PROCEEDINGS OF THE

ATLANTIC STATES MARINE FISHERIES COMMISSION

HORSESHOE CRAB MANAGEMENT BOARD

The Westin Crystal City
Arlington, Virginia
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Board Members

Dan McKiernan, MA, proxy for D. Pierce (AA)
Raymond Kane, MA (GA)
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David Borden, RI (GA)
Justin Davis, CT (AA)
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Maureen Davidson, NY, Administrative proxy (AA)
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Stewart Michels, DE, proxy for D. Saveikis (AA)
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Craig Pugh, DE, proxy for Rep. Carson (LA)
Michael Luisi, MD, proxy for D. Blazer (AA)
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Phil Langley, MD, proxy for Del. Stein (LA)
Pat Geer, VA, proxy for S. Bowman (AA)
Chris Batsavage, NC, proxy for S. Murphey (AA)
Jerry Mannen, NC (GA)
Robert Boyles, Jr., SC (AA)
Mel Bell, SC, proxy for Sen. Cromer (LA)
Doug Haymans, GA (GA)
Erika Burgess, FL, proxy for J. McCawley (AA)
Sherry White, USFWS
Chris Wright, NMFS
Martin Gary, PRFC

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

Ex-Officio Members

Staff

Robert Beal
Toni Kerns
Jess Kuesel
Mike Schmidtke
Kristen Anstead

Guests

Nora Blair, Charles River Labs
Sarah Blick, Assoc. of Cape Cod
Allen Burgenson, Lonza Walkersville, Inc.
Jon Hare, NOAA
Brett Hoffmeister, Assoc. of Cape Cod
Larry Jacobson, Hillsborough, NC
Wilson Laney, NC State Univ.
George Lapointe, Hallowell, ME
Arnold Leo, E. Hampton, NY
Willa Lerner, Blue Star Strategies
Jessica Lindgren, Blue Star Strategies
Mike Millard, USFWS
Samantha Underwood, Assoc. of Cape Cod

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, Wednesday, May 1, 2019, and was called to order at 3:15 o'clock p.m. by Chairman Joe Cimino.

CALL TO ORDER

CHAIRMAN JOE CIMINO: Okay we'll get started here. Good afternoon everyone; my name is Joe Cimino. I'll be filling in for the current Chair, Dr. Malcolm Rhodes. I have with me Doctors Anstead, Sweka, Schmidtke, and Jacobson. If that is not enough doctors to get us through this agenda, I think we'll need a TARDIS.

APPROVAL OF AGENDA

CHAIRMAN CIMINO: We'll start with Board consent. Are there any changes to the agenda?

APPROVAL OF PROCEEDINGS

CHAIRMAN CIMINO: Seeing none; you all have had a chance to review the approval of the proceedings from the October, 2018 meeting. Are there any edits or changes there? Okay seeing none we'll consider it approved by consent. This is the time traditionally for public comments on items not on the agenda.

What we will do is allow at a later point in time public comment on the stock assessment or the Peer Review of the stock assessment after those presentations are given. I realize we do have one signed up speaker for that. Just to let you know, we will do that after the presentations take place.

2019 HORSESHOE CRAB STOCK ASSESSMENT

CHAIRMAN CIMINO: Okay, so we'll get into the Benchmark Stock Assessment. We have our first presentation by, as I said, Dr. Sweka.

PRESENTATION OF STOCK ASSESSMENT REPORT

DR. JOHN A. SWEKA: Before I begin, I just wanted to thank all the other members of the Stock Assessment Subcommittee that are listed here, who have put in a tremendous amount of work over the past year, year and a half on this, also the Technical Committee, ARM Subcommittee, Delaware Bay Ecosystem Technical Committee, the Advisory Panel as well as the Management Board.

A little history of our Horseshoe Crab Stock Assessment, I kind of liken it to climbing a mountain. Back in 1998, we started off with a benchmark assessment that merely just had some trend analysis to it. In 2004, we continued with that trend analysis and then some regional meta-analyses. By 2009 that benchmark assessment, things got improved.

We had trend analysis, regional meta-analyses, auto regressive integrated moving average models, preliminary catch survey model, surplus production model was attempted and this was the beginning of the multi-species modeling for the Delaware Bay. However, in 2013, after the peer review of the 2009 assessment, we had to drop back a little bit.

The 2013 update just included trend analysis, regional meta-analysis, and the ARIMA models again. But here we are in 2019 now. I think we've come back up that mountain, adding to continued trend analysis with ARIMA a new catch multiple survey model, which is an extension of the Catch Survey Analysis. We've added discard estimates and we've now included estimates of biomedical mortality. Back in 2009, we did not have a formal set of reference points adopted by the Horseshoe Crab Management Board. We did see increased abundances in the southeast region and Delaware Bay regions but still declining abundances in New York and New England regions.

During the 2013 update, New England and New York still had declining abundances but we saw positive trends in the southeast and some also in the Delaware Bay. We realized we needed to start including biomedical mortality in our assessment, you know, and ideally at the regional level, which brings into question data confidentiality and the issues associated with that.

In this Benchmark Assessment we include biomedical mortality but we've also added something we've never looked at before, and that was discard estimates from other fisheries. We

still have our usual bait landings. We've also attempted more modeling approaches and a regional assessment for the Delaware Bay using a catch multiple survey analysis.

Management of horseshoe crabs began in 1998 with the fisheries management plan. And, over the ensuing decade a series of addendums that had essentially made a restricted bait harvest of horseshoe crab, more and more with each added addendum, or continued previous addendums. In 2012, Addendum VII was adopted by the Management Board.

This adopted the ARM framework for management within the Delaware Bay. Recommendations from the ARM framework were first implemented in 2013. This Adaptive Resource Management model takes into consideration horseshoe crab abundance as well as red knot abundance as input data.

The model ultimately results in the recommendation of one of five agreed upon harvest packages for management within the Delaware Bay. These harvest packages range from a full moratorium on both sexes to a maximum of 630,000 crabs at a two-to-one ratio as the most liberal harvest package.

Since 2013, since the ARM framework was first implemented, we've been recommending and implementing a harvest quota that had been 500,000 male-only harvest crabs in the Delaware Bay region. Current quotas along the coast and, you know, this table shows them, and in many cases voluntary state quotas are actually less than the ASMFC quota from 2017. In particular Massachusetts, New York, their state mandated quota is less than what ASMFC prescribed.
As far as biomedical harvest goes, there are no fisheries management plan limits on harvest. There are some state specific daily, annual, or seasonal restrictions. But, monitoring requirements were part of Addendum III and are annually reported to ASMFC in state compliance reports.

These requirements specify monthly and annual harvest percent mortality up to the point of release. Harvest methods, sex ratios of collected and bled crabs, and disposition of bled crabs and the condition of the holding environment of the bled crabs prior to their release. We have divided our stock assessment up into four different regions; and this has been consistent with previous stock assessments. We have the northeast region spanning from Maine down through Rhode Island, the New York region going from Connecticut down to the New York Bight, encompassing Long Island Sound. The Delaware Bay region from New Jersey down to Virginia, and then the southeast region everything from North Carolina southward.

Our regional breakdown is supported based upon genetic analysis of horseshoe crabs, as well as tagging information in the coastwide tagging database. This table here just illustrates how the majority of tagged and recaptured crabs are recaptured in the same general area as they were released but you do have some movement among regions.

Also, with the tagging estimates and the tagging analysis, we used those to come up with estimates of annual survival within a region. From this Cormack-Jolly-Seber model, we see estimates of apparent survival within a region. From this Cormack-Jolly-Seber model we see estimates of apparent survival vary across the regions.

It's highest in Delaware Bay at 76 percent annual survival, and it was lowest in the coastal New York, New Jersey areas at 62 percent. We get into coastwide bait landings. This is for the entire coast through the time series. You can see through management, horseshoe crab harvest for bait has greatly decreased through time.

The bars on this graph represent the breakdown between male and female harvest. In a lot of cases not all reporting in the landings was sex specific and that's why there is that gap between the bars and the solid line. You'll notice in recent years since 2013, the harvest has been predominantly males.

That is due to the implementation of the ARM framework within the Delaware Bay area that selects just for males. By region through time,

when we parse this out among our four regions, we still see that Delaware Bay contains the greatest amount of harvest relative to the other regions. The southeast is very little bait harvest. New York and the northeast region fall in between.

Here is a graph showing the Delaware Bay bait landings and again, you know we've definitely decreased through time as more addenda have been added. Again, you can see here in the most recent years from 2013 on very low numbers of female crabs are harvested. The females that are harvested as part of the bait landings come from Maryland and Virginia because not all of their crabs are of Delaware Bay origin, so there is some allowance there.

Moving on, one of the big things that we looked at within this assessment was biomedical mortality. Historically horseshoe crab management has assumed a 15 percent biomedical bleeding mortality rate on those crabs that are bled and then released. What we did was we scoured the literature of available studies that have looked at biomedical bleeding mortality.

From those published studies, we took all of their treatments and sample sizes and made a bootstrap simulation that randomly pulled values from these studies respective distributions of mortality, weighted by the sample size within each one of these studies. Through that bootstrap simulation process, we generated a new distribution of what the possible biomedical mortality rate could be. It just so happened coincidentally that it worked out that the mean of that distribution also ended back at 15 percent. But at least now we could also put some uncertainty on that. The rate, 95 percent confidence limits of that distribution range from 4 to 30 percent.

Along with the biomedical mortality, something that we examined was tagging information of those biomedically-bled crabs. We did a Cormack-Jolly-Seber analysis to look at survival of bled versus unbled crabs. The assumption going into this analysis was that due to bleeding there may be a decrease in long-term survival of the crabs that are bled.

Low and behold, we actually found the exact opposite of that, in that the bled crabs had a greater survival than the unbled crabs. This was particularly the case for female horseshoe crabs, so it was kind of a counter-intuitive finding that we found. Most likely the reasons for this is that the biomedical industry will select and only bleed crabs that appear to be in very good condition. Perhaps the reason for these results is the crabs that were bled are crabs that would have otherwise had a higher survival anyway, whereas the non-bled crabs were crabs reflecting both good and poor condition crabs within the entire population.

This graph, I'm sure you've seen this on the ASFMC's website. It just puts in comparison coastwide, the commercial bait landings compared to biomedical collections of horseshoe crabs and estimated biomedical mortality, applying a 15 percent bleeding mortality rate. As we see, between 2004 and 2011, the number of crabs that were collected for the biomedical industry, as well as the number of crabs that died because of the biomedical industry, you know, showed a steady increase.

But since 2011 it has stayed relatively constant. In terms of total mortality it's roughly about 70,000 since 2012 onward. Discards, this is another source of removals that was never really examined by the Stock Assessment Subcommittee in previous assessments. Horseshoe crabs aren't taken as bycatch in other fisheries; but they hadn't been quantified up until this point.

The Northeast Fisheries Observer Program, it's run by the Northeast Fisheries Science Center, collects data on harvested and discarded catch, gear, effort, and species and lengths and weight. This survey runs from Maine to North Carolina. It began in 1989, and horseshoe crab data actually within this survey began in 2004.

Horseshoe crab landings were very minimal in this data from several states, so our analysis of the discard data focused mainly on the Delaware Bay area, and was mainly used for input to the catch multiple survey analysis. Here are some estimates of total discards and then dead discards. We can

see the total discards in other fisheries increased through time as well, obviously, as dead discards.

I would like to say there is a lot of uncertainty in these data and it's something that we need to keep looking at to refine these estimates. One of the reasons why there has been an increase in the number of discarded horseshoe crabs is because harvest restrictions have become more and more stringent through time. On vessels commercial fishermen can't keep the horseshoe crabs they may catch as bycatch, they have to go back. This increase is really an artifact of our current management.

Moving on to fishery-independent data sources, we had a lot of data that we looked at. We tried to screen these data through a few criteria. Number one here you have a time series. Ideally we would like to have a time series of fisheries-independent data that goes for at least 20 years to accommodate the life cycle and life span of horseshoe crab. But, sometimes a 20-year period isn't available for many of our surveys so we recommended a survey for inclusion in any analyses to have at least ten years of data. Survey design, we tried to stick with surveys that had some sort of a statistical design, such as surveys with random stratified sampling. Gear, we included surveys that used gear that was set and operated in a space and time when they would likely catch horseshoe crabs and gear that were capable of catching crabs. Likewise with the spatial and temporal coverage. Methodology, we eliminated surveys whose methodology may have changed during the course of their time series.

