framework. I think the task that the PDT could work on between now and the next meeting, would be identifying what pieces of that might be decision points for the Board in the addendum, versus items that would just be updated automatically as part of the model. Things that are more technical in nature and wouldn't necessarily require a decision by the Board. Does that kind of give you a better idea for a sense of what we could work on with the PDT?

CHAIR CIMINO: Yes, absolutely. Again, you know there were some very important recommendations in my opinion in the Peer Review Report as well. Yes, I think that's a great way to lay it out.

MS. KERNS: Joe, you have Mike Luisi.

CHAIR CIMINO: Yes, go ahead, Mike.

MR. MICHAEL LUISI: Yes, I seconded the motion. I was planning to make a comment after I seconded that I liked the language that Caitlin used in her presentation regarding initiating the addendum,

and it included language, it involved the Peer Review and the other recommendations.

It was a little more clear as to painting a picture, not just for us today, but for anybody who is going back to read the actions that this Board took today. I think it would be more clear if that language was incorporated into this motion before we vote on it. That way that list that was generated in the presentation kind of sets that basis for what the PDT would start to look at, including the Peer Review recommendation, if that makes sense.

CHAIR CIMINO: I think it makes a lot of sense. I think it's a good potential addition. I think you know Robert's Rules better than I, so perhaps you or Toni could. Was that suggested to be like a friendly amendment to this?

MR. LUISI: Yes, when I raised my hand to second, I was going to make the point. But we jumped in. The conversation never came back. I raised my hand but then it came back down. I was going to ask John. Caitlin, there you go. That's the slide I was looking at. John, would use consider using the language below that Caitlin went through as establishing a little more detail in your motion? I would be happy to second that.

MR. CLARK: Yes, I'm fine with that, Mike. I assume that especially given Caitlin's follow up that the tasks that she had outlined there would be what the PDT was looking at. But I agree with you. To make it more clear what we're planning to do that would be great, I'm fine with that.

MR. LUISI: Yes, so I think that last part of that motion then, as recommended by the ARM Subcommittee and Peer Review Panel would fit in nicely with the motion that John made. I'm certainly willing to second that as well.

CHAIR CIMINO: Great, thank you, Mike, I really appreciate that. That was helpful.

MS. STARKS: Maya, could you put up the motion again. **I think just add, move to initiate an addendum to consider implementing changes to the ARM Framework as recommended by the ARM Subcommittee and Peer Review Panel.**

MR. LUISI: Perfect, thank you.

CHAIR CIMINO: What we have is a clarification and a more perfected motion. That was with the seconder, Mr. Luisi, and thanks again, Mike, for helping craft that next step, and Maya and Caitlin for getting that up there for us. I guess once again, with all of this new crafting, is there a discussion on the motion?

MS. KERNS: I see no hands.

CHAIR CIMINO: Okay, great, let's call this for a vote then. With no additional discussion I'll just ask, is there any objection to the motion?

MS. KERNS: I see no hands in objection.

CHAIR CIMINO: Okay, thank you, Toni. Caitlin, again, if you can help me on Agenda. Are we through down to Other Business, or is there anything else you need?

MS. KERNS: Before Caitlin says anything, can you just clear.

CHAIR CIMINO: I know, let's clear the decks. That is a text you should keep on hand for me is clear the deck. Do you need me to read it as well, Toni?

MS. KERNS: It would be great to read it, since I think it might have changed, and then if you could just say that it carries.

CHAIR CIMINO: That sounds good, okay. Move to initiate an addendum to consider implementing changes to the ARM Framework as recommended by the ARM Subcommittee and Peer Review Panel**. The motion was made by Mr. Clark, seconded by Mr. Luisi, and the motion passed by consent.**

MS. STARKS: Thank you, Mr. Chair. I do believe we are to the end of our agenda items.

CHAIR CIMINO: Okay, thank you. Any other business to come before the Board, and if we don't see hands, Toni, I do have one last thing.

MS. KERNS: I see no additional hands.

ADJOURNMENT

CHAIR CIMINO: Okay, so my last bit to add to the agenda is just to say goodbye as Board Chair. I will be turning the Board over to John Clark, so the Board will be staying in the hands of Delaware Bay members. I can't thank staff enough. I can't thank the RSF Committee and the Technical Committee, for all the hard work that has gone into this. Thanks especially to Kristen and to Caitlin and to Mike Schmidtke, if he happens to be listening down there. It was really great working with all of you. Good luck, John.

(Whereupon the meeting adjourned at 11:40 a.m. on Wednesday, January 25, 2022.)