PROCEEDINGS OF THE

ATLANTIC STATES MARINE FISHERIES COMMISSION

HORSESHOE CRAB MANAGEMENT BOARD

Crowne Plaza Hotel
Alexandria, Virginia
May 4, 2009

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ATTENDANCE

Board Members

Terry Stockwell, ME, proxy for G.Lapointe (AA)
Doug Grout, NH (AA)
G. Ritchie White, NH (GA)
Rep. Dennis Abbott, NH (LA)
Dan McKiernan, MA, proxy for P Diodati (AA)
Bill Adler, MA (GA)
Mark Gibson, RI (AA)
Lance Stewart, CT (GA)
David Simpson, CT (AA)
James Gilmore, NY (AA)
Pat Augustine, NY (GA)
Brian Culhane, NY, proxy for Sen. Johnson (LA)
Peter Himchak, NJ, proxy for D. Chanda (AA)
Tom Fote, NJ (GA)
Roy Miller, DE, Chair, proxy for P. Emory (AA)
Bernie Pankowski, DE, proxy for Sen.Venables (LA)
Tom O'Connell, MD (AA)
Russell Dize, MD, proxy for Sen. Colburn (LA)
Bill Goldsborough, MD (GA)
Jack Travelstead, VA, Admin. Proxy
Catherine Davenport, VA (GA)
Willard Cole, NC (GA)
Louis Daniel, NC (AA)
Robert Boyles, SC (LA)
Spud Woodward, GA (AA)
Jessica McCawley, FL (AA)
Brian Hooker, NMFS
Dan Perkins, USFWS

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

Ex-Officio Members

Mike Millard, HSC Technical Committee Chair, US FWS
Gregory Breese, Shorebird Technical Committee Chair, US FWS

ASMFC Staff

Bob Beal
Vince O'Shea
Brad Spear
Chris Vonderweidt

Guests

Gil Ewing, NJ
Richard Robins, Suffolk, VA
Jay Lugar, Seattle, WA
Bud Brown, Eco-Analysts, Inc. ME
Denise Baker, USFWS
Abigail Franklin, NMFS
Chip Lynch, NOAA
Dave Smith, USGS
Conor McGowan, USGS

The Horseshoe Crab Management Board of the Atlantic States Marine Fisheries Commission convened in the Presidential Ballroom of the Crowne Plaza Hotel Old Town, Alexandria, Virginia, May 4, 2009, and was called to order at 3:30 o'clock p.m. by Chairman Robert H. Boyles, Jr.

CALL TO ORDER

CHAIRMAN ROBERT H. BOYLES, JR.: Good afternoon, everyone. My name is Robert Boyles. I'm Chair of the Horseshoe Crab Management Board, and I would like to call the Horseshoe Crab Management Board Meeting to order.

APPROVAL OF AGENDA

The first order of business is board consent on the agenda. The agenda was mailed out in your briefing books. Are there any changes or additions to the agenda? Seeing none, the agenda is adopted.

APPROVAL OF PROCEEDINGS

Secondly, proceedings from our last meeting of October 21, 2008, at the annual meeting in Rehoboth Beach; those were also included on your briefing CD. Any changes to those minutes, additions, deletions? Seeing none, those minutes are approved.

PUBLIC COMMENT

Next we go to the section of the meeting for public comment. Public comment will be taken on items not on the agenda. Individuals that wish to speak at this time must sign in at the beginning of this meeting. Agenda items that have already gone out for public hearing and/or have had public comment and the public comment period is closed, I may determine that additional public comment may or may not provide additional information. Does anyone wish to speak on items not on the agenda? Okay, we will move on. Next we will go to Brad Spear for Plan Review Team Reports.

PLAN REVIEW TEAM REPORTS

MR. BRADDOCK SPEAR: Compliance reports were due February 1st, and I'll quickly run through state compliance and also update landings. Coast-wide landings for 2008 were down about 23 percent from the previous year; just above 600,000 crabs. This is down 24 percent from the previous five-year average.

To look at the historical landings, you can go to the FMP review and look at Table 2 or Figure 1. The largest decrease in landings from 2007 was in New York, Massachusetts, and Virginia. Those, by and large, were driven by increased restrictions on the harvest. The largest increases were seen in Delaware and North Carolina. Incidentally, both states went over their state quota by about 2,000 crabs each.

The biomedical fishery for 2008 reported bringing a little over 500,000 crabs to their facilities. This was a 22 percent increase over the previous three-year average, a similar level as to 2007. The PRT, using the methodology described in the FMP Review and a 15 percent mortality on bled crabs, came up with an estimated coast-wide mortality of just over 63,000 crabs.

You'll note that is above the FMP threshold established in 1998, and that threshold was 57,500 crabs. When that threshold is reached or exceeded, it requires the board to consider action. As far as state compliance concerns, the plan review team finds all states in compliance with the plan. The overages in Delaware and North Carolina will be subtracted from their 2009 quota.

Just to note, the District of Columbia did not submit a report for this year. The District of Columbia was put on the board to close a landings' loophole back around Addendum I, as was Pennsylvania. Since then Pennsylvania has put in regulations to prohibit harvest and landing in their state. The District of Columbia has done the same thing.

Pennsylvania has requested, through the policy board, to be removed from the Horseshoe Crab Board and its compliance requirements. The plan review team recommends the District of Columbia consider the same action. As I noted, the harvest overages for Delaware and North Carolina will be adjusted down in 2009.

In 2007 Maryland exceeded its quota and repaid its overage in 2008. Maine, New Hampshire, Potomac River Fisheries Commission, South Carolina, Georgia and Florida all requested de minimis and qualified, so the PRT recommends granting them de minimis for 2009. New Jersey also qualified but did not request de minimis. There were no significant enforcement cases reported.

Okay, just to note for the board, looking forward with the current addendum, Addendum V, the measures in place are through the 2009 fishing season. If you recall Addendum V, the board built in a provision that would allow the board to extend those measures by a period of one year through a board vote.

Anticipating this situation, the board has several options. The board can extend the measures, as I noted, through a board vote through the 2010 fishing season under the current addendum. If the board chooses not to extend the measures through a board vote, there are two possible options for the board.

One is to allow Addendum V to expire, which would revert management measures back to Addendum III. If you recall, that's up 150,000 crabs in New Jersey and Delaware, male or female. The second option, if the board chooses not to extend Addendum V, is to initiate a completely new addendum at this meeting.

CHAIRMAN BOYLES: Brad, thank you. If you all would, if we could wait on this last thing that Brad discussed about the management measures until after we hear an update on adaptive resource management, we do have several things that I would like to discuss. First of all is the plan does require the board to consider measures for the biomedical industry when the harvest exceeds that 57,500 crab limit. My question to the board is, is there any indication or interest in initiating any action? Pete.

MR. PETER HIMCHAK: Mr. Chairman, I have a comment on this issue. It seems that we did the compliance report and the FMP Review at the same time. We have to vote to accept the review of the FMP, which includes the issue of possible action for biomedical industries. I was wondering if the board could hold off on this discussion until after Brad gives his next report, which talks about the inventory of horseshoe crab-related research and education by the biomedical industry. I would hope that you would give us the advantage of knowing what they're currently doing before we take any action on potential actions for 2009. Thank you.

DE MINIMIS REQUESTS

CHAIRMAN BOYLES: Good suggestion, Pete. That sounds like a good plan to me. I am seeing heads around the table nodding so let's hold off on the FMP vote. How about the de minimis request; can we go ahead and do that? Is there a motion? Doug.

MR. DOUGLAS GROUT: **Mr. Chairman, I move that de minimis status be granted to Maine, New Hampshire, Potomac River Fisheries Commission, South Carolina, Georgia and Florida in the upcoming year.**

CHAIRMAN BOYLES: Motion by Mr. Grout; seconded by Mr. Adler. Any discussion? Any objection to the motion? **Seeing none, the motion carries.** Brad.