This is a big list of all the surveys up and down the coast that we examined. This table is in the report and it gives an indication whether that particular survey was accepted for use or if it was rejected, and what reason it might have been rejected. Once we decided which surveys we would use, we pursued several different approaches as to how we would standardize the data.

We explored nominal geometric means, GLM standardization of the raw survey data. We attempted to break apart surveys into stage or sex if we could. You know this was especially needed for the catch survey model, which I'll talk about later. The problem with these approaches was that in many of our surveys we have a high proportion of zero tows in most surveys, which made standardization very difficult.

In the end we decided to use a delta distribution for the mean and variance of each survey for each year. This sort of method is also used by the Virginia Tech Trawl Survey in the Delaware Bay. The use of the delta method can lead to more efficient estimators of the mean and variance, because zero tows, zero catches are treated separately, and positive observations are drawn from a log normal distribution. The final estimate or index of abundance are obtained from the product of the proportion and mean for non-zero tows.

In the analysis of trends we had two approaches: one is a method by Conn 2010, and the other was what we've been using as autoregressive integrated moving average models.

In the Conn method several abundance indices are combined into a single composite index using hierarchical modeling and this assumes that each index samples relative abundance, but is subject to both observation and process errors. The autoregressive integrated moving average models or ARIMA models. These derived fitted estimates of abundance over the time series for each survey individually. This minimizes the measurement error and ultimately we can estimate the probability of being less than some index-based reference point. The index-based reference points we've chosen, and we've used them in previous assessments, were the 25th percentile of the fitted index values, and also the 1998 fitted index value. The reason for using 1998 as a reference point was because that was when the FMP was put in place. It kind of tells us where we stand relative to when active management began.

Moving on, here I'll show a series of graphs for each region. Just depicting the ARIMA fits, and on each one of these graphs, the blue horizontal line represents the 1998 index-based reference point, and the red horizontal line represents the 25th

percentile reference point. Here for the northeast, a few surveys.

The Massachusetts DMF Trawl Survey north versus south of Cape Cod, the north survey doesn't show much of a trend, and that survey also rarely catches horseshoe crabs. You can see a lot of zero values in there. South of Cape Cod we do see an increase over the last five-year period, to where it's actually above the 1998 index-based reference point.

The New Hampshire spawning surveys for males and females, they don't extend to 1998, but have shown somewhat of a decline. Then, a conflicting survey is the Rhode Island Monthly Trawl Survey in and around Narragansett Bay has shown a rather steady decrease through the time period.

If we combine all these surveys into the Conn Index, or the two trawl surveys, you know we see very wide confidence intervals on that index coming from the Conn model. This is because we have two conflicting surveys that show opposite trends. Moving down to New York, the results are a little more consistent across surveys and, in general, all of our surveys in New York show a declining trend except the NEAMAP in the fall.

But the NEAMAP time series doesn't extend very far back into time. But the Connecticut/Long Island Sound Trawl Survey, Seine Surveys in Jamaica, Little Neck and Manhasset Bay's all decline, as well as the Peconic Bay Trawl Survey have all declined and continue to decline. As we combine all these surveys into the Conn Index, we can see kind of a steady decline through time.

On Delaware Bay is where we have the majority of our fisheries independent surveys. This slide looks at the Delaware 30-foot Trawl Survey that is conducted within Delaware Bay and we see in both the fall and the spring for males and females. We saw a declining trend through the 1990s. It kind of bottomed out in the mid-2000s and in the last five to ten years it has been steadily increasing.

Other surveys include the Delaware Bay, or the New Jersey Surf Clam Dredge Survey. That survey has shown an increasing trend consistently through time since the early 2000s. Unfortunately this survey has ended, and changed methodologies in 2012. That is why we don't have more recent data.

Along Maryland's coastal bays, things have just kind of been going up and down without a consistent trend and the NEMAP Survey from the fall doesn't have that many years of data, and we don't see a definitive trend in that. New Jersey's Ocean Trawl Survey, kind of conflicting trends whether you look at the data from that survey, whether it's in the fall versus the spring. The spring version of that survey shows an increase since 2010 in both males and females. However, the fall showed a declining trend and then kind of a leveling off throughout the time period.

The reason the bottom two figures here for spring female and spring males from the New Jersey Ocean Trawl Survey don't have a blue line for the 1998 reference point is because this survey didn't start partitioning sexes until 1999.

Here we have the Virginia Tech Survey, which is the only survey along the coast that actually targets horseshoe crabs. We've seen some ups and downs through 2010. Then from 2012 to 2015 the survey lost funding so there is actually a gap in data over that time period. Then it began again in 2016. We've seen some ups and downs but in the most recent years it's much higher than that 25th percentile reference point. The Delaware Bay Index from the Conn Model, when you combine all of these we generally see the declining trend through the 1990s, a low point in the mid-2000s, and then somewhat of an increasing trend towards the end of the time series with fairly wide confidence intervals on it as well.

Moving down to the southeast region finally, various surveys from Georgia, North Carolina, South Carolina, well what we saw here is fairly consistent with previous assessments was an increase in the early part of the time series, and then somewhat of an increase or a stabilization in more recent time.

That is kind of reflected also in the Conn Index for the southeast. You can see an increase in the mid

to late 2000s, or 2010, and perhaps even a leveling off or somewhat of a decrease in the most recent years. To kind of summarize the ARIMA models, we considered those surveys that had a terminal year in 2016 or 2017, the residuals from their ARIMA fits were normally distributed and combined sex surveys, because we didn't want to summarize based on surveys that were split into male versus female, to try to avoid double counting a particular survey.

What we're looking at here is the probability of an index-based reference point being either less than the 1998 fitted value, or the 25th percentile of the fitted values, and if that probability is greater than 50 percent. If it's greater than 50 percent that's good. That means that survey is fairly likely to be less than the reference point.

In New England we have one out of two surveys less than the '98 reference point. New York, things don't look very good. All four out of four surveys were less than the 1998 value, Mid-Atlantic, which would be Delaware Bay, two out of five and the southeast, zero out of two that fit these criteria for inclusion in this summary.

Then we also had the corresponding number relative to the Q-25 reference point. Some other assessment methods that we looked into and applied, the first one was a surplus production model using ASPIC from the Northeast Fisheries Science Center toolbox, and also an index method. Now from the previous 2009 assessment, one of the recommendations from the Peer Review Panel was to develop an operating model to make some simulated datasets and to test the surplus production model. We did that and found that the surplus production model just did not adequately account for the complex life history of a species like horseshoe crab; that has a late age maturity and lives a long time. That one was abandoned and the Index Method, we had high hopes for this. It's a relative F method that can ultimately give you some reference points to target your fishery at. We also tested that with the operating model and found that it couldn't accommodate the complex life history of horseshoe crab, so it was abandoned as well.

Now the operating model was used to generate some simulated data which was ran through the catch multiple survey analysis and it worked. That model accommodates the life history of horseshoe crab so we then moved forward with running the catch multiple survey analysis for Delaware Bay female crabs only. The underlying model for the catch multiple survey analysis is shown here and it takes into account the number of fully recruited animals or multiparous females and the number of newly recruited females, or primiparous females.

The way you can tell the difference between a primi and a multi parous female is just by looking. They're both sexually mature, both possess eggs, but a multiparous female will have marks from where it had previously spawned, when the male is in amplexus with it the previous spawning season.

Within this model we have the number of multiparous and primiparous females, natural mortality, the catch and it just gets decremented from one year to the next. We ultimately end up with an estimate of the multiparous animals in a given year. Just two graphs with some of the input data going into the catch multiple survey analysis.

These are the removals. The top graph here shows the bait harvest of female crabs within Delaware Bay, and how that has changed through time, and you see it has greatly decreased through time and in recent years, and then also our estimates of dead discards for Delaware Bay. Now again, this is female only.

The interesting thing is, because of our active management in Delaware Bay that targets only male harvest the dead discards are actually a greater removal than what the bait harvest is for females. The bottom graph illustrates the removals due to biomedical bleeding and you'll note that for confidentiality reasons I've left the Y axis off of this graph.

I won't say much more about that other than the trend has increased since 2004, when reporting of biomedical became mandatory to ASMFC. The fishery independent surveys that went into this were the Virginia Tech Swept Area Estimates,

which are broken down by primiparous versus multiparous animals.

You can see, you know, it's fluctuated through time. But, once the survey came back online you know we see an increase from 2016 and 2017 relative to where it was when the survey ended in 2012. Other surveys that were included as tuning indices were the New Jersey Ocean Trawl, and the Delaware Bay 30-foot Trawl from the spring. Base model parameters are given there. We assume the natural mortality of 0.274, which was based upon our tagging results that showed, this is an instantaneous rate, our tagging results showed a corresponding survival in Delaware Bay at 76 percent annually. Then model weights, these came from the Conn Analysis that we did. One aspect of the Conn Analysis is that it can give certain surveys a given weight, you know, depending on how much variability it explains in the survey.

The Virginia Tech Survey carried the greatest weight. Starting values were 2 million recruits, or primiparous females, 3.6 million multiparous females, and then some starting values for the catchability of the Delaware and New Jersey Trawls, and then S was the selectivity between Delaware and New Jersey.

We assumed that there was equal catchability for pre-recruits versus fully recruited animals. Then our base model was run assuming a 15 percent biomedical bleeding mortality. Fits to the individual surveys. The individual fits weren't great. They captured the general trends that we see, so they weren't great but they weren't terrible either and they do capture the general trends.

Ultimately in the end, these two graphs depict what we estimate for instantaneous fishing mortality and number of adult females within the Delaware Bay population. You'll note again for data confidentiality reasons I've left off the Y axes on both of these graphs. I will say that fishing mortality has decreased through time on Delaware Bay females and abundance has increased, especially in the most recent years.

One thing you'll note is the very large confidence intervals from 2013 through 2015 in our abundance estimates. The reason why we had these large confidence intervals is because we were missing the data from Virginia Tech during those years. This also illustrates the importance of that Virginia Tech Survey in our assessment to gain better estimates of abundance.

I will mention to that if we just look at the raw Virginia Tech data, the minimum swept area estimate was 8.6 million total female in 2018. We did a lot of sensitivity runs of the catch multiple survey analysis varied starting values of R, N, and Q, looked at our assumptions about natural mortality, the survey weights, survey CVs, the primiparous, the multiparous selectivity, percent biomedical mortality.

We varied that all the way from zero up to our 95th percent confidence limit of 30 percent bleeding mortality. We looked at the inclusion versus exclusion of dead discards. Also, the inclusion or exclusion of years when the Virginia Tech Trawl Survey did not operate. Due to confidentiality issues I can't show all of the sensitivity results but I will say, in general, the model outputs were very robust.

Biomedical mortality bleeding rate had very little effect on the outputs. The greatest sensitivity of the model was to freely estimating Virginia Tech Survey catchability, and also the weights that we had prescribed to each one of the surveys. This graph just shows you a retrospective analysis, again with the Y axis left off.

You see for the most part we don't have any retrospective pattern except during the years when the Virginia Tech Trawl Survey did not occur. Otherwise, the retrospective pattern looks great. Reference points, one of our terms of reference tasked us with developing reference points. We tried to develop reference points for the Delaware Bay. One method was based on a theoretical population projection model and this was to try to estimate a number at MSY and an F rate at MSY. Then, we also looked at yield and egg per recruit models for the Delaware Bay. Both of these

methods were ultimately considered not suitable for management.

The yield in egg per recruit models gave us reference points that just did not make biological sense; and the big reason for that, you know, the problem with horseshoe crabs is that the adults have a greater mortality than the juveniles, and that's because natural mortality increases once the adults start to come up on the beach. You know they're subject to being overturned, subject to more avian predation. That kind of basically wrecks any kind of a per-recruit analysis; and also the fact that once a crab is mature it has a terminal molt and does not gain in size anymore. If it doesn't grow in size any more than its fecundity isn't increasing; or its weight is not increasing, which is problematic for both yield and egg per recruit models.

The population projection model reference points, you know, the Peer Review Panel thought that they may be biased because they were developed outside of our actual assessment model, and recommended that we don't do a direct comparison between the catch survey analysis results and output numbers of abundance or fishing mortality estimates. But the Peer Review Panel said that they could be useful for other management purposes, perhaps to put things into context. The ultimate management recommendations for the use of reference points is to use the 1998 index based reference point from the ARIMA models to determine stock status.

In doing this, you know again, that summary that I showed from the ARIMA results, we looked at the time series of surveys that had a time series that extended back to 1998, combined sex surveys, residuals from the ARIMA fits were normally distributed, and the terminal year of that survey was either 2016 or 2017.

