

Atlantic States Marine Fisheries Commission

Horseshoe Crab Management Board

November 10, 2026
10:45 a.m. - 12:15 p.m.

Draft Agenda

The times listed are approximate; the order in which these items will be taken is subject to change; other items may be added as necessary.

1. Welcome/Call to Order (*E. Reid*) 10:45 a.m.
2. Board Consent 10:45 a.m.
 - Approval of Agenda
 - Approval of Proceedings from May 2026
3. Public Comment 10:50 a.m.
4. Review Delaware Bay Bait Harvest Specifications **Possible Final Action** 11:00 a.m.
 - Review Horseshoe Crab and Red Knot Survey Data (*J. Sweka*)
 - Consider Changes to Specifications for the 2027 Fishing Year (*C. Starks*)
5. Consider Updates to Adaptive Resource Management (ARM) Framework 11:15 a.m.
Model Reward, Utility, and Harvest Policy Functions **Action**
 - Overview of Model Revisions Based on Stakeholder Input (*J. Sweka*)
 - Delaware Bay Ecosystem Technical Committee Report (*J. Sweka*)
 - Advisory Panel Report (*B. Hoffmeister*)
 - Consider Initiating an Addendum to Implement Changes to the ARM Framework
6. Consider Approval of Fishery Management Plan Review and State Compliance 12:05 p.m.
for the 2025 Fishing Year (*C. Starks*) **Action**
7. Other Business/Adjourn 12:15 p.m.

The meeting will be held at Hotel Viking (One Bellevue Avenue, Newport, Rhode Island; 401.847.3300) and via webinar; click [here](#) for details.

MEETING OVERVIEW

Horseshoe Crab Management Board

November 10, 2026

10:45 a.m. – 12:15 p.m.

Chair: Eric Reid (RI) Assumed Chairmanship: 2/25	Technical Committee Chair: Ethan Simpson (VA) Delaware Bay Ecosystem TC Chair: Wendy Walsh (USFWS)	Law Enforcement Committee Rep: Nick Couch (DE)
Vice Chair: Carrie Kennedy (MD)	Advisory Panel Chair: Brett Hoffmeister (MA)	Previous Board Meeting: May 5, 2026
Voting Members: MA, RI, CT, NY, NJ, DE, MD, PRFC, VA, NC, SC, GA, FL, NMFS, USFWS (15 votes)		

2. Board Consent

- Approval of Agenda
- Approval of Proceedings from May 2026

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

4. Review Delaware Bay Bait Harvest Specifications (11:00-11:15 a.m.) Possible Final Action

Background

- In October 2026, the Delaware Bay Ecosystem TC (DBETC) and Adaptive Resource Management (ARM) Subcommittee met to review results of the horseshoe crab and red knot population abundance surveys in the Delaware Bay region (**Briefing Materials**).
- Addendum IX allows for male-only harvest specifications to be set for up to three years based on the ARM Framework. In October 2025, the Board set male-only harvest specifications for 2026 and 2027.
- Under Addendum IX, the ARM Framework is not used to inform Delaware Bay region bait harvest limits in interim years of multi-year male-only harvest specifications and the male-only harvest limit is based on the male:female sex ratio of spawning horseshoe crabs on beaches observed in the bay-wide spawning survey. If the sex ratio is greater than or equal to 3:1, the maximum harvest of 500,000 Delaware Bay origin males is permitted (**Briefing Materials**).

Presentations

- Horseshoe Crab and Red Knot Survey Results by J. Sweka
- Review of Specifications for the 2027 Fishing Year by C. Starks

Board actions for consideration at this meeting

- Review 2027 Delaware Bay bait harvest specifications

4. Consider Updates to Adaptive Resource Management Framework Reward/Utility/Harvest Policy Functions (11:15 a.m.-12:05 p.m.) Action**Background**

- The Commission initiated a stakeholder engagement process in 2025 to get input on changes to the reward, utility, and harvest policy functions of the ARM Framework to better reflect current stakeholder values. The Board reviewed the final report in May 2026, which included recommendations to consider several changes to the reward, utility, and harvest policy functions of the ARM Framework.
- In May 2026 the Board tasked the ARM Subcommittee with developing the recommended changes to the ARM model (**Briefing Materials**).
- The DBETC met to review these changes in October 2026, in addition to a model code error correction (**Briefing Materials**).
- The Advisory Panel met in October to review the proposed model changes and provide input (**Supplemental Materials**).