DISCUSSION OF BIOMEDICAL COMPANIES' HORSESHOE CRAB-RELATED ACTIVITIES

MR. SPEAR: Coming around is a summary table of the biomedical activities by company and by area broken down into tagging and research, conservation measures and education and outreach. My presentation will just be a summary of this table that's being handed out.

Okay, starting with the northern most company, Associates of Cape Cod in Massachusetts; some of the tagging and research that this company has completed; they've done tagging work with the Division of Marine Fisheries; cooperated on a bleeding and tagging study. Also, their fishermen have cooperated with these tagging efforts.

Some of the ongoing or future work, the company has recently agreed to tag or notch bled crabs. They continue to cooperate with DMF in mortality studies. Some of the conservation measures that they reported, they encouraged DMF to restrict bait harvest in Pleasant Bay in 2007. Back in 2006 I believe there was a large increase in effort in that area for the bait harvest. That area remains closed for bait harvest.

They reported that they are continuing to cooperate with DMF in this area. For education and outreach, they give presentations to museums and other interested parties; and in addition advise students on science projects. For future work they are involved in an educational session with some high school students in the area this month.

Moving down the coast to New Jersey, Limuli Labs reported tagging for many years as part of the NMFS permit that they apply for each year and tag 15 percent of the horseshoe crabs that they catch. As part of that research they measure and weigh 200 crabs each year. In addition they work with a project coordinated by the University of Delaware.

It's basically a volunteer horseshoe crab census crab survey on both sides of the bay. Limuli Labs helps coordinate it on the New Jersey side. For some of the ongoing work in education and outreach, as part of the tagging program Limuli provides a hat for recaptures that are reported. The company maintains a 1-800 number for people to call in when they do find their tags. As part of the census study, Limuli

produces and sends out reports on progress of the study to the volunteers.

Moving to Maryland, Lonza is now the company's name, formerly Cambrex and BioWhitaker. They reported funding and giving materials to Virginia Tech graduate students in multiple research projects. They continue to tag crabs with Fish and Wildlife Service tags. They also are involved in training programs for the Maryland DNR Conservation Corps.

The conservation measures that they told us about; they basically have developed a new product to reduce demand of horseshoe crab blood. In addition to that they have reduced the amount of crabs used in their current product. Their ongoing work in this area is essentially working with companies to use the new product and accept it.

In education and outreach they funded a horseshoe crab exhibit at Sound Waters in New York and continue to fund programs both there and with the Ecological Research and Development Group, which is a horseshoe crab conservation organization.

Wako Chemicals in Virginia coordinated with Dr. Fisher at VIMS on a tagging and research project. Some of the conservation measures, they carefully monitory mortality of the crabs once they receive them, and they maintain communication with their fishermen. In outreach they have participated in Sea Camp, which is an Old Dominion University sponsored education program in 2008. They continue to participate with the Green Eggs and Sand Program that several states have hosted; this one in particular in Delaware.

The last company, Charles River in South Carolina, completed a tagging study in 1999. If you recall that was a requirement in the original FMP. They will be working with Larry DeLancey, who is the vice-chair of the Horseshoe Technical Committee, on a study in 2010. They also provide hemolymph, which is a byproduct of their process, to researchers when they're interested.

The ongoing conservation measures practiced by Charles River, they hand harvest only in South Carolina. They say there is less than 1 percent mortality once they get the crabs. They have also developed a new LAL test that uses a twentieth of the LAL. Again, it is a matter of now finding companies that will adopt the test. They also provide funding to the Ecological Research and Development Group. Last, some of their education activities, they also participate in the Green Eggs and Sand Program in Georgia and give presentations to natural resource educators and scientists in the area. That's it.

CHAIRMAN BOYLES: Brad, thank you. Any questions for Brad on the presentation or on the materials that were handed out to you. Pete.

MR. HIMCHAK: I have to focus on this issue. I think overall the information that Brad has provided from the biomedical companies – I mean in my perception what they invest in the resource is pathetic in comparison to what the commercial fishing industry has suffered through restrictions all along the coast.

I don't know why the number of crabs are brought – 511,000 – there used to be around 300,000 many years ago, so that would be one question is why so many more crabs have to go through this procedure? The recommendation of the plan review team that the board consider action because they have exceeded this trigger is a very touchy situation for the board to be in because what action can you essentially take on companies that provide a life-saving product? At the same token, they are making a lot of money.

I don't know what else the board can do but to essentially ask them to invest in the resource. The Virginia Tech Survey, which is critical to the stock assessment, has financial funding secured through 2010; and then after that they'll be looking for money. I don't think it's outrageous for the board to ask these companies to at least invest in the very resource that guarantees them millions of dollars in profits.

The commercial fishermen have really suffered as a result of our management actions. The PRT recommends we consider action. I don't know what we can do other than shame them into supporting some of the research. That's all I have to say.

CHAIRMAN BOYLES: Thank you, Pete. Comments. Pete, do you have motion?

MR. HIMCHAK: Well, yes, it might be beneficial for the board to at least write a letter to these biomedical companies recognizing – yes, they represent like 9 percent of the mortality of horseshoe crabs along the Atlantic coast now. We can't deny them any horseshoe crabs, but at least we can point out that the very future of the horseshoe crab stock assessment needs a secure funding base and go hat in hand, I guess.

MR. THOMAS O'CONNELL: I think I know the answer for Maryland, but I ask for all the states that have these biomedical companies is do the states have the legislative authority to require some fee for accessing these crabs. Right now in Maryland they're required to get a free scientific collection permit, and perhaps that's another mechanism for the states to pursue this issue.

CHAIRMAN BOYLES: Tom, I know from South Carolina's perspective the permit is the same thing, no cost. Pete.

MR. HIMCHAK: Well, with that said, I'm prepared to make a motion, Mr. Chairman. I also might point out that if you go through the compliance reports, that there are a number of notations that – I mean Addendum III has been on the books and been implement for, what, four years now, and the critical monitoring compliance requirement was the monitoring of biomedical utilization of horseshoe crabs, and still a lot of the forms aren't even completed.

It's a little bit of arrogance is the way I interpret it. **I would make a motion that the board write a letter to the biomedical industries, those companies that bleed horseshoe crabs, requesting their consideration of potential funding for vital stock assessment programs to manage horseshoe crabs in the future.**

CHAIRMAN BOYLES: Motion by Pete; is there a second? Seconded by Representative Abbott. Mr. Fote.

MR. THOMAS FOTE: I was listening to Tom talk about increasing fees for those free permits. The problem with the fees for free permits, most of the time those fees going to the general fund and they don't wind up back in the places where they should be funding the necessary action. In the present climate all those funds seem to get raided.

I saw $11 million disappear from a DARE Fund that was supposed to be doing something else, and it's really tough. If you're going to fund the research, that's funded directly and put it into that and in fact not coming through the states because at this difficult time sometimes it's hard for the states to hold on to the money to do the research.

MR. G. RITCHIE WHITE: Mr. Chairman, I don't have a problem with the general concept, but I guess I would like to see more specifics as to exactly what is it that we're asking for and exactly how are we going to use it. I'm not opposed to the letter, but I think something in general terms and they turn around and send you a check for a hundred bucks; are you going to be happy?

MR. BRIAN HOOKER: As I recall from some of the previous discussions on this topic, the subject of standards and tagging requirements and best management practices came up. I don't know if that's something that the board wants to consider further.

EXECUTIVE DIRECTOR JOHN V. O'SHEA: Well, with regard to the funding issue, I think it's important that you articulate what problem you're trying to solve here. It was mentioned about the earmark that's in there for Virginia Tech right now. If the idea is that's going away and this letter is somehow seen as a vehicle to do that – I mean if that's what you intend to do, you might think about putting that in the letter.