We came up with a rule kind of a stoplight approach to determine status, based on the percentage of surveys within a region having a greater than 50 percent probability of their terminal years fitted value being less than the 1998 index-based reference point. A poor status was given to a region if greater than 66 percent of the surveys fit those criteria.

A neutral status was 34 to 65 percent and a good status was less than 33 percent. In the end, if we look at the column on the far right or the two columns on the far right for 2019, in the northeast we have a neutral status. In the New York region we have a poor status, Delaware Bay a neutral status, and the southeast a good status, overall for the coast a neutral status.

You know, if we apply these same criteria to the results from the 2009 benchmark assessment and the 2013 update assessment just for relative comparisons through time. One thing you'll note is the numbers of surveys included in each one of these assessments has changed. Earlier in 2009, we included every sort of survey that we did, whether that individual survey was split by sex and stage and so on. There is probably some double counting of a survey within a region. We've also changed the actual data that was used in the ARIMA model because before we just used whatever index a particular state calculated for a survey. This time we standardized them all using the delta method. But we still show these just for comparison and a thing to note on this is, you know, New York is the problem here. It started out green, went to yellow, and now it's down into red.

Taking a closer look at the individual surveys that were included in this summary, I show here the most recent five and ten year trends for each survey within each region. In the northeast, you know, we have conflicting trends between the Massachusetts Trawl Survey and the Rhode Island Trawl Survey. One is going up, one is going down.

In New York very consistent trends, especially over the past ten years, all of these surveys are trending downward. Delaware Bay, individual surveys are either trending upward or are stable and, likewise in the southeast, things are either trending up or at least stable in the last five to ten year period.

One of the other terms of reference we had to address was a comparison of this stock assessment to the adaptive management framework within Delaware Bay. Really it's kind of comparing apples

and oranges. I put this table together to try to illustrate this. You know the bottom line is there are different management objectives.

You could use a coastwide stock assessment, single species, you know, to ultimately arrive at a maximum sustainable yield or to try to stay greater than the 1998 index-based reference point. Whereas, in the adaptive resource management model, we also want to maximize yield, but maintain ecological function.

Ultimately we are constrained by the needs of shorebirds. The model types, you know, the coastwide assessment we can work with a single species model just for horseshoe crabs; under the ARM it's a multispecies model that has theoretical models of both horseshoe crab dynamics as well as red knots.

Management triggers, you know, we could have our typical FMSY, BMSY, or index-based reference points under the coastwide stock assessment, whereas under the ARM we have threshold values that change what we might do. These threshold values are based on red knot abundance of 81,900 birds, or female horseshoe crab abundance of 80 percent of a theoretical carrying capacity, which equals 11.2 million.

Under the ARM framework the harvest of female horseshoe crabs doesn't have any value or utility until these threshold values are met. Our status conclusions, you know, under a typical coastwide stock assessment, you would want to ultimately come up with not overfished or overfishing is not occurring.

In this case because we're using the 1998 index-based reference points, we would say for Delaware Bay it's a neutral status. Under the ARM the thresholds for each species aren't met, therefore female harvest is not valued. Management recommendations, depending on reference points, female harvest could increase in Delaware Bay; whereas under the ARM we would still be at a continued male-only harvest. I also put a big question mark there if female harvest could increase. Like all stock assessments, at the end we have a number, a myriad of future research recommendations. I'll just summarize those here, broken down into future research, data collection, and assessment methodology.

For future research we would like to have some more information on life history, movement, habitat associations of horseshoe crabs. You know, what effects climate change may have on population dynamics, and then better evaluation of spawner surveys and how we might improve those to be used in future assessments. Data collection, it would be nice if more surveys had standardized stage-based methods of bio-sampling.

It's easy enough to look at horseshoe crab and tell whether it's a primi or a multiparous animal. We also need some more gear efficiency studies for the Virginia Tech Trawl Survey; expand surveys out beyond Delaware Bay that have similar methodology and gears to the Virginia Tech Trawl Survey, and you know, some continued evaluation of biomedical mortality.

Future assessment methods include further development of the catch multiple survey analysis, continued tagging analyses, and a possibility of once we have enough data, perhaps moving or including or exploring a delay difference model. Ultimately, we think that we would recommend the ARM use of the catch multiple survey analysis population estimates.

Our overall conclusions from this assessment, the catch multiple survey analysis provides the most accurate estimates of abundance to use as input to the ARM for the Delaware Bay. We should definitely maintain and continue to pursue funding for the Virginia Tech Trawl Survey because really that survey drives the catch multiple survey analysis.

We should consider management action in New York; given its poor status and continued declining trends. It seems each time we look at the New York region, you know, each one of our assessments paints a worse and worse picture. We should also continue to monitor in the northeast. We don't have much data in the northeast and we have conflicting trends, you know between that

Massachusetts Trawl Survey and Rhode Island Trawl Survey, so continue to take a close look at that area.

Then ultimately the population impacts of biomedical bleeding are probably minimal, given the sensitivity analyses that we ran with the catch multiple survey model, and you know, the robustness to changes in our biomedical assumptions within that model. It really had no impact on output values.

Finally discard mortality may be a significant factor, you know, and it could be greater than bait harvest in recent years for the Delaware Bay, at least for females it looks like it might be. That is something that we need to get a better handle on. This is the first attempt at it. We need to get a better handle on discards and continue to improve our estimation of discard mortality.

The next assessment on the SAS recommended an update in five years and a benchmark in ten years. The Peer Review Panel recommended a benchmark in five years due to the potential for improved discard estimation and model updates that could significantly affect the stock assessment.

PEER REVIEW REPORT

DR. SWEKA: With that I think we'll move to the Peer Review Panels.

CHAIRMAN CIMINO: Go ahead, Dr. Jacobson, and thank you, John.

DR. LARRY JACOBSON: Well my Momma told me, she said Larry whenever you're going to give a presentation make sure you show some leg. Here it is; and I hope that helps. It gets me right to my joke. Lying in bed last night I get a phone call and there is a voice on the other end that says; this is a voice that sounds like John Sweka.

He said make sure you wear shorts tomorrow; no jacket, and a dirty tee shirt. He said it's very informal. I said, I just did the laundry, sorry no tee shirt but I can handle the rest. I hung up and went to bed, got dressed and came in this morning. The moral of the story is the smart presenter is the guy with the long pants.

I chaired the Horseshoe Crab Stock Assessment Review Report and I chaired the Committee. As you know, you know everything on this slide. The Horseshoe Crab Technical Committee and Stock Assessment Subcommittee reviewed their stock assessment then we had a review meeting. Our scientific review was focused just on the science, data inputs, model results and so forth.

We had terms of reference and we tried to follow them quite closely. We had no interest in policy or any other controversies. We had access to all of the data, so the review panel was not limited to the publicly available data. We had access to all the data, including the details from the biomedical industry and we saw the actual catches, the landings, all of it.

There were three of us and it was a good team, a good review team, myself excepted. We had myself, we had two other people, we had Ruth Carmichael, who is a very well-known and very well respected horseshoe crab biologist, as well as many other things, and we had Matt Cieri, who works at the Maine Department of Marine Resources, and he's a widely experienced stock assessment biologist, does a lot of review work.

I used to work at NMFS. I was a Chair of the Invertebrate Subcommittee and worked there for about 30 years. Basically, from our point of view it was a sound assessment. It provides the best available information. It should be used by managers. The information is sound. It doesn't go beyond what it can justify, and so forth.

We were pretty happy with it after some discussion. We thought the assessment team was also a very fine team. They were all capable but even more important they were cooperative, and they worked really diligently to improve the assessment. The assessment work was well documented. We appreciated that.

Here are our first terms of reference. We were supposed to consider whether all potential data sources were considered, evaluated, and selected

correctly and we believe they were. In particular, as John described, the process for including or admitting surveys was clear and satisfactory and reasonable. It appears that the biological sampling for horseshoe crab, sex, length, things like that in the commercial fisheries and the other fisheries is less than you would find in most other fisheries. But it was adequate for the assessment at hand; because very little could be done with the catch data, given that there was so little information about discards. But in the future it may be important to have more information about the biological characteristics of the catch.

We believe that the analysis that was done supports that 15 percent bleeding rate. As a result of that 15 percent bleeding rate, you know to get the biomedical losses, the dead crabs due to biomedical harvest, you have to take the biomedical collection; I think they like to call it, which you guys don't get to see, multiply it times 15 percent, which is the fraction that died, and then you get the number of crabs that may have died in the biomedical end by sort of multiplication. Consequently, when you do that, you see that the biomedical losses based on that 15 percent mortality rate are always less than 13 percent of the bait harvest.

Now, maybe they've got the biomedical harvest mortality rate wrong by a factor of two and 30 percent of them die. Even so, you would still have biomedical mortality of less than 26 percent. But we're comfortable with the 15. We're comfortable with the idea that the losses, in terms of dead crabs to the biomedical industry is about 13 percent, never more than 13 percent of the bait harvest.

We're going to suggest that this bleeding mortality stuff is no longer a major uncertainty. It seemed to us that there was too much time devoted to it in the assessment but, of course, you didn't have the results of the assessment when you formulated the terms of reference. The bleeding mortality is no longer a major uncertainty, given the relatively small biomedical take, the 13 percent and the comparison to bait landings, in particular discards.

Now it is discards I'm going to hit over and over and over again. The discard estimates were made for the first time; there were questions about how they were done. There was some more work done at the meeting and so forth and most attention was focused on Delaware Bay for discards. But it's potentially, it's possible, that the discards are as large as the combined mortality in any of the other fisheries.

All of the other fisheries put together could be higher than that or could be lower than that. There is a lot of uncertainty but it could be a major source of uncertainty, a major source of mortality. I think that is probably where you could devote whatever energy you have for horseshoe crabs in the near term in terms of research and so forth.

This is a slide that shows, that is meant to make the point about the biomedical losses relative to bait. The top slide shows for the whole coast in actual numbers, millions of horseshoe crabs. It shows the bait landings, it shows the biomedical collection, which is green, and then if you apply the 15 percent mortality rate to the collections, you get the biomedical mortality.

That is the little red knobs going along the bottom. You can see they're small relative to the bait landings; and that's not to criticize the bait landings, it's really only to say that it appears the biomedical stuff isn't that important. The bottom slide shows the dead discards estimated for the Delaware Bay region, just the Delaware Bay region, and you can see that it's got confidence intervals. The confidence intervals are pretty wide. But who knows what's going on anywhere else?

Here are our review findings: Recommendation 1, estimate those discards. See if you can estimate discard mortality too. We've got the discards, which have to be estimated based on fishery observer data, the so called NEFOP data. Then you've got to estimate the discard mortality rate, which we worked on here, and probably didn't need to make it into the slide. But we like to do it on a regional and a whole stock basis if we can.

Recommendation 2 is to add discard estimation experience to the Assessment and Management Teams. Now this discard estimation stuff is an art. You have to understand the fishery, you have to

understand the horseshoe crab fishery, horseshoe crabs, you have to understand the fisheries that might intercept horseshoe crabs, and you have to understand the data bases. You have to understand the history of the databases. You really do want to get some experience in doing it into the Horseshoe Crab Assessment and Management Teams. I think that it would be reasonable to allow the ASMFC staff to access the discard databases directly. That would be very efficient if you can manage. It would be a good idea to provide them with some training to shave a few years off of the process of learning to do this discard estimation and to do it more accurately.

Back to the TOR, evaluate the methods and models. The ARIMA model as used here and was actually used previously, are good models for horseshoe crabs under the circumstances. They may appear simple to you but they are objective. There is not much to argue about in connection with them. They are well grounded statistically, and they make best use of the available data, which are the surveys. They are robust to uncertainties about catch because they don't use them. No estimates of natural mortality involved and so forth. I think a practical business person working in their own interest would not hesitate to use information like this to track what's going on with their business.

We like the catch-multiple-survey analysis. We believe that they provide the best available estimates of abundance in F and they provide reasonable estimates for Delaware Bay females only. However, there weren't any comparable reference points available in order to do a sort of overfishing/overfished determination for just the Delaware Bay. We recommended not doing it. It didn't seem necessary because we had the ARIMA models to fall back on and the ARIMA models were being used elsewhere.