Presentations

- Overview of Model Revisions Based on Stakeholder Input by J. Sweka
- Delaware Bay Ecosystem Technical Committee Report by J. Sweka
- Advisory Panel Report by B. Hoffmeister

Board actions for consideration at this meeting

- Initiate an addendum to consider adopting changes to the reward, utility, and harvest policy functions of the ARM Framework based on 2026 stakeholder input

6. Consider Approval of Fishery Management Plan Review and State Compliance for the 2025 Fishing Year (12:05-12:15 p.m.) Action**Background**

- State Compliance Reports were due July 1, 2025.
- The Plan Review Team reviewed each state report and compiled the annual FMP Review (**Briefing Materials**).
- South Carolina, Georgia, and Florida have requested and meet the requirements of *de minimis* status.

Presentations

- FMP Review of the 2025 Fishing Year by C. Starks

Board actions for consideration at this meeting

- Approve FMP Review and State Compliance Reports
- Approve *de minimis* requests

7. Other Business/Adjourn (12:15 p.m.)

DRAFT PROCEEDINGS OF THE
ATLANTIC STATES MARINE FISHERIES COMMISSION
HORSESHOES CRAB MANAGEMENT BOARD

The Westin Crystal City
Arlington, Virginia
Hybrid Meeting

May 5, 2026

These minutes are draft and subject to approval by the Horseshoe Crab Management Board.
The Board will review the minutes during its next meeting.

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2. **Approval of Proceedings of October 2025** by consent (Page 1).
3. **Move to adjourn** by consent (Page 13).

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ATTENDANCE

Board Members

Dan McKiernan, MA (AA)	Roy Miller, DE (GA)
Raymond Kane, MA (GA)	Craig Pugh, DE, proxy for Rep. Carson (LA)
Rep. Sarah Peake, MA, proxy for Rep. Armini (LA)	Carrie Kennedy, MD, proxy for K. Charbonneau (AA)
Nicole Lengyel Costa, RI, proxy for J. McNamee (AA)	Russel Dize, MD (GA)
David Borden, RI (GA)	Ethan Simpson, VA, proxy for J. Grist (Acting AA)
Eric Reid, RI, proxy for Sen. Sosnowski (LA)	Chris Batsavage, NC, proxy for K. Rawls (AA)
Shanna Madsen, MD (AA)	Ben Dyar, SC, proxy for B. Keppler (AA)
Bill Hyatt, CT (GA)	Malcolm Rhodes, SC (GA)
Robert LaFrance, CT, proxy for Rep. Gresko (LA)	Chris McDonough, SC, proxy for Sen. Cromer (LA)
Jesse Hornstein, NY, proxy for M. Gary (AA)	Doug Haymans, GA (AA)
Emerson Hasbrouck, NY (GA)	Spud Woodward, GA (GA)
Monica Martinez, NY (LA)	Gary Jennings, FL (GA)
Joe Cimino, NJ (AA)	Ron Owens, PRFC
Adam Nowalsky, NJ, proxy for Sen. Gopal (LA)	Chris Wright, NMFS
John Clark, DE (AA)	Lowell Whitney, US FWS

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

Ex-Officio Members

John Sweka, ARM Subcommittee Chair

Staff

Bob Beal	Caitlin Starks	Katie Drew
Toni Kerns	Tracey Bauer	Jeff Kipp
Tina Berger	James Boyle	Samara Nehemiah
Madeline Musante	Chelsea Tuohy	Jainita Patel

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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, via hybrid meeting, in-person and webinar; Tuesday, May 5, 2026, and was called to order at 1:15 p.m. by Chair Eric Reid.

CALL TO ORDER

CHAIR ERIC REID: Good afternoon, everybody, welcome to the Horseshoe Crab Board. My name is Eric Reid; I am a Legislative Proxy for Senator Susan Sosnowski from Rhode Island. I have the honor of chairing this Board. To my right is Ms. Starks and Ms. Nehemiah, and we have online Mr. Sweka if we need him. He's in the on-deck circle that if we need him, we'll be happy to connect you with him.