The second is in cases where you ask industries to pay for something it raises the issue of what kind of say do they have in the program that they're paying for. Not in all cases do they get a seat at the table to do that, but that's another potential issue that probably doesn't have to be covered in the letter, but that's another issue that you're going to open, I think, when you send a letter like this. I'm not recommending against it; I'm just saying be aware of that.

REPRESENTATIVE DENNIS ABBOTT: I seconded this motion for discussion purposes and to have the debate that we're having. As Vince said, we would have to know what we intended. Then as I was sitting here thinking, we know that the biomedical industry uses probably 10 percent of the crabs; why aren't we assessing the folks that use 90 percent of the crabs the same amount.

Why are they singled out? Just because they're using them for a different purpose really shouldn't be important to us. I mean they are harvesting a percentage, plain and simple. Last weekend on PBS – I think the show was a repeat, but they had this show about the red knots and the horseshoe crabs.

I didn't hear it the first time, but I think I heard them say that a quart of the blue blood is worth $15,000. It seems like a lot of money, but it is still a business that costs money to conduct. I really don't know the wisdom of sending a letter until we really would know. If someone if someone came in with a grant proposal or something, we could support it and

maybe ask that people involved in this industry would contribute. I think just saying throw some money in a blind direction probably isn't the best thing to do.

MR. HIMCHAK: I've probably given Vince more gray hairs over my attempts at making motions, and I was not prepared to make one today. Considering the tenor of the discussion, it would not be improper for me to withdraw the motion from the board; is that correct?

CHAIRMAN BOYLES: **Okay, the motion is withdrawn and the second is withdrawn.** Just talking and having a sidebar conversation here, maybe this is something we can kick to our technical committee and ask them for some specific guidance on what we may ask of the biomedical community. Dave.

MR. DAVID SIMPSON: I just wanted to comment that I think this is kind of thing that states should do and not the commission. I mean if the commission issued permits that would be one thing, but states and the federal government issue the permits. If you wanted to collect a fee from a user, I think it would be more appropriate, say, in New Jersey or wherever that fishery occurs to levy that fee there and use it according to whatever guidelines the state has. We certainly do that in Connecticut and I am sure other states do as well.

MR. ROY MILLER: Mr. Chairman, it seems to me that if we were to pursue this idea in lieu of the motion; wouldn't it be more appropriate to have some sort of tax-exempt foundation that they could make a contribution to so they could gain a tax benefit from their contribution rather than as a tax or toll imposed by the Horseshoe Crab Board?

CHAIRMAN BOYLES: What does the board want to do? Are we moving on; we have considered this? I'm seeing heads nodding affirmatively; we're moving on. Pete, good discussion. Benjie Swan, you had signed up to comment on this particular agenda item. Come to the public mike and tell us who you are.

MS. BENJIE SWAN: My name is Benjie Swan. I think a lot of you know me. I am with a small company, Limuli Laboratories, in Cape May, New Jersey. Brad had called me I guess about a month ago to ask me about conservation of horseshoe crabs by biomedical companies. I've put together a paper; it's called "Early Conservation of the Horseshoe Crab, Limulus polyphemus" by LAL Pioneers. Brad has a copy of it and he can e-mail you if you'd like to see it. I think what we're missing here is that the earliest and greatest contribution in conservation of horseshoe crabs was by the LAL Pioneers. It first started with a "Bang", Dr. Frederick Bank, who worked with the horseshoe crab. Then he was joined by Dr. Levin, and Dr. Levin was joined by Dr. Cooper.

They're the people that actually discovered it and then applied the product. Dr. Cooper was joined eventually by Dr. Hochstein and Dr. Seligmann from the Food and Drug Administration to actually use this test as a replacement for the rabbit test. The rabbit test was the official test in 1942, and it remained that way until the early seventies when Lysate was developed.

Lysate tests, as you all know, for contamination in injectable drugs and medical devices, and it is a requirement of all pharmaceutical companies. In the seventies the Federal Register had to put out a notice and eventually some regulations regarding the capture of the horseshoe crab and the release, and in that regulation they started – it was called "The Return to Sea Policy", and that was thought of in 1970.

Dr. Cooper knew firsthand that the horseshoe crabs could survive the process. His paper from 1971 stated that it was less than a 5 percent mortality of the bled horseshoe crabs. He knew that the horseshoe crabs could survive the process. At that time there was a company called Difco that was in Ann Arbor, Michigan.

He heard that they were taking horseshoe crabs and bleeding them to make the product and then they were destroying the horseshoe crabs in an autoclave. He didn't think this was very prudent and so he mentioned it to Hochstein and Seligmann, who were in charge of issuing the regulations. That was when the Return to Sea Policy was put into place, which meant all crabs, once they were bled, had to be returned back to their natural environment after a single collection of their blood.

This policy remained in effective actually up until just recently, probably 2001 when I believe the company in Massachusetts started giving some of their crabs back to the bait industry. This policy was written in stone in the Federal Register from probably about 1973 all the way up until 1996, when at that time it wasn't the biomedical companies that wanted it taken out, but it was actually under the directive of President Clinton.

He had a new initiative called "Reinventing Government", and he wanted all the federal regulations to be looked over; and any that were out of date he wanted taken out. It was also a requirement to get a license that you had to return the horseshoe crabs back to the water, so they ended up saying, well, this was a redundant regulation, let's take it out.

Still it is honored by most of the biomedical companies that return these horseshoe crabs. And one can argue about the mortality rate and it's affected by many, many different things, but say if it's still 10 percent, we're still saving 90 percent of these animals and we have been since the seventies when Lysate was first developed and used.

In this day and age we would almost term that as a risk-adverse approach that biomedical companies put into place in 1970. I just want to make that point and I think it should be applauded that these gentlemen went to those extremes when really conservation wasn't a hot topic. I think that is very important. It's kind of like a different perspective to look at that.

We have been conservation – it's almost preservationist working with these horseshoe crabs. I'm not saying that we shouldn't always do more, but we save 90 percent if not more of the animals. I think that leaves little leeway for improvement on the survival of these animals. I think that maybe we don't want to keep doing mortality rate studies over and over again, and maybe we should look at the bigger picture and think about what we really need to advance the understanding of horseshoe crabs.

As one gentleman pointed out, every state might have different needs. I think that the technical committee should look at it and look at each state differently. I think we could use some tagging done in South Carolina, but I don't know if it's that important in the Delaware Bay Region. Maybe in the Delaware Bay Region we need to work on artificial bait.

I think biomedical companies should be applauded for all the years, 30-some years of conservation efforts, and the early LAL Pioneers should be applauded as well. We should think about maybe not – I always feel like everyone wants to punish us and that we should maybe move away from that thought and just think more of how we can move on and really advance the understanding of horseshoe crabs.

My feeling, when I talk to the companies, is that they would be more willing to help. I don't know how you want to reach to them, but I think reaching out to them first would be the best step and also with specifics; not just saying give money but tell them what the money is going to go for. That's about all I have to say. Thank you.

CHAIRMAN BOYLES: Thank you, Ms. Swan. We have got two plan review team reports. We need a motion to accept the plan review. Mr. Adler.

MR. WILLIAM A. ADLER: **Motion to accept the plan review report**.

CHAIRMAN BOYLES: Seconded by Mr. Augustine. Any discussion? **All those in favor raise your right hand; opposed same sign; null votes; abstentions. The motion carries.** Dr. McGowan, talk to us about the Modeling Report.

ADAPTIVE RESOURCE MANAGEMENT MODELING REPORT

DR. CONOR McGOWAN: I want to thank the commission for having me here today to present the work that we have been doing. I'm here to talk about the progress of the Adaptive Research Management Working Group, where we've come from and where we stand and hopefully where we're going.

First of all, all the people listed on the slide here have made tremendous contributions to this work. This has been a group effort for many individuals on this subcommittee, as what we're calling it, that I've been working with. This process was initiated at the National Conservation Training Center at a structured decision-making workshop that I believe was initiated by Greg Breese to bring shorebird biologists and horseshoe crab biologists and structured decision-making experts together to try to gain some traction on horseshoe crab management in the Delaware Bay and try to bring in a process to help make some decisions about management of horseshoe crabs.