There were some other reasons as well, and I'll go into them if you would like. But it seemed fine to us to use the Collie-Sissenwine model the CMSA estimates for other purposes besides comparison to reference points. There was a theoretical population model that John alluded to and it was a nice piece of work, but it wasn't comparable to any of the other models we had either. We didn't make much use of it. However, there was one major result and it seemed to estimate that FMSY was less than 0.1 that is to say low, which would indicate that the horseshoe crabs are not really resilient to much in the way of fishing. You know, with an FMSY of less than 0.1, so less than 10 percent per year to get maximum sustained yield. Recommendation 3: calculate the reference points and projections within the Collie-Sissenwine model, I'm sorry, the Catch Multiple Survey Analysis model or other assessment model for comparability. You should compare apples to apples. The reference points should come from the same model that you used to compute the stock status, you know, the abundance or the fishing pressure. That goes for projections too. If you're going to do projections, do the projections inside the model that you're using for the rest of the work. That way you don't get into an "apples to orange" comparison when you're making the estimate in 2018 based on one set of assumptions, and doing the projections based on another. We believe you should continue to improve that catch and multiple survey analysis. We thought it was a big step forward and particularly for use in other regions and for both sexes, because remember we've only used it for females in Delaware Bay.

TOR 3, does this work? Can you guys hear me okay? I feel myself turning away.

Evaluate the diagnostic analyses performed, including sensitivity and retrospective analysis. There was no shortage of sensitivity and diagnostic analyses. We had residual analyses, identified poor ARIMA model fits, and they did some historical analysis to demonstrate that the ARIMA was pretty stable between assessments. It inspired more confidence than uneasiness. It appeared to be a good way to go. They did a historical retrospective with that new 33 percent/66 percent status method that he showed you; and there were some changes over time in the number of stocks that were below the 1998 reference point, but they seemed reasonable, those changes seemed quite reasonable given the trends in the surveys and so forth, and the changes in the number of surveys that might have been used in each assessment. They did a lot of

sensitivity analyses with the CMSA; and they were robust, no retrospective patterns to speak of and so forth.

Recommendation 5 goes back to the CMSA and this is something that John alluded to. One of the reasons the CMSA model in Delaware Bay is so stable is because they assumed that the Virginia Tech Survey catches 100 percent of the crabs in the path of the net. It's probably a pretty good assumption for that survey because it's a net, and it's a survey designed for horseshoe crabs. But it's probably not quite 100 percent. It would be a good idea to go back and do some field experiments, go out there and drag that net over the heads of a bunch of horseshoe crabs, and see exactly what fraction you actually do collect. That would be worth doing.

However, even with that criticism we were comfortable with the estimates from the Catch Multiple Survey Analysis, the CMSA. All right, what else have we got here? Evaluate methods used to characterize uncertainty in model estimates. This is all fine. The ARIMA model fits used standard statistical approaches; which are quite good. You can eliminate that second bullet. Well the first part of it is true. The nice thing about the ARIMA proposal and the business about using the reference point from 1998 is that you automatically include uncertainty in both the estimated trend, and also where the reference point is. If something is done to make the survey run high, the reference point goes high, too, because they're linked together. That is why you like to take them from the same model. They move up and down together and if there is any bias they sort of cancel.

The Catch Multiple Survey Analysis, standard sensitivity analysis and standard variance calculations, it's all fine. Recommend the best estimates of stock biomass, abundance and exploitation from the assessment for use in management. We say use the relative abundance from the ARIMA models, the 1998 reference point and the 33/66 percent method to determine stock status.

As it happens, we can't calculate exploitation measures from the ARIMA model or from any other approach; short of the tags, because of all that uncertainty about discards. You know until you get the discard numbers nailed down, the discard estimates nailed down, it's very difficult to say anything about how much fishing pressure there is or what the trends in fishing pressure have been like.

We don't believe the CMSA should be used for status determination at this point; for the reasons I alluded to. But they are suitable for use for other purposes, like that ARM model. The only other thing is that even though we don't want you to make a comparison of the CMSA to the reference points, for example from some other model.

It was pretty clear to us looking at the CMSA results, these are results that you can't see that the fishing mortality levels are very low there. It's extremely unlikely, I think extremely is fair, extremely unlikely that there is overfishing occurring in the Delaware Bay area in the FMSY sense. What I'm saying is it is very likely that fishing mortality, particularly for those females, is lower than FMSY, probably quite a lot lower.

Evaluate the choice of reference points and methods used to estimate them; recommend stock status determination. Panel conclusions, use relative abundance in 1998 from the ARIMA models as abundance reference points, and then use that 33/66 status method to combine results from multiple surveys at regional and whole stock levels.

The multiple surveys, for example in the Delaware Bay area, you might see that as a disadvantage. It is certainly more convenient for stock assessment people; when you can treat any survey anywhere in a region of being a replicate of the other ones. However, for horseshoe crabs it seems to us that there probably are different population dynamics in different bays and areas within a region.

It just isn't necessarily a good idea to assume that they are all the same. We see it as sort of a strength in this assessment that it really does include the realism of different trends and different regions. Recognizing the need to

combine these surveys a little bit to get enough data to actually do something. We think that this apparently primitive looking technique is probably quite reasonable under the circumstances. Review and prioritize research recommendations. Estimate discards and discard-mortality rates by gear. Make discard data and expertise more available to plan and assessment teams, that is our biggest take-home. The second one and this is not a small point either is that there are a lot of surveys. What we think is that it would be good to take some of those survey programs, and if it's feasible, do a better job of collecting data from the horseshoe crabs that are taken.

In other words, count them, measure them, sex them, and do it sort of consistently and on a routine basis so that, over a certain period of time, we might collect better data for the stock assessment and might make it easier to apply these catch multiple survey analyses and so forth and so on.

There is a lot of survey work out there. There are a lot of surveys in this assessment. But they don't all track horseshoe crabs equally well. Perhaps the people in charge could get together and decide to regularize the collection protocols or something. That is one thing we think you guys should do as a matter of some priority. In other words, coordinate collection across survey programs.

Continue that Virginia Tech Horseshoe Crab Trawl Survey. They managed to bring it through with those three years of missing survey data. But if they had been any closer to the end of the survey series they might not have; things might have become too imprecise. We think you should keep that survey going and operated on an annual basis if possible.

Then keep up the good work on the stock assessment models and so forth. Timing of the next assessment, from our point of view, and this is one of the two areas where we had some discussion and a little bit of disagreement, at least initially with the Assessment Team. We would see, ideally, another benchmark stock assessment in five years because of the discard questions.

It seems possible to us that the information about discards might be such that you would want to consider different management approaches, particularly to manage to reduce discard. It might be that the discard is occurring in certain fisheries at certain times of the years in certain areas, for example. It might be that the actual fishery-induced mortality is twice what you think it is.

Maybe that will help explain what's going on in New York. That kind of work is more along the lines of a five-year timeframe. We also think, and of course this is none of our business, it's yours, that it would be prudent though to start work on the discards soon, because you know you'll start talking to the NEFOP people.

The NEFOP people are short on resources. They'll start arguing with you about whether it's the best use of available resources. You'll go back and forth. You'll come to some sort of a compromise. It may be that the protocols that are used to collect the observer data will need some adjustment and that will take some negotiation too.

You know, John Hare will have to talk to folks and so forth. It will take a little time for the discard question to percolate into the culture, into the horseshoe crab culture. Maybe display some of the biomedical mortality questions. You know we've got to get people sort of thinking along a new track, at least for a little while. If you were going to do an assessment in five years, considering the cultural change that's required, considering there may be training involved to bring the team staff up to speed, to get use to the databases, to make changes to the data collection protocols that we think it would probably be a good idea to start on the discard estimation soon. I think that's my last slide. Have you guys got any questions for John?

CHAIRMAN CIMINO: Okay let's get started. Roy Miller.

MR. ROY W. MILLER: Thank you Dr. Jacobson and Dr. Sweka for your fine presentations. I have a question concerning the discard loss. I don't remember if you mentioned the sources of potential discard mortality, but in Delaware Bay

you have a gillnet fishery, you have a conch dredge fishery, you have a crab dredge fishery.

Other than that, the only other source of discard loss, if you want to call it that, might be commercial dredging operations from main channel deepening. Do you have any feeling for the relative importance of those potential sources of discard mortality relative to each other?

DR. KRISTEN ANSTEAD: I will answer that question. As part of the NEFOP dataset we did have the commercial trips in the Delaware Bay states for all fisheries and if they kept horseshoe crabs, if they discarded horseshoe crabs what the gear was, what the state was. We could look at that and the discard estimates were actually performed by gillnets, midwater trawl, and bottom trawl, and dredge separately.

Those estimates were made separately for each of the three gears and different mortality rates were applied to each of those gears. We used 50 percent for trawl and gillnets and 5 percent for dredges and the scale of the discards from those fisheries did vary by gear and by state. That was all taken into consideration as part of those estimates, but certainly more work can be done to fine tune that as Dr. Jacobson has indicated.

CHAIRMAN CIMINO: Follow up, Roy.

MR. MILLER: Please. Of those sources do you have a feeling at this point in time which one might be the most important source of discard mortality in Delaware Bay, considering the volume of course of each of those activities?

DR. ANSTEAD: I hesitate to point the finger at one thing because the dataset isn't designed to capture horseshoe crab discards. Dr. Jacobson has indicated that maybe we need to kind of talk with NEFOP about how we could get this dataset to be better for horseshoe crab but there were some years of just massive dredge catches.

But we only assigned a 5 percent discard mortality to the dredges, thinking that the horseshoe crabs might sustain being caught in a scallop dredge, for example. Some of those peaks that you see in the discard are just a really large haul in one year of horseshoe crabs in a dredge fishery. But I think consistently the trawls maybe caught the most. But again the dataset is not designed for that. We need to do some work around it.

CHAIRMAN CIMINO: Okay, Jim Gilmore.

MR. JAMES J. GILMORE: I've actually got two questions but the first one is for John. Are there any conclusions or even speculation as to why we are seeing this rather odd thing, where we have a decline in New York but either stable or increasing things around us? The second question then I'll just put it out. I'm not sure who could answer it. But when did the New Jersey moratorium, what year did it start?

DR. SWEKA: To your first question. Yes, it is very odd that New York continues to see a decline. You know, your allowed quota from ASMFC has declined. Then at the state level you take less than half of that. There is no biomedical collection or mortality going on in New York. The two hypotheses that could still explain the continued decline are one, either what little bait harvest is allowed is still too excessive, or their habitat has changed.

That would take some additional research into the areas around New York to see if the amount of available spawning habitat has changed, if water quality has changed. But it is strange that given the reductions in harvest and no biomedical, it's hard to point the finger at that as the leading cause. To your second question, when New Jersey's moratorium went into effect, it was 2007.

DR. JACOBSON: John, there is the discard hypothesis, too. Intense fishing in a variety fisheries around the New York region, plenty of discard and so forth.

MR. GILMORE: Just a follow up, and I think there is a fourth reason and it might be illegal harvest. Just so we have that on the table. We've seen quite a bit of enforcement action on this fishery because of the supply and demand issue with once we get closures in other states the price goes up and the supply goes down. Demand goes up, price

goes up. Anyway, we're thinking that has something to do with it also.

CHAIRMAN CIMINO: We've got Mike Millard, Adam Nowalsky, and then Dan McKiernan.

DR. MIKE MILLARD: Thank you gentlemen for both of your very thorough reports. It's hard to believe we've been at this horseshoe crab thing over two decades now. John, a question for you, a comment and a question about the biomedical mortality, I guess the take-home message from both of your reports is that it is essentially insignificant.

I think back as a TC member. Our relationship with the biomedical folks has been colorful, to say the least about the use of their data and access to their data. Given that though, and I think it's a fact that their estimated bycatch or estimated discard mortality has exceeded the cap in the plan six out of the last seven years, or something like that.

This Board has never forwarded a motion, either accepted or defeated, to cap or limit the biomedical harvest. I'm sure there have been many reasons we've not taken that up, given they violated the cap. But, I guess a charitable interpretation now is that we had the wisdom to see that the juice wasn't worth the squeeze anyway; because it is an insignificant harvest. I understand the confidentiality issue and you redacted the Y axes on many of your drafts. But is there some context you can give us just to help me wrap my head around just how insignificant that estimated mortality is?

DR. SWEKA: Sure Mike. I mean, the numbers in the reports represent the coastwide biomedical mortality because, then, by reporting the coastwide we don't violate any confidentiality issues. If we wanted to make a very, very extreme estimate of what biomedical mortality might be, perhaps you could take the coastwide numbers that are bled, which in 2017 was over 440,000.