We also have with us today Mr. Crawford and Ms. O'Donnell, they are from Compass Resource Management, they did some work for us, and we're going to get a presentation from them and from Ms. Starks. Then we have a path forward we would like to present to you, and we'll see if we can do that without too much fanfare.

APPROVAL OF AGENDA

CHAIR REID: Let's get started. Approval of the Agenda, is there any changes to the agenda? Seeing none; agenda stands approved.

APPROVAL OF PROCEEDINGS

CHAIR REID: Approval of our proceedings from October 2025 meeting, is there any problem with those minutes? Seeing none; those proceedings stand approved.

PUBLIC COMMENT

CHAIR REID: Is there anybody in the audience that would like to make a public comment that is not on this agenda? Is there anybody online? Seeing none; very good.

CONSIDER REPORT ON STAKEHOLDER ENGAGEMENT PROCESS ON ADAPTIVE RESOURCE MANAGEMENT FRAMEWORK REWARD/UTILITY/HARVEST POLICY FUNCTIONS

CHAIR REID: We're going to have a presentation. We're going to consider the stakeholder engagement process report on the Adaptive Resource Management Framework, Reward/Utility/Harvest Policy Functions and that will be from Mr. Crawford and Ms. O'Donnell. Then Ms. Starks is going to give a presentation at the end and we will take questions at that time. We're going to go through all the reports first.

MS. TONI KERNS: Really quick, Eric. I just want to note that Adam Nowalsky from New Jersey is participating online, as well as Monica Martinez from New York.

CHAIR REID: Thank you, Ms. Kerns. With that, Mr. Crawford, Ms. O'Donnell, take it away.

MR. BRIAN CRAWFORD: Hello, Board members. Thanks for the opportunity to present today, where we've been looking forward to it for some time. My name is Brian Crawford, as was stated, my colleague Katie O'Donnell and I are facilitators and decision scientists with Compass Resource Management. Over the past eight months-ish, we've supported ASMFC in running a structured stakeholder engagement process to inform those updates of the value-based requirements of the Horseshoe Crab Adaptive Management Framework.

Today we want to briefly summarize the process, and focus on the stakeholder recommendations and rationales that emerge from it. Right up front, before we really launch into those recommendations, we want to acknowledge the people who invested in this process, specifically those 14 stakeholder representatives you see on the right side.

We gathered them from 6 broad interest groups engaged throughout the process, these were bait fishers, dealers, the biomedical industry and ecosystem horseshoe crab and shorebird

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conservation groups. We also had key participation and input from technical staff, especially the DBETC and ARM Subcommittee, and also had additional folks observe the process along the way.

Again, wanted to say thanks to that stakeholder group and others for the commitment to the ARM process of the whole and this process specifically, and really thanks for them for being open and genuinely listening to each other, and for working together to reach the recommendations we'll present today.

We also wanted to acknowledge and thank the Core Planning and Technical Committee that Compass worked with through this effort to design and implement the process. Most of them are on the call today, and maybe will be available to help answer any questions. Diving into what we did. Overall, this engagement process focused on these three objectives.

First, we wanted to continue to build stakeholders' understanding of these value-based functions in the ARM called the Utility, Reward and Harvest functions. Sometimes you might see them as U/R/H functions in this presentation. Second, we wanted to discuss and identify broadly supported recommendations for revising those functions that better represented stakeholder values.

Lastly, we, oh and along the way, in reaching those recommendations it is very important we also wanted to clearly document when different perspectives remained. Lastly, along the way, we really identified next steps and opportunities for improving the ARM Framework and the process around it as a whole. We'll kind of end the conversation today with some of those.

How did we get heretoday? Well, the stakeholder process began back in October with a short on-boarding period where we established the stakeholder group, had some initial interviews. After that we held

educational sessions that really focused on that first objective of building the group's understanding of the ARM, especially the U/R/H functions.

This also allowed for a good dialogue between the stakeholders and modelers. Next, we held an in-person workshop in January in Ocean City, Maryland, to discuss and elicit values and initial recommendations for updating the ARM. Last, we conducted post-workshop activities of discussing the stakeholder input with the Delaware Bay Ecosystem Technical Committee and ARM Subcommittee, which we will be referring to throughout this presentation as the Tech Committees occasionally. We also finalized those recommendations, documented remaining disagreements within the stakeholder group, and that was done with a meeting with them just a few weeks ago. We also established; we produced a report for this process that you should have received.