That process was brought to the joint technical committees, which was the Shorebird and the Horseshoe Crab Technical Committees. Their first joint meeting was in October of 2007 where they introduced this idea of structured decision-making in adaptive management to the technical committees and from there decided to move forward.

A few months later, in May of 2008, I was hired as a post doc and a research associate to develop these models, work on some of the computer programming and some of the parameter estimation. Following that, in September of 2008 there was the second joint

technical committee meeting, and at that meeting we worked on refining management objectives, refining management alternatives and beginning to talk about model structure and how we were going to make predictions about management actions.

Following that was the third joint technical committee meeting, which happened just a few weeks ago in Baltimore, at the end of March. Again we refined our objective statements, we refined our management alternatives and we presented and refined our alternative model set for making predictions about the system.

All along the way we have had a number of ARM Working Group meetings. We get together about every two months and discuss our progress and discuss where we're going. What we're trying to do is bring in this process called "structured decision-making" to the management of horseshoe crabs in the Delaware Bay and adaptive management, more specifically.

Adaptive management is just structured decision-making with decisions that made over and over again through time. It is a pretty intuitive name. The idea is to break a very complex and difficult set of decisions down into their component parts. The keys are to bring all your stakeholders together and to have them, through consensus and agreement, come up with management objectives, come up with management alternatives, develop models to predict how management actions are going to affect the system and then develop a monitoring protocol to assess whether your models were correct and how the system responded.

We call that the setup phase. From there you implement the management actions. You do it annually or biannually or whatever your time scale is. You collect the monitoring information to evaluate how your models performed. Maybe every once in a while you can re-evaluate your objectives, add new management alternatives.

We call this a double-loop learning process for adaptive management. It is a great system because it is learning about the system and learning about your decision-making as an explicit part and an explicit goal of what you're doing. You're regularly over time re-evaluating your models and comparing predictions with monitoring data and so on and so forth.

I would say that we are right about here in the process. We have brought the stakeholders together. We've established objectives, alternatives and seem to have agreed upon a set of candidate models to describe the system. We're making plans to develop monitoring protocols for monitoring once this plan is – if it is accepted and implemented.

One of the real primary goals of this process is to account for as much uncertainty about the system and about this management decision as we can. In natural resources we typically acknowledge four types of uncertainty. Ecological uncertainty would be uncertainty about how the system operates; how did these two species, the red knots and the horseshoe crabs interact; how does the horseshoe crab affect red knots, if at all.

Environmental variation is simply weather or other unpredictable stochastic environmental events. Partial controllability is a form of uncertainty in which you cannot fully control your management action. I like to use the example of setting up a duck hunting season. You can set the limits on numbers of days, the number of ducks that individual hunters can go out and collect or shoot ducks on, but you can't ever be sure that perhaps some hunters are going to take a couple extra ducks here and there, maybe go out an extra day, and so that is not a fully controllable management action.

Partial observability is also called sampling error and that represents – it is basically when you can't have full knowledge of your system; we'll never really know how many horseshoe crabs are out there despite the best sampling efforts that we could design. We can't actually go out and census or individually count every single one. Those kinds of uncertainty can all affect how successful your management decision is going to be and can affect how the system is going to operate under the management action that you choose.

Our efforts primarily are focusing on ecological uncertainty and environmental uncertainty. Partial controllability is probably or could be an issue in this system, but we have decided within the ARM Group and within the larger joint technical committees to roll partially controllable or extra harvest into natural mortality. That's going to come out in our survival estimates, and so it will be included in the model in that sense but not explicitly included.

Partial observability, especially with an animal like the horseshoe crab or even the red knot, where counting these individuals is so hard, estimating survival presents a lot of challenges; we just don't have the software or computer capability at this time

to really incorporate that kind of uncertainty, so, unfortunately, we just have to bypass that at this time.

We're mostly focused on ecological uncertainty and environmental variation. Most of what I'm going to talk about – well, not most of, but a good portion of what I'm going to talk about today is how we are incorporating this concept of ecological uncertainty. As I said, we've brought together the stakeholders and we've tried to come to agreement on a broad management objective for the Delaware Bay and for horseshoe crab harvest in the Delaware Bay.

This is sort of the qualitative statement that we've agreed upon. We want to manage the harvest of horseshoe crabs in the Delaware Bay to maximize harvest but also to maintain ecosystem integrity and ecosystem stability and provide adequate stopover habitat for shorebirds migrating through the Delaware Bay.

This is a fine statement and a fine goal but it is rather hard to quantitatively measure with data. How do you define ecosystem stability and integrity? We tried to convert that or translate that into something a little bit more quantitative and something that's a little bit more tangible so far as monitoring data would go.

This is the first effort from that workshop at the National Conservation Training Center back in 2007: "To maximize allowable harvest of horseshoe crabs with the constraint that 90 percent of early arriving red knots reach 180 grams by May 28th, so 180 grams is the magic weight for red knots. It is a weight that they have to – according to most published reports and various metabolic studies that have been done, 180 grams of weight is what required for a red knot to survive the flight from the Delaware Bay to the Canadian Arctic where they breed.

And 90 percent seems to like it would be an awful lot and a really good target to reach; however, this kind of a statement doesn't prevent us from having just maybe a hundred red knots out there and 90 of them making weight each year. We needed to translate this original statement into something that really was more reflective of what the stakeholders were interested in, and that's abundance of each of these species.

We tried to translate this into something that can be measured in numbers of individuals in each species or each population. What we have come up with is pretty clunky and complex and it involves a lot of words, but that's because we're dealing with two different species and some complex issues.

We're still trying to maximize the allowable harvest of horseshoe crabs in the Delaware Bay, but harvest of females is going to be constrained by either red knot abundance or horseshoe crab female abundance. If either of those two exceeds a predetermined threshold value, then harvest of females will be valued. For males, they are valued when the sex ratio of the population is two-to-one males on the spawning beaches.

I have some graphical representations of what these, we call them utility functions look like. This first graph up here is sort of a hypothetical population trajectory for red knots. Really, the point is that as the red knots increase and they reach this threshold of 45,000 individuals, then we apply value to the horseshoe crab harvest.

When they are up in this range above 45,000, female harvest has a value of one; when they are below 45,000, female harvest has a value of zero. If this condition is not met, we have allowed in the system for situations where red knots are still floating down here below this threshold; however, horseshoe crab populations have increased to very high levels and the red knots are not responding yet, so incorporated in our objective statement is a component that says either this condition has to be met; or, if horseshoe crab female abundance reaches 7 million, we start to allow for value on that harvest. Once they reach 11.2 million we have full value on that harvest.

This point down here is 50 percent of carrying capacity according to the population models and this up here is about 80 percent carrying capacity according to the population models. For male harvest this is what the utility function mostly looks like. This is the declining sex ratio that says males on this axis and females on this axis, and this is the operational or spawning sex ratios that we would count on the beach.

We have said that two-to-one females should be present, and that's really where we think, based on the best scientific data and population modeling series, that the horseshoe crab population would be growing at its maximum natural rate. Any males in excess of that are unimportant as far as fertilization and population growth rate goes and therefore could be harvested without affecting population growth rate.

These utility thresholds were sort of group derived. We got together with the joint technical committees at the end of March and hashed out where we thought these values should be, where the red knot population threshold should be, where the horseshoe crab population threshold should be, where that sex ratio threshold should be.

They reflect our best judgment as far as scientific information goes about, say, historic population sizes for red knots. We looked at some data and it looks like the Delaware Bay used to regularly support about 45,000 red knots during the stopover period, and therefore that was set as the target for future management goals.

They also reflect risk tolerance. We, in the group discussion, decided that – you know, obviously, we're very concerned about shorebird populations and red knot populations, but if we haven't seen much response from those species but horseshoe crabs continue to increase, we wanted to start allowing for horseshoe harvest, which is where that complex female utility function comes in.