If you make the assumption that every one of those crabs was a female, and all of those crabs also came from Delaware Bay. To put that in kind of context, you know, the coastwide bleeding mortality relative to say just the Delaware Bay only population. If we assume they're all from Delaware Bay, all females, and we would assume that 30 percent of them die after bleeding, which is on the upper end of our estimates of bleeding mortality.

That would be 139,000 crabs dying because of the biomedical industry. Relative to the female population in Delaware Bay at the same time in 2017, which was 7.6 million crabs coming just from the Virginia Tech minimum swept area estimates of abundance, which we know are probably an underestimate, because it's not 100 percent catchability.

If you just divide those two alone, you know biomedical mortality would represent 1.8 percent of that population and that would be in a very extreme upper limit, assuming the worst case scenario for everything. Even that, and then take into account, the natural mortality of adult female horseshoe crabs, which we estimate as 24 percent per year. You're comparing 1.8 percent versus 24 percent. That kind of puts it in as an absolute maximum extreme impact of the biomedical industry on Delaware Bay alone.

DR. JACOBSON: John, wasn't it also the case, there is a table in the Confidential Report that showed coastwide biomedical deaths, assuming the 15 percent mortality rate in comparison to bait landings, and it was always less than 13 percent. The mortalities lost to the biomedical were always less than 13 percent of bait landings; so that is a comparison to landings. You just did a comparison available to biomass. I think you can go at it both ways.

DR. SWEKA: Yes, and we have done that in the past, looked coastwide what the estimated coastwide biomedical harvest was relative to bait landings and it's always been fairly low. It's not insignificant. We realized back after the 2013 stock assessment update. It's not insignificant where we can completely ignore it, but it is still low compared to bait.

DR. JACOBSON: I think the 13 percent was in a year prior to the institution of regulations and so forth

too; so in most years it was much lower than 13 percent.

CHAIRMAN CIMINO: Adam Nowalsky.

MR. ADAM NOWALSKY: I was going to ask for a response to a comment in materials that were submitted to us after the assessment. ASMFC apparently did not conduct a detailed analysis of biomedical mortality or its impact on the Delaware Bay spawning population and, specifically female crabs which produce eggs. I think I just heard that detailed analysis. Unless there is anything else to add, I think I'm comfortable that my question was answered. Thank you.

CHAIRMAN CIMINO: Dan McKiernan.

MR. DANIEL McKIERNAN: In the document is the discards enumerated by say gear type and area that we could look at?

DR. ANSTEAD: Yes in the document there are the total discard estimates by gear before they're combined, and then attributed dead, and then the attributed dead to females in Delaware Bay.

MR. McKIERNAN: But what about some of the other regions like New York or the northeast? Is it there too?

DR. ANSTEAD: No. When I got the dataset from NEFOP they go from you know most of the coastal states. But the dataset wasn't as robust outside of the Delaware Bay, so the confidence intervals were even larger. That's why we really focused on the Delaware Bay. For example, in New York they are very low bycatch values in that dataset, and I don't know if that's because of the way that the data is collected, or if that is true.

There were just too many questions outside of the Delaware Bay states to really zero in on that. Massachusetts had pretty good data actually from the NEFOP that could be looked at further but we really focused on that because we wanted it as an input for the catch survey, and that's where the data seemed the most complete.

MR. McKIERNAN: My last question is, I wonder at some point if there is going to be a discussion about a preferred method to manage horseshoe crab fisheries sustainably. In my state we benefit from something that was opposed years ago but lives on and that is the refuge closure at Monomoy.

We've got the National Park in parts of Cape Cod as well, and those areas are off limits to harvest. I think we might be the beneficiary of sort of that kind of management strategy even though Massachusetts didn't institute it. I think it represents a pump for recruitment and maybe protection of adults.

I guess I wonder about how things seem to be declining elsewhere, and I don't know if there are some recommendations. We did adopt the Rhode Island lunar closures; which seemed like a good idea, and I just wonder at some point might there be an assessment of good management strategies for this species.

DR. SWEKA: I guess I would say that's kind of a difficult question to answer. I mean obviously there are a lot of different avenues that if the Management Board considered a management action. You know a lot of different things that you could possibly do with seasonal closures, lower harvest limits.

You know, more refuge area, perhaps around New York. We didn't do any sort of and I don't think we have the data. We don't have the data to really do a management strategy evaluation. It would be nice if we had population estimates in these other regions like we have in Delaware Bay. Perhaps on down the line if we can somehow get some hard population estimates, say around the problem area of New York. Then maybe we could start modeling some of the dynamics there and do a management strategy evaluation to look at alternative management there, more than just reductions in bait harvest alone.

CHAIRMAN CIMINO: We will be considering management responses so, if in that discussion there is a task to either the Technical Committee or if we're going down the line of starting a PDT, I

think we can continue that discussion there. I have Stew Michels next and then Bob.

MR. STEWART MICHELS: Excellent, excellent assessment and review. The picture of that mountain that you showed is certainly not steep enough to reflect the accomplishment that you guys made here. I had a question regarding the discard conversion factors that were used. They seem a little light to me, like by about half. I was just wondering where those data came from.

DR. ANSTEAD: Sure, we used the ratio estimator. They were scaled up to ACCSP landings for those states; all species landings for the same gear. That's one of the challenges of this dataset as well, is the NEFOP gear is the same as the ACCSP gear, but it's not necessarily categorized the same way, so sometimes it can be hard to compare those two datasets to each other.

It is a crude estimate at this point. We have the NEFOP data to do the ratio of horseshoe crabs discarded to species landed. Then it's scaled up by the ACCSP all species landed for the similar gears and states. Does that answer your question?

MR. MICHELS: That does answer another question I had but the actual estimates for the weight of a male versus the weight of a female for the conversion.

DR. ANSTEAD: Yes, the bio-sampling in NEFOP for horseshoe crab is also quite thin. With the exception of the trawl gear, we had some bio-sampling from that and so we could use annual bio-sampling to do some of those conversions. Otherwise we looked to the state conversion factors to get between the weights and the numbers.

Traditionally, what is used is one pound for a male and then 2.67 pounds for a female. They can be controversial conversion factors but that is generally what is used and so, at that crude level with about a 46 percent female, I believe is the ratio we used for that in those weights. That is how those conversions were made.

MR. MICHELS: Okay, that is probably something that we should take a look at when we delve into those discards. If I may, Mr. Chairman, the use of the Delaware Bay Spawning Survey, I'm kind of curious as to why it was not used as an index of relative abundance. I understand in the ARM model the sex-ratio data is used. But I wonder if you could speak to that.

DR. SWEKA: Yes Stew, part of the problem with that is you know we believe it's a gear saturation issue, in that you can only fit so many crabs within a square meter, you know the square 1 x 1 meter quadrant on the beach. It doesn't show the same sorts of trends that some of the trawl surveys are showing, because you fill up that quadrant and that's all the more crabs that you can fit in that space. You know perhaps if there was somewhat of a redesign of the survey that accounted for more longitudinal distance along a beach; you know that takes into account more of the spreading out of horseshoe crabs. Maybe that would make it a slightly better survey. It has been used, you know, Dr. Dave Smith has used it in some analyses to see how crabs have spatially redistributed through time across Delaware Bay. It's still useful for that and it's also like you've mentioned, we use it in the ARM framework to look at the sex ratio of males per females.

MR. MICHELS: Then Dr. Jacobson, you mentioned that and I probably misunderstood, but the catch multiple survey analysis, recommended its use for the ARM model would be appropriate. But then I thought I heard you say for females only.

DR. JACOBSON: The model as it was run for females only; because it takes advantage of some aspects of the reproductive biology. At this point it should only be used for females only. But we look forward to extensions or developments or more work that might make it possible to do it for males also, and also, for males and females in other areas. Does that address your question?

MR. MICHELS: I think that does. But then how do we accommodate the male harvest packages by only incorporating the female component into the model?

DR. JACOBSON: I'll probably let the Assessment Team answer that but I think that, in Delaware Bay there is enough information, even if it's not complete, to split the total landings into males and females. Of course I think most of the landings have been females recently, but John.

DR. SWEKA: I'll just back up and state why we didn't try to estimate male abundance within the CMSA. The reason why was because there are some years. You know the nature of that model, it always assumes that there is going to be more multiparous individuals than primiparous individuals.

For whatever reason, sometimes with the males you end up with more primiparous than you do multiparous individuals in a given year. It seems like there is a little more interannual variation and those ratios between multi and primi don't stay consistent through time. The problem there was when we tried running it in the model, the model just would not converge. To the second point then, you know, what do we use in the ARM model for males?

That is obviously something we would have to discuss within the ARM Subgroup. Just off the top of my head right now, if we're getting an estimate of females that we're confident in. From the trawl survey itself we have the ratio of total males to females. We could apply a sex ratio to that or get the sex ratio from the trawl and apply that to the female estimates of abundance, and then use that as our estimate of male abundance, you know for input to the ARM. That is one quick possibility off the top of my head.

CHAIRMAN CIMINO: Stew, you good? Bob Ballou.

MR. BOB BALLOU: I'm interested in the blending of the Massachusetts and Rhode Island surveys into a single regional index and, because the Mass survey is trending up and the Rhode Island is trending down, they sort of cancel each other out and you end up with a neutral status. Then juxtapose with the New York situation where they're all trending down and showing up as bright red. As a Rhode Islander, I'm not sure if that leaves me feeling lukewarm or lukecold. I am wondering whether there was any thought given to differentiating Rhode Island as a standalone. The survey that Rhode Island conducts appears to have warranted its inclusion as a contributor to the assessment.

But again, because we were blended together with Massachusetts, it puts us in this kind of interesting juxtaposition between a trending up status to our east and a trending down status to our west, and a Rhode Island survey that's trending down. I'm wondering if you could speak to that issue a little bit. Thank you.

DR. SWEKA: Yes, we definitely thought a lot about Rhode Island. You know, which region it should be in. Should it be lumped in with New York? Should it be in with Massachusetts and the rest of New England or the northeast? It's hard to say. Yes, the trends are more like the New York area, but where the Rhode Island Survey is conducted is awfully close geographically to where the Massachusetts Trawl Survey south of Cape Cod.

It is interesting how geographically close the Rhode Island survey is to Massachusetts and yet we see completely different trends in the two. I don't have a good answer for you other than that we did have many, many long debates, not only in this assessment but in previous assessments. Where do we fit Rhode Island? Where should we really break the New York versus New England?

Also, even with the rest of New England, once you go up around north of the Cape then that survey just kind of bounces around without a consistent trend or lots of zero tows out of there too. There is certainly, you know that's why in the end one of our conclusions is we need to keep looking at New England. It shows a neutral trend but it's based on two surveys with conflicting trends of each, so continue to watch and examine that.

CHAIRMAN CIMINO: Mike Millard.

DR. MILLARD: Thank you, Mr. Chair, for a second go-round. Dr. Jacobson, it occurs to me that the development of reference points outside of the assessment model framework is not without precedent yet you said several times it's a bad

idea. Is there something about the horseshoe crab in particular that makes it a bad idea or is it just in your opinion a bad idea across the board?

DR. JACOBSON: It's viewed I think the technical consensus is that it's a bad idea across the board and some of the reasons stem from experience with real uncertain assessments where you are pretty sure of the trend but the biomass may be 100 or 200, off by a big amount between models. The difference between two models may be substantial and unexplainable, even though they show the same trends.

If you were to take a reference point from one and compare it to the say a biomass estimate from another, the difference, the ratio may be due more to different assumptions in the model, than to the real status of the stock. When you take the reference point and the status measure from the same model, you take any relative bias in the two and it's the same on both sides. If one is high by 50 percent, the other one is high by 50 percent, when you divide them, take the ratio you've got the status measure, the biomass on the top and the reference point on the bottom. The 50 percent biases cancel out. If you have two models, one of them may be high by 50 percent the other may be low by 50 percent.

Depending on which one you take the reference from, 0.1, and which one you take the biomass from. You'll come out with a number that is off by a factor of 2 or 50 percent, depending on which way you flip them. It's just from a technical point of view in general, and a consensus technical point of view I think, viewed as not a great idea. But, we tried to be responsive and we tried to be as helpful as we could and we think that there was real information in John's theoretical model. The theoretical information is that the FMSY is probably lower than 0.1.

If you look at the results from the Collie-Sissenwine model you see that the mortality estimates for the most recent years from it were very low, you know very low, even low relative to 0.1. We're comfortable saying that it's pretty unlikely that fishing pressure exceeds FMSY at this time in the Delaware Bay area, but we drew the line at actually making the comparison. It's just bad practice in our view.