To make the process tractable, we were really explicit with the stakeholders about the scope, what was in and out of the scope of this particular process. The focal question we wanted stakeholders to really engage with is how their priorities and values should be better represented in the ARM model through the U/R/H functions.

We specified that kind of the underlying population assessment science, the fundamental structure of the ARM framework and past management decisions were all out of scope of this particular process. However, we really kind of acknowledged and were reminded by the stakeholders throughout this process that there is a connection, of course, between the science and values in the ARM.

We collected some of those concerns during the process and will return to them and insights for improving the ARM at the end of the presentation. Speaking of those connections, this was a diagram we developed to use throughout the process for stakeholders to represent kind of a more technical based and more values-based components of the ARM Framework.

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On the left we have the technical components that used best available science to predict kind of a current and future status and trajectory of horseshoe crabs and red knots in the Delaware Bay. These science-based outcomes are kind of what we expect the system to look like, feed into the values-based utility reward and harvest functions.

These functions encode the values of how satisfied we are with different levels of horseshoe crab harvest and red knot abundance, how to trade off those two competing interests, and ultimately how many horseshoe crabs should be harvested. This right side of the figure is really where the process focused.

What were the key outcomes of the process? We wanted to kind of give you a snapshot of these right up front, and then go into more detail then. Here we present kind of in broad strokes the 5 recommendations that emerged with broad agreement among stakeholder and technical committees in this process.

We'll walk through each of these in detail in the next slides. Overall, the group recommends changing the value of females to male horseshoe crabs in the harvest utility function. They recommend maintaining the current maximum harvest limits for male and female horseshoe crabs, updating the harvest policy function to trigger 0 harvest if the female horseshoe crab population falls below threshold.

Updating the red knot utility curve using values that we listed from stakeholders, and finally maintaining the current reward function structure that includes components of horseshoe crab harvest and red knot abundance. I used a term in that last slide called broad agreement that we want to define what that means and how we documented it.

At the final stakeholder meeting we asked participants to communicate the level of

support for each recommendation using these three defined levels. Endorse means I fully support this. Accept means I can live with this, it may not be my first choice, but I'll support it here and outside this group. Oppose means I cannot support it.

For the purposes of this presentation and the Final Report, broad agreement describes the recommendations where all or most of the stakeholders endorsed or accepted a recommendation, and where the rationales of any opposing views are documented.

It's also worth noting that for this accept option, some participants really emphasized to each other during the meeting the importance that the group adheres to this overall principal of kind of communicating openly within the group, and maintaining that honesty when communicating about the process and their views for any recommendations more broadly. With that, I am going to turn it over to Katie, and she can walk through the 5 recommendations in more detail.

MS. KATE O'DONNELL: I'll be diving into each of the 5 recommendations. In each of those we'll generally describe what is currently in the ARM Framework, the approach that we used, and then the emerging recommendations and rationale. The first topic that we discussed was around the horseshoe crab harvest utility function.

The current ARM treats one female as equivalent to two males, in terms of harvest value. The group have agreed to an elicitation where we asked 8 fishers, dealers and biomedical participants, what is the expected value of catching one female equivalent to versus how many males over the next 5 years.

For biomedical participants, males and females are equal in value for their industry. For the fishers and dealers, the median response was a value of 2.65 males per 1 female for the bait market, given that female crabs are larger and can bait more traps relative to males. The full group recognized that this utility function specifically addresses the bait context and, on that basis, all participants, including

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the biomedical representatives agreed to adopt 2.65 to 1 as the updated ratio. The technical committees also supported this change.

The second recommendation concerns the sex-specific maximum bait harvest limits. These are the hard caps on what the ARM can recommend in any given year, and they are currently set to 500,000 males and 210,000 females. During discussion, fishers and dealers voiced that they do not want to see a decrease in these limits, but they should at least be maintained.

Noting that actual harvest has been well below these limits since about 2020, due to a market downturn. Also, that keeping the current caps in place provides an opportunity for the market to recover. The fishers and dealers also suggested that the caps could be increased in the future, but some other participants did not support increasing either of these harvest limits.