Basically we're trying to balance between the idea of a maximum sustained yield would say that about 50 percent of carrying capacity is where you would want to manage for, but because of our concern over the corollary shorebird species, we have that sliding scale up to about 80 percent of carrying capacity, and hopefully we can find somewhere in between.

We're avoiding risk but allowing for a value to be extracted from the system. The process here is that the program that we're working with is called ASTP, Adaptive Stochastic Dynamic Programming, and it tries to find the maximum value or the maximum reward of harvest using a function somewhat like this. The utility functions that I just described are multipliers in this equation that says for every female harvested you multiply it by this utility function, and that will tell you what your value is for harvest of that year.

The program sets up these giant matrices of all possible population size combinations for horseshoe crab females and males and red knot abundance, and it applies each management action to each one of those possible combinations of population size and says, okay, what is your reward from this management action, what is the combination of these management actions that gives you the maximum reward over time? It is fairly mathematically intensive.

That brings us to alternative actions. Again with the joint technical committees we've come up with a limited list of six possible management actions ranging from full moratorium all the way up to 495,000 males and 330,000 females. This is the current list. There are possibilities, of course, for altering this list. There were some suggestions made at the joint meeting in March for possible alterations and we are entertaining those ideas.

We are trying to limit it to six maybe seven possible alternatives because each time you add another alternative you have a whole new set of comparisons to make. We're taking each possible population size combination with each management action. If you add another management action it gets exponentially bigger with each one, so we're trying to limit that list to just six or seven management actions.

We have developed a set of predictive models, and this is really where the ecological uncertainty comes in and our efforts to try to account for differing science and differing opinions on that science and how the system actually works. We settled on one horseshoe crab population model that is based on this Sweka et al publication from a couple of years ago.

We've modified that slightly into a stage-based model. We have said that the adult horseshoe crabs reproduce; they produce juveniles; the animals stay as juveniles for a number of years. Most likely they have small probabilities each year of transitioning out of that in a sub-adult phase or into a breeding adult life stage.

We have expanded the model, as well, to include a male component down here, and those males affect the population growth rate by affecting fertility rates of females. We've used parameterization of this model to reflect that of the Sweka et al. We had entertained for quite a while the use of a Logistic Growth Model based on Michelle Davis' work. In conjunction with the joint technical committees we've decided to set that model aside for the time being.

Because the complexity of the decision process is already so tremendous, we've decided to try and just focus on the one stage-based model at this time and perhaps revisit the utility of the Logistic Growth Model as part of that double-loop learning cycle that I mentioned in the very beginning and re-evaluate the appropriateness of the stage-based model compared to the logistic growth model and move forward from there.

I did mention the model has males and females, and the males affect the population rate through fertility rates essentially. What the theory and the best data available indicate is that females will not crawl up on the beach and spawn unless they are emplexus with the male prior to coming up on the beach. What the data available show is that you have to have about two-to-one males to females on the spawning beaches in order to reach near full emplexus of the females out under the water.

What we've designed in this model is a declining function that if males comprise fewer than two to one of the spawning population on the beach that fertility function is going to decline again because those females aren't crawling up on the beach to lay their eggs. This is where the real ecological uncertainty comes into play. We basically have three alternative models to describe red knot population dynamics.

One is we're calling a no-effect model, which says that the horseshoe crabs have no effect on red knot populations. This might reflect the view of horseshoe crab fishermen or somebody on one end of the spectrum. We have a model that say horseshoe crabs affect red knot fecundity only, which would mean that birds that aren't able to get enough food during stopover forego the opportunity to breed that year or perhaps don't migrate to the Arctic; perhaps head back south.

Then we have a third model over here on the right that says horseshoe crab abundance would affect both red knot fecundity and their annual survival; so even though birds aren't making weight, they do try to make that migration and most likely fail because of poor condition. This is the essence of the three models.

This is a complex slide and I don't plan to spend too much time on this, but it's all based essentially on the Baker et al model from 2004. It's a published in the Proceedings of the Royal Society of London, I believe. It's a three-stage model. The adults produce the young of the year; the young of the year become juveniles that don't breed in their first year; and then those juveniles can become adults.

This is the no-effect model. Under the affect model, fecundity or the survival model, each year the population is split into a proportion that make the required weight to survive or the required stopover weight or proportion that don't make that required stopover weight. Then in those two models they would either survive at different rates or reproduce at different rates and so on and so forth.

But, pretty clearly evident right away is that the proportion of birds that make 180 grams is a key component and understanding what dynamics drive that is going to be really important for success and validity of these models. We're trying to use mark recapture data. The state of Delaware and the state of New Jersey for a number of years have been catching birds and putting bands on these birds and trying to track survival and stopover times and those kinds of issues.

We're trying to use that very same data set to look at the probability of becoming over 180 grams while secure in the bay. We're able to track the arrival of individuals. Whether or not they arrive above or below this weight threshold, we can estimate from that information what probability of those birds transition to above this 180 grams threshold by looking at within-season recaptures.

Then we can come up with up with probabilistic estimate of what proportion of this population is leaving the bay having achieved that golden weight or not. Some actually fairly simple calculations; this is the birds that arrive at lightweight during the first time period and transitions to being heavy, so A to B is light to heavy. You can add to that the probability of arriving heavy in the first period and staying heavy and then the probability of arriving heavy at the end of the season, and that's your proportion of birds that reach 180 grams.

The key here is that these transition probabilities, the TAB and the TBB, are going to be linked to horseshoe crab abundance and specifically female spawning abundance during the stopover period. We have data on population size and data on spawning that takes place during the stopover period.

Currently this is a linear function, but we're using the mark recapture data to evaluate what functional form this would take. We can apply a function that says the probability of transitioning from one weight class to the other is dependent on the number of females that spawn during the stopover period.

All this work is continuing work. We are currently deep in the throes of parameterizing this red knot survival model using that mark recapture data. We are trying to come up with those transition probability relationships from that mark recapture data. We are continuing to work on these models. We have plans to put weights on the alternative model.

We have three red knot models; what is our confidence in each of those models? We are going to put weights on those models going into the optimization process. We are going to be developing a monitoring protocol looking at the current monitoring efforts and trying to relate those to our model outputs and looking at ways to adjust and possibly improve those monitoring efforts to help re-parameterize models and help evaluate the success of those models as we move forward.

What the program is going to do is take all these population models that I just described and the input parameters that we put in there and spit out a gigantic decision matrix that tells you again each combination of population size. We have juvenile horseshoe crabs, pre-adult, adult females, adult males, and then we have juvenile red knots and adult red knots.

This gives you a population status for each of those state variables and then a corresponding management action that would be best or optimal under those conditions. So if you go out in the field and measure these abundances, this would be your best management action at that time. The table that this spits out is on the order of 100 megabytes in size. This is a huge output file, and we're trying to work on ways to simplify that into something that is a little bit more useful.

We're hoping to come up with something that looks more like this, to be able to put the population sizes in bins and say if you have 10 million juveniles and 10 million pre-adults along with 5 million of each adult six and a lot of red knots around you can harvest the Package 6. However, if red knots are not that abundant or at least juvenile red knots are not that abundant, the optimal option here would be to scale back and do Package 4.

We're hoping to come up with a decision matrix that is simplified compared to the original model output. Our goal for this work is to continue doing this model development through the summer and hope to have some initial preliminary runs and an initial preliminary decision matrix developed by July.

We will be hopefully having another joint technical committee meeting in July to evaluate that preliminary work and discuss model weighting and how to proceed in the future. We would like to have a relatively finalized product done by the fall so that we can enter an ASMFC peer review of that work in October of 2009; and then if all goes well, a presentation to the ASMFC board on the products and on this project in February of 2010.

Following that we would love to implement this monitoring and modeling work that we have done with continual updates on a two-to-five year cycle as we move forward. I think that is all that I have prepared to present today.