CHAIRMAN CIMINO: Adam Nowalsky.

MR. NOWALSKY: I would like to make a motion if you're ready. I move to accept the Benchmark Stock Assessment and Peer Review Report for management.

CHAIRMAN CIMINO: We have a whole bunch of seconds. Well okay, Mike Luisi. We did promise to allow the public to have a chance, and we do have one individual that signed up to speak. I didn't know, Mike and I were thinking that we would like to hear their questions before a Board vote if that's all right.

PUBLIC COMMENT

MR. BRETT HOFFMEISTER: Want me to go ahead and make the comments now?

CHAIRMAN CIMINO: Yes. Brett Hoffmeister if you can come up, we have a public microphone at the end of the table here. Hopefully I got your name right, but if you state your name and affiliation.

MR. HOFFMEISTER: Yes indeed, you did get my name right; thank you, it's not easy to do. Thank you for the opportunity to speak. This is a great opportunity. As you said my name is Brett Hoffmeister; I'm the LAL Manager at Associates of Cape Cod. I also am Vice Chair of the Horseshoe Crab Advisory Committee; two roles I take very seriously.

I've got a couple comments today regarding the assessment and some of the assessment process. First off, I would like to say that I've had the opportunity to be in attendance for some of the meetings. It was really something to watch. I would personally, and my Company ACC would like to thank them for the work and the effort they put into this assessment.

I personally have a new found respect for the painstaking process of analyzing this data from so many different sources. This was by no means an easy task as it was a privilege to watch these ladies and gentlemen work. The team did so thoughtfully, skillfully, and professionally. I would

also like to thank the team for their efforts in maintaining our privacy in matters protected by confidentiality laws.

It was very clear to me that this was a priority for the team and ACC recognizes that this made a tough job tougher and we sincerely appreciate those efforts. That said, I did pore over the draft assessment and I do take issue with one certain aspect of the assessment, and if you allow me a few minutes to describe that I will make it quick.

ACC has a 45-year history of conservation efforts that began with the catch and release model, size limits. We've worked with the state to prohibit bait fishing in some embayments. We participate in the rent-a-crab program, utilizing the resource officially and most recently instituted a project that uses in vitro fertilization to restock the wild population.

The takeaway from that is that our Company does care, and always has cared, and always will care for these horseshoe crabs. This is a resource that we depend on for our business. It is for that reason we were distressed to see the inclusion. We didn't talk about it here today, but Section 4.2.2. There is a section called sublethal effects of biomedical bleeding. In this section they specifically reference two papers, the Anderson paper and the Owings paper from 2013 to 2017, respectively, coming from the University of New Hampshire.

I'm familiar with these papers. I've read them, and I went over them again as part of this comment section. I would like to make it abundantly clear to everybody in this room that the processes described in these papers does not reflect our longstanding industry practices as they repeatedly claimed to do. For the benefit of those who haven't read these papers, please allow me to read from them. This is from the Owings Paper.

The bleeding process replicating industry standard processes, took a total of three days. From the get go they are inaccurate. The 60 gallon barrels of the treatment animals were placed outside in direct sunlight for four hours or next to a space heater in the greenhouse; depending on the temperature of ambient sunlight during the selected day to replicate duration of time spent on the deck of a boat prior to transport to biomedical facilities. The average temperature the crabs experienced during this time was 32 degrees Celsius; plus or minus 2.7 degrees.

For the benefit of those here that's about 90 degrees Fahrenheit. After the first four hours the barrels were placed in the back of a car and driven around for an additional four hours; to simulate time spent in the truck traveling to the bleeding facility. Temperature here was about 23.2 plus or minus 1.7 degrees Celsius (that's about 75 degrees Fahrenheit).

After these four hours the barrels were placed indoors for another 16 hours to simulate the time spent overnight in a bleeding facility. These were held at about 70 degrees Fahrenheit. After the 16 hour of sitting time, hemolymph was extracted as below. They go into a description of how the process was done; and then they go on to say that the bled animals remained in their barrels overnight for another 24 hours to replicate a second night at the bleeding facility, again at 70 degrees Fahrenheit. Then the barrels were placed in the back of a car for four hours to simulate transportation back to the dock where they would eventually be loaded on vessels and returned to their capture location. The fact of the matter is that before Ms. Owings even began her bleeding process, ACC would have taken crabs from the supplier, bled them, and returned them to their natural surroundings; so before she even got started.

Whereas she still had in comparison the crabs that were enduring the process and enduring the conditions that they cite here had another 36 hours to go. Claiming that this process is industry standards is simply wrong; and much can be said about the Watson paper, much the same can be said about the Watson paper.

It says Cape Cod is well aware of the relationship between hypoxia, hemocyanin levels and stress on the animal's well-being and we have been for decades. The fact that exposing these crabs to inhumane conditions that might result in high mortality an altered behavior should not be a

surprise to anybody in this room. I think we all can acknowledge that.

I understand the author's good intentions but claiming that the treatment in these studies is accurate and mimics those of our longstanding practices is wrong. It's disappointing that the ASMFC is giving credibility to that claim by publishing the results and the conclusion from these experiments as representative in this industry, in both this assessment and back in the September issue of the Fisheries Focus.

What can be and should be acknowledged is that the good results come from good treatment. This is something that we've known for decades. This is something my colleagues in the biomedical industry have known and this is something that this Commission knows, and documented in the 2011 best practices.

Every paper reviewed by the Stock Assessment Subcommittee has demonstrated similar results with crabs that are treated well. Often those numbers are overlooked. Focusing on the results of extreme and poor handling condition only misinforms and that is not the purpose of this Commission.

To state that these are the effects of biomedical bleeding is simply wrong, and I believe has no place in this assessment. I don't mean my criticism to undermine the good work that was done because there was some very good work done here, and I was witness to it. But I want to make it abundantly clear that the claims that these papers make that this is an accurate description of what happens in the biomedical industry is completely wrong and I thoroughly believe there is no place for this in this assessment.

Just to finalize again. I do want to thank you for the good work that was done by the Subcommittee. I have to give a nod to Massachusetts DMF, who I think is doing an excellent job maintaining and managing the horseshoe crab fishery. We've seen the benefit of some of their management actions. I would like to thank you all for taking my comments today.

CHAIRMAN CIMINO: I wanted the Board to have a chance to hear any public comments or questions for either the Peer Review or the Stock Assessment folks. We do have a motion on the floor that has been seconded. Adam Nowalsky.

MR. NOWALSKY: I hate to belabor it but those are some pretty strong comments. Is there any response from staff with regards to this, because unless there is something otherwise, I'm inclined to with the consent of this body modify that motion to remove 4.2.2?

DR. ANSTEAD: I can respond to that a little bit. Just to back up a couple steps with how we approach this biomedical issue for the stock assessment in all of those studies we looked at. We did portion those studies out by region and had a representative from the SAS evaluate each of those studies by region, as part of the appendices in the report.

They all concluded that for the most part many of those studies are not in line with practices that they're aware of in their respective regions; and that is reflected in the appendices of the stock assessment. Additionally, we had a TOR to evaluate sub-lethal effects of biomedical bleeding and those were the only two studies we're aware of.

I'm not pushing back on you. I'm happy to remove it if that is the will of the Board, but it was one of our TORs, and so we were only limited in our capacity of those two papers to address that TOR that was assigned to us. Certainly, I don't think that section says that we believe that is how biomedical is operating. Those are just the two studies that have evaluated sub-lethal effects of bleeding; not necessarily the practices of the facilities.

CHAIRMAN CIMINO: Dan.

MR. McKIERNAN: The question that comes to mind is it cited a Master's Thesis. Was that Master's Thesis work published in a Peer Reviewed Journal?

CHAIRMAN CIMINO: I don't think we have the answer.

MR. McKIERNAN: Consistent with Adam's comment, is it possible to remove that reference if it wasn't published in a journal?

DR. ANSTEAD: Yes. We can remove that study if that addresses your comments, Adam. How about the Anderson study though?

MR. McKIERNAN: Brett, do you have a comment on the Anderson study?

MR. HOFFMEISTER: Only to say that similar conditions. I mean in the Anderson study these crabs were put on, I guess the aquatic equivalent of a hamster wheel. To get a baseline they put them in water for two weeks and then bled again. In that study they were looking specifically at sublethal effects, and they took a lot of blood out of some crabs and not so much out of others.

The groups that didn't get a lot of blood taken out of them fared pretty well and, I think that during the mortality studies that was evidence in these studies. But similarly these crabs were exposed to conditions that were not even close to what we do. I don't know how else to say that. These are extreme conditions and it's bothersome that they claim that this is the biomedical procedure when it is not. If they want to claim that this is what they did that's fine, that's what they did. It's not what we do. I think that needs to be acknowledged somewhere.

CHAIRMAN CIMINO: We also have another member of the public that would like to speak, I'm assuming it's to this issue.

MR. ALLEN BURGENSON: Hi everybody, and thanks for allowing me to speak at this meeting. My name is Allen Burgenson; I am the Chair of the Advisory Panel for the horseshoe crabs, and I can echo pretty much everything that Brett said. Now several years ago when there was first an excursion of the threshold we all got together at ASMFC Headquarters, all the manufacturers and our State Representatives, to come up with best management practices. We all developed them, we all agreed to them, and we all practice them. There has been some comment that these practices are just guidelines and voluntary and we don't have to follow them. That is incorrect. We have taken the best management practices, put them into standard operating procedures, and this is what we follow.

We are also regulated by the U.S. Food and Drug Administration; who can audit us at any time all the way from horseshoe crab collection all the way to the final product manufacture. These are something that they are not just guidelines; they are hard coded into what we do. As far as my company Lonza, I can tell you, we go out at night after 9:00 o'clock at night, so it's dark.

If anybody has been out on the water at night, you know it could be 80, 90 degrees on the land, but it's going to be pretty cool out on the water. When we collect crabs, you guys were right before, we don't use the term harvest, we collect. Those horseshoe crabs are collected and they're put into insulated totes and then they're brought back to shore and put into an air-conditioned vehicle. They are then that same night brought to our bleeding facility, put into an air conditioned facility, and we try to approximate air temperature.

Then they're brought into the bleeding facility, which is kept at about 65 degrees F, because all of our bleeders are wearing Tyvek suits, and if you've ever worn a Tyvek suit you know how hot you get. After they're bled they are put back into the tote and they are put back into our bins, which are then returned with the next trip out.

Our total time out of water is less than 24 hours. All of those articles that say that they reflect what we do, they are wrong. Unfortunately, a lot of those articles are the data that is used to determine our mortality rate. Of course if you take all those papers all along you're going to come to 15 percent.

But, none of those papers follow our practices, and those practices have been audited by all the companies here, as well as our DNR representatives who go out with the fishermen to

see what happens when they collect the crabs. The FDA has seen what we do. Our mortality, we've been arguing this for years and years. But we don't even agree with the 15 percent; it's much lower. That's pretty much it. Thank you.

CONSIDER ACCEPTANCE OF BENCHMARK STOCK ASSESSMENT AND PEER REVIEW REPORT FOR MANAGEMENT USE

CHAIRMAN CIMINO: Thank you, and Adam before I turn this back over to you, one thought that was expressed here is that removal of this entire section from the document may not lay out that this was at least looked at, whether or not.

MR. NOWALSKY: My proposed way forward to that Mr. Chairman, is I would like to see all references to the Owings Thesis removed from the document; leave 4.2.2 in with the first paragraph, but add a sentence or a paragraph that notes that the study protocols referenced are different than industry best practices. That would be my proposed way forward.

CHAIRMAN CIMINO: I look to the seconder of the motion.

MR. MICHAEL LUISI: I will agree with my colleague from New Jersey if it helps things move along here.

MS. TONI KERNS: Could I help you guys instead of having to write out all of this stuff that we say as modified today based on the comments on the record, or to that degree. Is that all right, Adam?

CHAIRMAN CIMINO: Seeing nods, but we also have a hand. Robert Boyles.

MR. ROBERT H. BOYLES, JR.: Parliamentary inquiry Mr. Chairman. I understand what we're trying to do and I appreciate the comments from industry. We're editing a Stock Assessment and a Peer Review with this motion, correct? Is that the net effect of what we're doing? If that is the case I'm a little uncomfortable with that.

CHAIRMAN CIMINO: Yes, the answer is since this is the approval of the Peer Review and the Assessment document that we're talking about an edit to the Assessment Document. We have several hands. Start with Emerson Hasbrouck.