CHAIRMAN BOYLES: Dr. McGowan, thank you, excellent presentation, very informative. Mr. Adler.

MR. ADLER: On that package thing where you have harvest versus red knots, does anybody have a model as to how many horseshoe crab eggs we need to save for the horseshoe crabs? I don't know what portion of eggs the red knots eat, but we do have to save enough – never mind the red knots, we do have to save enough eggs to keep the horseshoe crabs functioning.

I don't know if that's anywhere in the mix of models and also the fact of the other species that push away the red knots like the laughing gulls and everything else, and all that stuff needs to sort of be in somewhere in the package of whatever packages. I just wanted to put that in.

DR. McGOWAN: Thanks for that. Before I get right into your question, Dave Smith is essentially my supervisor. He is here as well and sometimes I may defer to him or he may interject better responses than I have for you. I don't think that anybody – well, the Sweka et al model did quite a bit on density dependence and how abundance of females can affect the reproductive rate.

It's all through eggs, essentially. They have a density-dependent egg mortality function in that model. That model could probably be used to look at varying egg densities and how that would affect the population growth of horseshoe crabs. As far as red knots are concerned and most of the bird species in the bay are concerned, they are basically, as Dave likes to say, egg scavengers.

They are consuming eggs that have already been brought to the surface through wave action or through other females disturbing nests, and those eggs aren't going to be viable, anyway, because they have been brought too close to the surface, they will defecate within a few days and won't be contributing to the population growth for that species.

As far as other species like the gulls and even other shorebird species that are competitors for those eggs that have been brought to the surface, we're not really explicitly addressing that in this model. What

are basically unfortunate computer limitation reasons we don't – the work that we're doing is I tried to impress upon you the tremendous amount of mathematical calculations that go into each iteration of this model.

Everytime you add a new variable and a new state variable to keep track of, the complexity just blows up very, very quickly, so we're not going to try explicitly model seagull populations because that adds a whole new dynamic model to keep track of. Instead we are going to do our best to convince you that those kinds of dynamics are going to be rolled into variability surrounding the transition probability, the weight gain relationship of the red knots.

So, if years where there is sufficient eggs and it looks like the red knot should be just fine but weight gain isn't very good and it's because of increased gull populations that year, we're hoping that kind of thing will be rolled into a distribution on the slope of that relationship between the weight gain and crab abundance probabilities.

We're having to rely on that kind of explanation quite a bit. We're having to rely on – this is an incredibly variable system. There are lot of variables that – if we could we'd love to keep track of everything, but for the sake of simplicity and because of limitations in computing power we're going to have limit of variables that we can include and incorporate a lot of stuff into the model as stochastic variations in the environment.

MR. PATRICK AUGUSTINE: I'm not sure if it was a good presentation or a bad presentation because I'm baffled. It just seems to me if you have all this calculating capability that you just in the last three minutes blew everything out of perspective in my mind, being an old guy I can't think broad, so let me scope it into the last three sentences or so.

When you said you can't account for the shorebirds or the seagulls or whatever they happen to be and their impact on the stock or the food for the red knots and you talked about how we're going to use some other way of determining what that impact is, you come up with a recommendation I think in the final analysis to this board that has to make a hard decision based on a limited assessment of the impact on the horseshoe crabs and the food available.

Maybe I didn't state that clear enough, but it just seems to me when you talked about the three models that you're looking at and the interaction between the three models, the amount of mathematical computations you have to do to come up with this analysis, and then at the end you say, well, we're not considering the impact on the seagulls or shorebirds, that number needs to come up from someone, whether it's from Mike's work or somebody else's work, but how do we quantify that because it definitely has an impact. I don't know if I've confused you or you can pull a question out of that, but anything you could give me would be helpful. Thank you.

DR. McGOWAN: Perhaps I misspoke. I guess what I'm trying to say is that we are not explicitly going to be saying this component is the gull component, this component is the dunlin component, this component is the – we're going to be accounting for all that variation and all those external influences in environmental or stochastic variability on these two components of this relationship.

They're written here as specific values, but in the model they're going to be stochastic parameters in the simulation and in the optimization. We can set up a distribution on these two. We can specifically describe a distribution for the program to select a value for the slope of this line and the intercept of that line in any given year.

The variation around that slope or around that intercept is where we are implicitly including the effect of other shorebird species or other bird species and even weather events and those kinds of issues. That's how we are going to incorporate that into the model at this time.

MR. AUGUSTINE: That helps a lot; thank you very much.

MR. FOTE: After looking at the horseshoe crab problem in the Delaware Bay for many years and being involved in this for many years, when we would look at it we would look at the loss of habitat. I mean some of these aerial photographs I've seen over the years, you know, there were a lot more sandy beaches for them to come up and spawn on and we've lost a lot of that.

With the rise in the Delaware Bay and the rise of water columns, it is going to have a great effect on what horseshoe crabs do and what the birds can feed on. I guess I'm having the same senior moment that Pat is having here because those are the variable I look at. They are the ones that are the major players as we basically walk along through this process.

Again, as I talked about a couple of board meetings ago about winter flounder, I got to things that we are talking care of the power plants, but we are not taking care of the sewer plants and everything else that is contributing to the environmental factors. I notice that we just reauthorized another power plant in New Jersey without requiring cooling towers, but I didn't want to get into that discussion.

So, the habitat issues to me are really of paramount concern here, and there's just so much you can model. Unless you take in full consideration of what was there previously, what is there now and how that affects the birds, because now you're pushing more and more birds into a smaller area and competing against each other to feed on the eggs.

CHAIRMAN BOYLES: More questions? Seeing none, Dr. McGowan, again, thank you very much for a good presentation. We're going to now go to the Joint Horseshoe Crab and Shorebird Technical Committee Report. Mike, you're going to go first with a presentation.

JOINT HORSESHOE CRAB AND SHOREBIRD TECHNICAL COMMITTEE REPORT

DR. MIKE MILLARD: Trust me, folks, that was the simplified version. The joint committees, the Horseshoe Crab Technical Committee and the Shorebird Technical Committee, met jointly at the end of March in Baltimore. As there always is when these two groups get together, there were a few exciting moments.

As usual when these joint meetings are over, I go home irritated and grumpy because of certain things that go on at the meetings which I should come to expect by now. I can tell you there is an advocacy fox at play in the scientific henhouse, and I get irritated by that. It is an intolerance that I'm working on; that's all I can tell you. That's the bad news.

The good news is – and this is my point here – that these folks to my left, it doesn't seem to bother them. They are keeping their eye on the prize; they remain tied to the mast; and they're moving forward in what I believe is the most appropriate direction. I guess I'm just telling the board I think you should feel good about the way this is going. It's going to be a good answer; the best we can get out of this process, I think.

I know my colleague, Greg Breese, is tired of hearing me rant about some of his charges over which he has no control, but, again, I'm trying to work on that problem. Given that, I'm here to give you a little bit of an update on the abundance surveys for horseshoe crabs, tying in last year's results to the time series that we're building.

This is the tenth anniversary of the Spawner Survey, and whatever I say about the Spawner Survey I need to give credit to the folks who generated – many people generate the data, but the people who pulled this together for the most part are Stew Michels from Delaware, Dave Smith to my left for USGS, and Sherry Bennett from New Jersey, so I want to give them credit. Benjie and Carl were instrumental in the formation of this.

As you know, you have this heard this now, this is the tenth year, as I said. It's one of the better, I think, more accurate surveys you're going to see for something this size. CVs are less than 10 percent for the last seven years. In '08, as most of you know better than I do, we had a tremendous storm event on May 12th, a northeaster, that significantly altered the habitat, the thermal habitat and the beach habitat particularly on the Delaware side of the Bay, and we think this likely influenced a lot of the results you're going to see now.

Particularly this one, the female – that ISA is the Index of Spawning Activity. That's the response for what we're talking about here. The spawning activity peaked in the third lunar period, which is basically the beginning June. It declined between the first and second, at the end of May, something we've never seen before.

Most female spawning occurred in June. For the first time there was more May spawning in Delaware than in New Jersey. Dave has performed this analysis. The female spawning is highly correlated with water temperature. Despite what is a downtick – as we'll see in the graphs, last year was a downtick in almost every graph. The index remained stable. Statistically there is no significant trend over the ten-year study. That was for females.

For males it's a little bit more variable. The CVs are less than 20 percent in the bay-wide male spawning activity; again, like females showed no significant trend over the ten-year study. Here is a graph of the females in Delaware and New Jersey and you can see for last year, the last point on the graphs, was a downtick in both cases.

If we combine both states into a bay-wide index, again, this barely noticeable downtick in '08; and the

same for males. I don't think we're too concerned about that. No one thought this was going to be a monotonic increase from now until eternity, so it doesn't trouble us that much at this point, I think.

This looks complicated; it's not; I'm going to make it simpler here in a minute. This is just the spawning divided up into the lunar periods. Number 1 is basically the first two weeks of May; the last two weeks of May; the first two weeks of June; and the last two weeks of June. What I want to point out here is last year – I just highlighted the '08 line – you can see we started out roughly in the middle of past years, but then in the second lunar period we went down.

That has never happened before in this ten-year survey. This is first time we have seen a decrease at the end of May in spawning activity, and that's when this storm event hit. It dropped water temperatures, blew away some beaches, I guess, pretty much whole spawning beaches. That is a fairly unique event that we think is significant in the data you're seeing.

Then it went up the first couple weeks of June, one of the higher ones we've seen in the last ten years, and then back down where the rest of them were. Here is the water temperature record. Here is where the northeaster hit. We were just crawling over 15 degrees C. in the beginning of May and then the northeaster hit and dropped the water, and we kind of crawled along right below 15 for the remainder of May for the most part, which was significant.

This is the correlation – I'm sorry you can't see that – these big dots are '08. The temperature increases across the bottom here and the spawning index increases on the Y-axis. Of course, where you want to be up here is warmer temperatures and up here where the spawning index is higher, but the '08 numbers were down here. That's it with the spawner survey.

Now our major tool is the Virginia Tech Offshore Trawl Survey, which we heard a little bit about a couple of minutes ago. Just to remind you, it has a core area, both sides of the Delaware Bay and then a peripheral area expands out a little bit beyond the core area. This has been going on in the core area for eight years now, counting '08, and seven years in '02. This is a fall trawl survey. We give credit here to David Hodd and Eric Hallerman of Virginia Tech for this data.

Similar to the spawning survey, there was a downtick in '08. Nearly all demographic groups were lower in '08 than in '07, but on a year-to-year annual comparison it wasn't a statistically significant dip. The data do indicate continued recruitment, which is the good news, of small horseshoe crabs to the survey area.

I'll just run through a few graphs here real quick. The details aren't important. You're going to see this same sort of downtick in '08 compared to the preceding years. This is for immatures, crabs that have not yet spawned. These are pre-spawners. These are crabs that they determine are mature, have eggs but have not yet spawned; the same general pattern.

For mature spawners, these are crabs that are showing rub marks or have spawned in the past and are mature adults; the same general pattern – and the total. Again, we are seeing the increase and then last year we had the downtick. This slide I'm afraid is not going to show too well, but these are smaller crabs. This has to do with the recruitment showing up, recruitment of smaller crabs into the survey area.

I've highlighted these length frequencies for smaller crabs, which you didn't really see in previous years showing up in the trawl survey and now you are seeing them show up in the trawl survey, which is good news. We think it indicates recruitment of the smaller crabs, better recruitment of the smaller crabs into the survey area.

Virginia Tech also, in response to the peer review panel last year, conducted a pilot study on juvenile crabs. They went nearshore from zero to three miles off with a four-inch net and then used the six-inch net, which is what they normally use in the fall. They tried this sort of new survey nearshore with a four-inch net also for juveniles.

They sampled 15 sites off of Delaware Bay, caught 20,000 horseshoe crabs, 65 percent of them in the four-inch net. They saw three or four immature cohorts in the study area. Just to show you where the study was, it was south of the mouth of Delaware Bay in this stippled area here. The bigger dots mean better CPUE in this nearshore juvenile survey.

These are immatures greater than 140; no clear pattern; and these are immatures less than 140, and it looks like the younger ones were more abundant further south from the Bay. My last slide is males and females. The circles are filled in now. The blacks are first-time pre-spawners. Those are the ones that we think are going to spawn this coming year but have not yet spawned. Then the white part

of the circle is the repeat spawners, adult repeat spawners.

There seems to be some signal here that there are more black in the circles further away from the Bay and the repeat spawners are closer to the Bay, which might be consistent with crabs coming out of the Bay during the summer after the spring spawn. Well, I'll stop there and open it up for questions. Those are the two major tools as you all are aware by now, the Virginia Tech Trawl Survey and the Spawner Survey, that we're using for keeping track of population abundance.

CHAIRMAN BOYLES: Mike, thank you for that. Any questions or comments from anyone from the board? Okay, thanks for the presentation, Mike, great job. Greg.

DR. GREGORY BREESE: As Mike already said, there was a joint committee in March. That's the only meeting since the board last met. We don't have a lot of new material or information to present or update, but it won't hurt to go over a few things quickly. The meeting was primarily focused on the work of the ARM Workgroup, but we did get a quick update from Virginia Tech on the work they've been doing down in Virginia.

It appears from the work they've done that red knots have been using that part of the coastline for a long time. It's fairly stable. They're feeding on a different food source down there, coquina clams. There are seeing birds from all the wintering areas that are known, so apparently a variety of birds are coming there. It's not just the South American birds, Tierra del Fuego, or just the northern birds or just the Florida/Georgia birds. It is a mixture of them.

That's from the tagging that's been done and the resightings. There seems to be some mixing. They've been doing this for two years and they're seeing a little bit of a shift in a small percentage of the birds. That was a quick update we managed to get in after we got through the other discussion.

This is the area that they're doing the work in case people aren't familiar with where they're working compared to Delaware Bay. Mike covered the nor'easter we had last year in great detail. I'll just add that we saw out on the beach, trying to work on birds, that the sand, especially on the Delaware side, had been pushed way back into the marsh and that there wasn't any spawning firsthand, and that the birds were spending a lot of time moving around from beach to beach, so it definitely had an impact.

What I'll do is go over quickly the indices that we've been using to help you in your deliberations. There is only one that has new data that you haven't seen before, and that is for the winter count down in Tierra del Fuego. The Shorebird Weight Index you saw at the last meeting. Again in 2008 weight gain or the proportion of birds that had reached that 180 or above body weight was down from previous years.

There are two egg abundance indices that have been going on; once since 2000 and that was what New Jersey got started and has continued up through 2008. You can see not a large change, but 2008 was definitely a dip down. Then the Baywide Egg Index which began in 2005; I don't have an update on that, but I did talk to the people who are in charge of that, and they pointed out that the peak in egg abundance did occur in June, just as spawning peak occurred, which you would expect, but just so you know.
The winter count down in Tierra del Fuego, I got some personal communication from Guy Morrison in Canadian Fish and Wildlife who told me that the value you can see over on the right was a little bit higher than 2008, more along the lines of 2006 and 2007; so again a relatively flat, no trend type of a picture we're getting for the last five years.

In Delaware Bay, as you know, there's an aerial count that more looks at bird use rather than populations. It's affected by when the birds arrive and how long they stay. Again, the trend is pretty flat for the last six years. If you look at the count for the combined six major species that use the Delaware Bay, again you have a similar pattern.

Now you might not have seen this graph. I think these next few graphs will be new, but you heard the results. This is a survival estimate using recaptured birds based on the metal bands, so there is a very small sample size to this, but this is what the survival estimates look like over the time period.