MR. EMERSON HASBROUCK: Well, I appreciate what the motion is trying to do, I have to agree with Robert Boyles. Are we going to start editing stock assessments now? I think that's a dangerous path to start to go down, where management boards are going to start to edit and change stock assessment reports. I'm not comfortable with that.

CHAIRMAN CIMINO: I've got Erika Burgess.

MS. ERIKA BURGESS: I would vote against this motion based on the fact that I do not feel it's the responsibility of the Board to edit Peer Reviewed Stock Assessments that come before it. I've read Section 4.2.2. I understand the speakers and the AP member's concern about the findings of this research.

However, I find nothing inflammatory in that section and I appreciate staff's clarification that the Stock Assessment Subcommittee or Committee, looked at biomedical mortality at an individual stock level basis, and addressed that specifically in the appendices, and that satisfies my concerns.

CHAIRMAN CIMINO: Mike, do you still want to?

DR. MILLARD: Sure I will quickly. I also would have a problem with this motion. I think it's a slippery slope for the Board to start judging the validity of papers referenced in stock assessments. That could go a long way.

CHAIRMAN CIMINO: Stew Michels.

MR. MICHELS: Yes, I agree with my colleague's comments and I would just like to point out that there is a number of Master's Theses cited in the documents that we typically use in our actions here at the Board.

CHAIRMAN CIMINO: Mike Luisi.

MR. LUISI: That's the last time I second a motion by Adam. It seemed very, very simple when we

started**. I would move to substitute to accept the 2019 Horseshoe Crab Benchmark Stock Assessment and Peer Review Reports.**

CHAIRMAN CIMINO: Second, Jim Gilmore; comments, Adam Nowalsky.

MR. NOWALSKY: Is there an alternative here whereby there is some action we could take that this could be looked at again by the SAS and/or Peer Review, and bring it back to us modified, so we're not modifying anything, they're modifying it and giving it back to us. Is there some pathway for that?

MS. KERNS: In trying not to edit the document, we could take the information that is already in the appendix that says that this does not reflect the best practices sentence; and bring that into the main part of that section. That would be maybe a compromise of the Board and not really editing, and as Stew said before many of our assessments has gray literature, as well as master's thesis. It's not uncommon to have that in a document.

CHAIRMAN CIMINO: Robert Boyles.

MR. BOYLES: I would suggest for the Board's benefit that we've noted the public comment. We've noted the concerns that have been expressed. We've had rather extensive discussion about this now. I think that's on the record and we can move on. Thank you.

CHAIRMAN CIMINO: Well, before we do I'll have to point out that I did need to bring in another doctor, so we got that far. Dan.

MR. McKIERNAN: I really like Toni's suggestion that if we could bring a statement from another part of the document and embed it into that section; that reflects something that's already in the document. At least the reader is going to be left with a more accurate depiction of these studies. Is there something, Mike that you could amend your motion to endorse Toni's suggestion?

DR. ANSTEAD: I'm happy to make those changes along with some other minor edits that we have found before it gets published in the spirit of what we've talked about today, to soften that language and make it clear that these studies do not follow best practices that this was a TOR, this was what was available. But it's not part of the biomedical practices.

CHAIRMAN CIMINO: I'm going to agree with Robert that we've had a healthy discussion on this, so I'm going to ask if with the motion and second that we have right now if there is any objection to this motion.

MR. McKIERNAN: Well as long as the motion includes amendment as we just discussed during this and it's not on the board.

MS. KERNS: I think it's on the record unless you need us to change the motion, we will make those changes.

MR. McKIERNAN: I trust the staff.

CHAIRMAN CIMINO: With that I'll take it that we have, we now have a main motion. I'll ask the question again. Is there any objection to the now main motion? Okay, good then, with that consent our next agenda item is Consideration of Management Response.

Sorry, the motion is; move to accept the 2019 Horseshoe Crab Benchmark Stock Assessment and Peer Review Reports for management use. Subtitle with edits. This motion was by Mike Luisi; second by Jim Gilmore.

CONSIDER MANAGEMENT RESPONSE TO 2019 HORSESHOE CRAB STOCK ASSESSMENT

CHAIRMAN CIMINO: With that I'm going to turn it over to Mike and he'll give a presentation. Then we will open it up for consideration of Management Response.

DR. MIKE SCHMIDTKE: Given the time that we're at I'll try to keep this a brief as possible. I wanted to lay out for the Board some of the recommendations from the assessment that could lead to a management response as well as some of the previous discussions or actions that have been postponed until after the assessment.

Specific actions or motions don't necessarily need to be made today but, if any of these or other items want to be taken up or further discussed, and require staff or committee work, Board direction on what tasks need to be completed would be helpful for doing that. First, I'll highlight two of the assessments conclusions that have management implication throughout the presentation.

What would be necessary to initiate any of these responses is shown in bold. The assessment review indicates that the catch multiple survey analysis population estimates are the most accurate estimates of abundance to use as an input for the ARM in Delaware Bay. The only thing that would be required to start using these population estimates in the ARM model would be Board guidance to do so. It doesn't change anything inherent of the model as written in Addendum VII, so we would just need that Board guidance.

Next, the assessment concluded that the New York region, which includes New York and Connecticut, has a poor status due to continued declining trends in abundance indices for that region. Whether and what type of work would be necessary to respond to this recommendation would really depend on how the Board wants to respond. It may need a management document, it may need state action. It really depends on some discussion that may occur today. Now, moving on to some of the previous actions and discussions that have been delayed, first of all draft Addendum VIII that was proposed and eventually postponed in October of 2016, that was initiated to address incorporation of biomedical mortality in the ARM model, as well as bait harvest packages that would allow for female harvest in the Delaware Bay.

This, obviously, is an addendum would be required to carry this out. This will need to be taken up, not necessarily in this meeting but at some point, because it was postponed until after the assessment and we are now after the assessment. The biomedical mortality incorporation options that were involved here, we had two different options.

One of which could actually be done without an addendum, if the biomedical mortality was incorporated as an additional source of mortality within the ARM model and the harvest packages were maintained. There was some work done in the meantime since this action was postponed.

In October of 2017 that information was presented to the Board and showed that neither of these methods for incorporating biomedical mortality altered the harvest package recommendations that have come to the Board. Additionally there has been discussion about the incorporation of new or altered harvest packages that would allow different levels of female harvest in the Delaware Bay.

One point that has continued to be said and is relevant to this, is that unless the female population of horseshoe crabs exceeds that 80 percent carrying capacity threshold, there will not be any female harvest recommended by the ARM model, regardless of any additional harvest packages. That is something for the Board's consideration when thinking about draft Addendum VIII.

Finally, Addendum VII describes the use of a double-loop process, which includes the iterative process that we conduct every year when we set our harvest specifications. Then, there is also a set-up phase that is in the Addendum, set to be reviewed every three to four years. This is done to update the model assumptions, stakeholder information, monitoring information, and things of that nature. This type of a review has been characterized in two forms: a long-term review, which could be expected to take up to two years, and a short-term review that could be done in six to eight months.

The last review conducted in 2016 was a short-term review. Given the considerable amount of information from the new assessment, the Board may want to consider conducting another review in the future. As part of this, it would be helpful also to migrate the software platform from ASDP, which is the current program that is not a very widely used program, to something that is more useable and can be housed in house and run potentially by staff or other scientists on the ARM Subcommittee. To conduct this review in either

form, and especially to migrate that platform, would require a significant amount of time and money. That is something for the Board's consideration, and depending on the recommendations from the review, a management document may have to follow as well. With that, I can take questions as the Board needs them on these types of processes. I do want to reiterate that final decisions are not necessary today but, if the Board desires any type of work to be done between now and the next meeting in achieving any of these tasks, guidance on that would be helpful.

CHAIRMAN CIMINO: Stew Michels.

MR. MICHELS: Mike, the long term look at the double-loop process. I think the slide indicated that it was going to be costly. Do we have a source of funding available for that or are we soliciting funding sources for that?

DR. SCHMIDTKE: I am not aware of a funding source for that. Really, one part of that if we're going to be migrating the platform that's been talked about a couple times before, and that is something that would take potentially a graduate student or postdoc, somebody like that. Half a year or year's-worth of time to do. That could bring in some cost as well as paying for whatever workshops need to be done to do the review itself.

CHAIRMAN CIMINO: Roy Miller.

MR. MILLER: I just wanted to quickly bring up one thing that was not mentioned in Mike's presentation and it was stressed by Dr. Sweka, the value and importance of the Virginia Tech Trawl Survey. I understand our funding is available for this survey through 2019. I'm uncertain as to whether there is funding available beyond that. If not then I just want it on the record that that should be a priority for our organization would be to help secure funding if possible to continue that Virginia Tech Trawl Survey.

CHAIRMAN CIMINO: Thanks Roy. I'm going to turn to Bob Beal.

EXECUTIVE DIRECTOR ROBERT E. BEAL: Summer flounder stole my voice. We do have money for '19 and '20, Roy; so we've got a couple years in the bank, so to speak. Anytime we put in our appropriation request and Commission priorities this survey is one of the high priorities. We're going to keep working on it.

Having a couple years funding is good to have but it's not the long-term funding source that we would like to have. I think we're just going to have to piecemeal it, you know year by year, and the good news is we're two ahead right now so we'll just keep making sure the appropriators know this is a priority for the Commission and the importance of that survey for the Horseshoe crab management.

CHAIRMAN CIMINO: Yes, go ahead Jim.

MR. GILMORE: I'm not sure if this is a charge to look at yet but let me lay it out, and then maybe I'll see if there is some work they've been doing. It's getting back to my question about the reason for the decline in New York. This goes along with what Dan McKiernan said before, it's like looking at different things we can do. New York has already reduced their harvest from 360,000 to 150,000. We have spawning area closures already. We've got this massive monitoring system going, not a scientific one, plus we have a volunteer-based one, and they filled my conference room last week with all the volunteers we have going on. We're essentially doing all this and then the suggestions we have moving forward would be to do more quota reduction, or whatever. But that doesn't seem to be where the problem is. Here are some other facts that are starting to come together:

The New Jersey harvest, I'm sorry moratorium, started ten years ago and all your data shows a steady decline over ten years right when that moratorium was put into place. In addition, from our monitoring in New York, we have better survival in the Peconics. The further you get away from New Jersey the higher the survival goes.

Jamaica Bay has got the lowest survival. It's starting to look like we've got the issue of what we were concerned with all along, is that that New

Jersey shut down their horseshoe crab bait fishery but they didn't close down their whelk and their eel fishery. The demand for bait still exists. What I'm suggesting are two things:

I would like to know is overharvest the reason, illegal harvest going on that we don't know about that's not coming up in any of the assessments? Are there some things that maybe we could suggest; or maybe Jersey does and looks into it, for instance an artificial bait requirement or getting into the male-only fishery, some things along those lines?

Because we're just going to eventually close our fishery, it looks like. Then we're going to drive the issue further to the east, and now we're going to have Rhode Island and Massachusetts population going down. It seems like maybe that's not the right way to be doing this. I want to get that looked at but I don't know if it's actually a specific charge, or can we focus in on why we have this very strange thing going on in New York.

From a biological standpoint it doesn't seem like it's maybe the biology. It seems like it is maybe illegal harvest. The other thing and I'll add we're working with Connecticut right now to put a size limit on our whelk fishery. Hopefully that will reduce demand. But I still don't think that is going to be enough unless we address the problem of maybe there is no harvest in New Jersey, but there is still a demand.

CHAIRMAN CIMINO: Well, I'm not going to assume it's something that we would be tasking a Technical Committee with, but it may be a question for our Law Enforcement group, if that's something that's on their radar currently. I have a couple hands up. I saw Mike Luisi first, Tom Fote and then you, Justin.

MR. LUISI: Mike, could you go back one slide to the slide that has Addendum VIII on it? Maybe one more, yes that's the one. If you're looking for some advice, if you go down to the second to last bullet there, the additional or altered harvest that would allow for females in the Delaware Bay sounds like something I would have suggested maybe a couple years ago.

At the time, I think we were looking to explore alternative ways of coming up with a way that the state of Maryland or those harvesting in the Delaware region could harvest a few females. Now, given the fact that it's understood that until we reach some certain threshold level exceeding 80 percent carrying capacity, or 11.2 million females, we're not going to be able to develop something to get there. I would say if you're looking for advice, that if it was advised to continue with this draft Addendum, that you could eliminate that part of it from any further consideration. If the other portions of the Addendum were to be explored further then that would be fine with me.

CHAIRMAN CIMINO: Tom Fote.

MR. THOMAS P. FOTE: We also looked, I think, and talked about it years ago about the sea level rise and the rise in the bays and estuaries, which we lost all the sandy beaches where the horseshoe crab spawn. I don't know if that contributes to the decline or not. I don't know that we have ever surveyed. I don't know how it is in New York after the results of Sandy. We've seen the Bay is much higher than it's ever been before; and we lost some of the areas that they spawned on.

CHAIRMAN CIMINO: Justin Davis.

DR. JUSTIN DAVIS: I have a motion if you're ready for that. I don't know if we're done with discussion.

CHAIRMAN CIMINO: One more, Chris Wright.

MR. CHRIS WRIGHT: Given that the Peer Review and the Stock Assessment folks brought up discard mortality, I would like to have the TC evaluate what kind of studies we would need, and get a cost estimate of what they would cost, because if we have five years, we need to start addressing that sooner than later.

CHAIRMAN CIMINO: Agreed, thanks. Okay if no others I will turn it back to Justin.

DR. DAVIS: I move we postpone consideration of management response to the 2019 Horseshoe

Crab Benchmark Stock Assessment until the August, 2019 ASMFC meeting.

CHAIRMAN CIMINO: A second, Dan McKiernan. Discussion, go ahead Justin.

DR. DAVIS: I think we've had a very robust discussion today about the stock assessment and the issues around horseshoe crab management. I think the hour is getting kind of late. I want to echo some of the comments made by Jim Gilmore when it comes to the New York region and Connecticut. Our fishery is pretty small scale.

Landings have been low; around 20,000 crabs and stable for a number of years. Over time we've taken measures to restrict harvest; we have closed areas. I sort of feel the same way that while I'm concerned about the results that came out of the stock assessment. I don't feel that further harvest restriction is necessarily the path forward.

I'm interested in taking a really broad look at all the factors that might be affecting horseshoe crab abundance in the New York region. I feel like at least from my standpoint; I would benefit from an opportunity to have some more discussions with my partners in the region about what we might want to task the Technical Committee or the PDT with investigating for a potential management document. I just sort of feel like at least from the standpoint of the New York region from Connecticut, I'm not ready today to lay out all the things we might want to have in a draft management document. That was my reason for asking for postponing.

MR. CIMINO: Sounds fair. Any additional comments? Stew.

MR. MICHELS: Just a clarification perhaps. Does that include incorporation of that CMSA model into the ARM model? Would you include that or can we make a recommendation for the Committee to pursue that?

DR. DAVIS: I would be fine with that recommendation being made today.

MR. CIMINO: Right, we won't need a motion specifically for that. Maureen Davidson.

MS. MAUREEN DAVIDSON: Hi, speaking as Jim Gilmore's proxy. Thank you. I agree with Justin. I think that we would be able to benefit if we had some additional time to look at where we can make management changes to see what's happening to our horseshoe crabs, try to determine where our loss is. Whether it is attributed to mortality or they're not there they are leaving, and other sources of our horseshoe crab loss. I think we would just benefit with a little more time.

CHAIRMAN CIMINO: If we don't have any opposition to this motion I will consider it approved by consent. Also, making note that there were no objections to including the catch survey estimates.

RECOGNITION OF DR. JAMES COOPER

CHAIRMAN CIMINO: Last item on the agenda is to review and populate the Advisory Panel membership but, before we do that I would like to recognize a longstanding member who is stepping down, Dr. Jim Cooper, who also wanted to provide some comments to us. First, I'll turn it over to Bob Beal for recognition; and then over to Robert Boyles to provide Dr. Cooper's comments to us.

EXECUTIVE DIRECTOR BEAL: Great, thank you, Mr. Chairman. Just very briefly, I wish Jim Cooper was here, but he couldn't make it today. I just wanted to, you know on behalf of the Commission and the Commissioners and the Board thank Dr. Cooper for two decades of service to the Horseshoe Crab Management Program. He was here at the very beginning when Horseshoe Crab was separated from American eel management; and Tom O'Connell from Maryland was the drafter of the plan, and also to those things.

He's been here from the very beginning and provided a great perspective from the biomedical community to the Board. He also chaired the Advisory Panel for a decade at least, if not a little bit more. Just, he's been a great part of this process and a really valuable advisor to the Management Board. I just want to thank him for

his couple decades of service that he gave us. Thank you, Dr. Cooper.

CHAIRMAN CIMINO: Absolutely, thank you, and Robert.

DR. BOYLES: I would like to echo our Executive Director's remarks about remarkable Dr. Cooper. He regrets that he could not be here today on his final day as a member of the Advisory Panel. Mr. Chairman, I would seek unanimous consent of entering Dr. Cooper's written remarks, which were sent to the Board as part of the supplemental materials.

Enter those into the record verbatim please, with unanimous consent, recognizing the hour is late, but at the same time I did get a note from him. He did not intend necessarily to read these comments himself, but I think it's certainly worthy of recognizing his many contributions to the Commission, to our family, and to these resources.

I'm thanking him for his stalwart leadership and support of the Commission and his leadership in the biomedical industry, and helping us sort through some challenging times as Bob said from the beginning. Mr. Chairman, I would seek unanimous consent to enter those remarks into the transcript of the meeting if it pleases the Board, and again, recognition and thanks, and my gratitude as a South Carolinian to Dr. Cooper for his leadership and service to the Commission.

CHAIRMAN CIMINO: Not seeing any objections, we'll assume that. Thank you.

DR. JAMES F. COOPER: "Mr. Chairman, Board Members and guests,

It has been an honor and privilege to work with the Commission and a remarkable group of marine resource managers and scientists for the past 28 years to conserve the Atlantic horseshoe crab, *Limulus polyphemus*. Upon my last day as a member of the Advisory Panel, I offer a tribute to the Commission and individuals who created the remarkable HSC Fishery Management Plan (FMP) with their initiative, vision, dedication and hard work.

While searching for horseshoe crabs for my new LAL firm in Charleston, I discovered that truck-loads of crabs were being collected and transferred to Virginia for the bait market. After calling this matter to the attention of our SCDNR director, Robert Boyles, he led his staff and my wife in an effort to draft and find sponsors for a bill prohibiting out-of-state transport and for conserving this resource; the bill passed the SC Senate in 1991. Our bill became a model for conservation.

At the same time, biologists near Delaware Bay were responding to overharvesting for bait. The Univ. of Delaware sponsored a forum in February 1996 that drew 81 stakeholders for the first coordinated effort to address the crisis. The following issues were addressed by notable scientists and resource leaders:

- Carl Shuster discussed HSC exploitation and abundance;
- Robert Loveland and Mark Botton presented HSC life history and commercial use;
- Stu Michels addressed stock assessment;
- Tom O'Connell described Maryland's crab fishery;
- Peter Himchak described HSC resource monitoring and management in New Jersey;
- Benjie Swan discussed spawning survey activities; and
- Jim Cooper gave an overview of the new LAL industry.

Focused leadership was urgently needed to create an FMP. In response to harvest reduction measures in NJ and DE, MD State leadership expressed support for an Atlantic coast Interstate Fisheries Management Plan via ASMFC. The Commission lacked the staffing and financial resources at that time, so the MD Department of Natural Resources offered one of its Fisheries Service employees, Tom O'Connell, to serve as the Commission's Horseshoe Crab FMP Coordinator. ASMFC agreed, and Tom moved into this role with his salary covered by MD DNR.

Tom continued to serve for several years, coordinating the development and approval of the HSC FMP, Addendum 1 that established state-by-state harvest quotas and survey requirements. The FMP was accepted in October, 1998. Carrie Selberg took on Tom's duties at ASMFC in 2001. My recent interview with Tom provided the following details about the FMP development.

Plan Development Team (PDT): The success of the PDT that drafted the FMP and Addendums was due to the following individuals, who brought different skill sets to this team:

- Tom O'Connell, for his organization, interpersonal and planning/coordination skills;
- Eric Schrading (US FWS) for his biological knowledge and writing skills;
- Stew Michels (DE DNREC) and Peter Himchak (NJ Marine Fisheries Division) for their biological insight and technical knowledge of HSC and population surveys; and
- Paul Perra (NOAA NMFS) for his ASMFC experience and strong partner relations.

Technical and Stock Assessment Committees:

- Dr. Dave Smith, US Geological Survey, Leetown Science Center, for his survey design, statistical analysis and decision support skills. Dave was a lead author of the Adapative Resource Management framework for horseshoe crabs, and member of the HSC SAC;
- Dr. Jim Berkson (VA Tech Univ) for his ability to work with technical experts and limited data to design a horseshoe crab stock assessment framework. At an early meeting at VA Tech, Jim was credited for laying out a vision of a framework to assess horseshoe crabs that was accepted and implemented by the SAC;
- Dr. Mike Millard (US FWS) for his leadership and technical skills; and
- Carl Shuster, Benjie Swan, Stew Michels, Pete HImchak, Joanna Burger, Mark Botton, Robert Loveland and many other state biologists for their early technical contributions.
- (Stock Assessment Report No. 98-01 was published February 1999.)

Advisory Panel:

- Dr. Jim Cooper and Robert Munson for co-chairing the AP and working with a very diverse group of stakeholders, and for representing their views even when in disagreement.

Tribute is also paid to Roy Miller who skillfully chaired the Horseshoe Crab Board during the contentious early period of development and implementation of the FMP, when watermen and environmentalist vigorously argued their positions. Roy recently said that the biggest disappointment of his era was failure to find a suitable bait alternative, a view we all share.

A personal tribute is also paid to Robert Boyles, SCDNR Director, who exemplified how industry and marine resource managers can work together for the best use of public resources. Robert always had a skillful and cheerful way to manage the most challenging problems. Thank you, Robert.

As indicated by the recent Stock Benchmark Assessment, the implementation of the FMP, the prudent use and conservation practices of the LAL industry and the continued work of marine scientists has secured the sustainability of the Atlantic horseshoe crab.

Finally, as your LAL resource, I have some comments about the future of LAL. The Chinese horseshoe crab is threatened because of habitat loss, overfishing for human consumption, and production of TAL (*Tachypleus* amebocyte lysate). In the absence of a return-to-sea policy, TAL crabs are subject to 100% mortality, a vivid reminder that a similar fate could have befallen our horseshoe crab without the protection of LAL practices in the US.

Cooper and Levin applied a return policy for LAL production from the outset of our biomedical-use discovery in 1970. TAL firms produce about 15% of the amebocyte lysate global market. They will turn to using LAL as their crab population is exhausted. Some TAL firms will purchase LAL directly from US firms while others may attempt to establish bleeding facilities in the US; ASMFC member states need to anticipate their response to this possibility.

Mortality does not occur during the LAL-related bleeding process of donor crabs, which is analogous to human blood donation. Rudloe (1983) studied the impact of bleeding on a large number of crabs in a Florida bay and estimated that bleeding increased the risk mortality by about 10%. The SAS considers this number trivial in comparison to other HSC threats.

Only older HSC, which have thinning shells and are heavily laden with a vast array of parasites and other organisms, are susceptible to the stress conditions of bleeding. The tagged crab found at Moore's Beach, NJ, is evidence that bleeding does not discourage spawning activity. In closing, I express my sincere appreciation for the opportunity to participate in Commission activities that conserve our horseshoe crab. It has been a truly rewarding experience. I consider it 28 years well spent! Respectfully submitted, James F Cooper, PharmD".

REVIEW AND POPULATE HORSESHOE CRAB ADVISORY PANEL MEMBERSHIP

MS. TINA L. BERGER: Yes hi, I would like to present for the Board's consideration and approval Nora Blair as South Carolina's newest member to the Horseshoe Crab Advisory Panel. She replaces Dr. Cooper.

CHAIRMAN CIMINO: Do we have a motion? Robert.

MR. BOYLES: I move to approve the nomination for Nora Blair to the Horseshoe Crab Advisory Panel.

CHAIRMAN CIMINO: **Second by Jim Gilmore. Is there any objection, approved by consent?**

OTHER BUSINESS/ADJOURN

Okay, with that in other business, the Board had asked about updates on development of LAL alternatives. There is an update but in recognition of the late hour, and I already lost my promise to Mike Millard that I was going to get us out of here much earlier. The AP Chair does have information on that but we will be getting that out to the Board by e-mail. Thank you, and if we have a motion to adjourn, Justin Davis, thank you, so moved.

(Whereupon the meeting adjourned at 5:40 o'clock p.m. on May 1, 2019)