But what we have been able to do by color markings so many birds and being able to resight individual birds with spotting scopes is really increase the confidence of the estimate. This is the same survival estimate although for a shorter time series since the birds haven't been tagged or color marked individually, but you can see much a tighter estimate of survival.

One interesting thing that is in this analysis is that the Tierra del Fuego birds, the dark bars for 2005-2006, seemed to have a higher survival rate although they're migrating further than the birds in Northern

Brazil and Southeastern United States. No speculation on why; it's just a curious thing that you can see pretty clearly here.

Recruitment estimates have been done based on what you see when you recapture birds. You can identify second-year birds, which is the first time they reach Delaware Bay, by their plumage. Based on that, this estimate is looking at two-year-old birds that are recruiting into the breeding population by showing up at Delaware Bay.

So you can see this recruitment estimate, and it's fairly striking that there were four pretty good years; two years that look like pretty much a bust; and then three years are sort of in between there. Then last graph, again you have seen this, this is looking at semi-palmated sandpipers which are more heavily dependent on horseshoe crab eggs than least sandpipers.

The left graph is semi; the right graph is least. The thing to pay attention to is the least graph on the right shows a very similar pattern over two time periods, an early time period and a late time period; whereas, the semi-palmated sandpipers on the left show a significant difference between the weight gain and the weight gain for the last year of this work was sort of intermediate.

In summary the 2008 nor'easter seemed to have an effect in terms of reducing weight gain. There hasn't been much trend over the last five years in the Tierra del Fuego winter count or in the last six years over the peak aerial count at Delaware Bay, and we're looking forward to some recommendations on how best to do the monitoring to support the Adaptive Resource Management Workgroup's efforts.

CHAIRMAN BOYLES: Greg, thanks for a great presentation. Questions for Greg? Now, Brad, terms of reference.

MR. SPEAR: I'm going to go over two different sets of terms of reference. In the peer review that is scheduled for the fall, the technical committee will be bringing forward both the Adaptive Resource Management Modeling efforts with the Horseshoe Crab-Only Stock Assessment. We have broken up the terms into those two different categories.

The ARM Modeling Terms were included on the briefing CD and you're just now receiving the Horseshoe Crab-Only Terms of Reference, and I will go through both. First, looking at the ARM Model Terms of Reference, the purpose of the review is to evaluate whether the ARM framework and predictive modeling is appropriate for the horseshoe crab/red knot issue.

The terms of reference basically follow the key elements that Dr. McGowan had in his presentation. The first term of reference is in the category of objectives, and that is to complete an explicit objective statement to reflect societal values relevant to the Delaware Bay Region Horseshoe Crab/Red Knot Issue.

The second term under objectives is to assign an objective function that accurately represents the objective statement, addresses competing objectives, and is expressed in terms that can be evaluated using monitoring data. The third term of reference is in the management alternative section, and it is to produce alternatives that result in a range of cost and benefit to all interested parties that are designed to remain static until expected results can be evaluated; alternatives that can be implemented in a timely manner and that are politically feasible.

Most of these terms are based on kind of the theoretical background on this modeling that has been done in the past and published in the literature. The third section is the predictive models. Term Number 4 is to evaluate the precision and accuracy of the data used in the assessment. Number 5 is to evaluate the models used to estimate population parameters, biomass and abundance.

Still in the predictive model section, the sixth term is to evaluate the use of multiple models to clarify uncertainty. Number 7, state and evaluate assumptions made for all models and explain the effects of assumption violations. Number 8, evaluate uncertainty of model estimates and to perform retrospective analyses.

The next section, measures of model credibility, the group will establish model weights that reflect relative credibility and establish procedures for updating model weights based on new observations. The last section is the monitoring piece, and that is to develop a list of ongoing monitoring programs and develop a list of gaps where the monitoring activities are needed to populate data use for the modeling, and then to provide a list of recommended monitoring programs to fill those gaps. Okay, that is the Adaptive Resource Management Modeling Terms. Any questions on those before I move on?

Okay, the next one is the Horseshoe Crab-Only Terms of Reference. Again, this Horseshoe Crab-

Only Assessment will be going through concurrently with the Adaptive Resource Management Review. If you recall, the last assessment was broken down into regions, and it was essentially a trend analysis due to data limitations for horseshoe crabs.

This assessment, the goal is to actually model the Delaware Bay Region's population because that's where the most data is and using the trend analysis for the other populations. One is to evaluate the precision and accuracy of data; two, determine the most appropriate assessment analysis or analyses; and, three, evaluate methods used to evaluate population dynamics and determine stock status.

Number 4, evaluate the current practice of conducting assessments at a regional level rather than coastwide; state and evaluate assumptions made for all methods and explain the likely effects of assumption violations on those results; number six, evaluate uncertainty of the results and biological or empirical reference points; recommend stock status or relative status from the trend analysis; and, finally, develop a prioritized list of research and assessment methodology for future assessments.

CHAIRMAN BOYLES: Any questions for Brad? Louis.

DR. LOUIS DANIEL: **I was just going to make a motion that we approve the terms of reference.** I think they're well thought out and well presented.

CHAIRMAN BOYLES: Okay, Pat Augustine seconds. Any discussion? Pete.

MR. HIMCHAK: Mr. Chairman, I just had question not on the terms of reference, but, Brad, could you comment very quickly on the composition of the peer review panel, and will the single panel review both the ARM Model and the Horseshoe Crab Stock Assessment?

MR. SPEAR: The panel hasn't been chosen yet. I believe the MSC weighs in on that as well as the science department and the executive director. Initially it was thought that because the Horseshoe Crab-Only Stock Assessment would be strictly a trend analysis, that any scientist with background regardless of shorebird or horseshoe crab would be able to review objectively that assessment.

Since the committee is now considering using models for the Delaware Bay population, there may have to be some sort of split in the peer review group or an additional person brought on just for the horseshoe crab aspect.

CHAIRMAN BOYLES: Louis, if I could, it is my understanding that the staff has not heard yet completely back from the entirety of all the technical committee on these terms of reference so would you make that that we conditionally approve this provided there are no other changes?

DR. DANIEL: Either that or I will withdraw my motion, whichever you prefer.

CHAIRMAN BOYLES: I prefer your original motion just with that understand.

DR. DANIEL: That's fine.

CHAIRMAN BOYLES: Is that okay with the seconder?

MR. AUGUSTINE: Yes, Mr. Chairman.

CHAIRMAN BOYLES: We have a motion to conditionally approve the terms of reference as presented for both models and seconded. Is there any need for discussion? Any objection to that motion? **Seeing none, that motion carries.**

I just want to remind the board where we are and what we've got in front of us. Just for you all to consider as we move into our next meeting, we do have the addendum that does expire. The management measures do expire at the end of Calendar Year 2009. We're going to have a couple of options before us as we meet in August, and I'm certainly looking forward to the results of the ARM.

I just wanted to put this in your mind as we move down the road. Our options, when we come back together, will be to extend the current measures as provided for in Addendum V for Calendar Year 2010. We have another option which is to allow that Addendum V to expire, in which case the management measures go back to those contained in Addendum III. Of course, we always have the option of initiating a new addendum. I just wanted to remind the board of that as well.

DISCUSSION OF LETTER RECEIVED BY EXECUTIVE DIRECTOR O'SHEA

The next item on the agenda, back in April the executive director received a letter requesting removal of participants from the Joint TC Meeting back in March. Staff shared that with me; and based

on my comments that I've heard back from staff, I understood that was a very productive meeting, but we did have those members to that meeting appointed and seated by this board and wanted to know if anybody had any comments or questions about that.

ADJOURN

You all received both the comment letter as well as staff's response. All right, seeing none, we will move. Is there any other business to come before the Horseshoe Crab Management Board at this time? Seeing none, we stand adjourned.

(Whereupon, the meeting was adjourned at 5:15 o'clock p.m. May 4, 2009.)