Given these diverging views, the full stakeholder group agreed to retain the current harvest limits, where public acceptance for female harvest at these current levels should be established first, before considering any increase. Again, the technical committees supported this approach as well. The third recommendation responds to a concern that was raised in the 2021 ARM Framework revision. The current new harvest policy functions do not technically pass to 0, which means that the model cannot recommend 0 harvest, even if populations were to reach critically low levels.

The technical reason is that the model is fit to historical data, and it never predicts near 0 population sizes, as shown in the light green blob of future population sizes predicted by the ARM, because the model is optimizing towards sustainable populations. Still, participants wanted an explicit precautionary mechanism, a clear threshold below which 0 harvest would be triggered.

The group discussed several options for this, and favored setting a user-defined threshold for female horseshoe crab abundance inside the ARM Framework model to preserve the framework's adaptive learning. But where should this value be? Ultimately, the stakeholders deferred to the technical committees to identify an evidence-based threshold.

The Delaware Bay Ecosystem Technical Committee and the ARM Subcommittee reviewed a range of historical abundance benchmarks, ranging from 0 all the way up to 20 million females, and did an elicitation of where that minimum female abundance threshold should be for triggering 0 harvest.

The recommendation then coming from this process is to add a threshold that would trigger 0 harvest when the female horseshoe crab population is estimated to be less than 7 million. That is based on the median response from the Technical Committee elicitation exercise. For context, that 7 million is a little higher than some of the low annual abundances in the 2000s.

This number was viewed as an evidence-based safety net, but it still allows for learning within the model. However, there were two participants who only accepted this level as a near-term measure, and requested an additional process to explore higher abundance thresholds that would be more precautionary.

They noted that 7 million females would be roughly a 63% decline from the current estimated population, which is approximately 19 million females. The fourth of the five recommendations, we considered changes to the red knot utility function. This is the function that translates predicted red knot stopover abundance to a utility or a satisfaction level.

The current function, which is shown here, rises sharply from 0 to 1, which is full utility, at around 81,900 birds. This count was designed without specific stakeholder input in the last ARM revision,

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which occurred during COVID. We used this process to conduct elicitation exercises with participants from the shorebird, horseshoe crab and ecosystem conservation groups to better represent their values.

Those groups reviewed a list of benchmark stopover abundances, and completed a final exercise, which asked their level of satisfaction at different levels of red knot stopover abundance in 2050. Participants confirmed that this question framed the future conditions relative to the current population size, and it captured their values and their risk attitudes to population losses or gains. Using responses from the individual participants, which are shown in the thinner colored lines here. The group and technical committees recommended updating the red knot utility curve using the median responses from those stakeholders as represented by the thicker black line in this figure.

Participants supported this curve as a reflection of their values, especially for avoiding low abundance, and increasing utility more gradually as abundance increases from current estimates. The fifth and final component that the group examined was the reward function, which currently combines horseshoe crab harvest utility, red knot abundance utility, and the product into a single annual reward.

This structure gives additional credit to management actions that achieve both objectives for horseshoe crabs and red knots. In this process, participants discussed whether and how to change the reward function. Some participants were satisfied with the current structure, others suggested adding terms that reflect broader ecosystem values, such as habitat quality, horseshoe crab abundance, other shorebirds or other indicators of ecosystem integrity.

Also, some suggested changing the relative weights of these terms. Currently, they are given equal weight. To values that give more

weight, to red knots or to other ecological terms. The group worked through the technical and philosophical challenges of each option, in particular the requirements that any new term that would be added to this reward function be measurable, predictable, and within the scope of the ARM.

Through final discussions with stakeholders and with the technical committees, we achieved a near consensus recommendation to maintain the current reward function. Most members of both groups supported this because for one, red knots were already selected as an indicator of broader ecosystem health. Secondly, many ecosystem values are not measurable, or predictable with current data, and third that additional ecological terms proposed by the group are partially correlated with current ones that are included in the function.

The one stakeholder, and one committee member who opposed the current reward structure suggested either adding a term for horseshoe crab abundance or placing greater weight on ecological terms, stating that this would better capture broader ecosystem values that are not represented in the ARM.

In summary, here are the 5 recommendations that I just went through that emerged with broad agreement among stakeholders and technical committees. Just noting that two of the five with the asterisk had a few participants with reservations.

MR. CRAWFORD: Lastly, we just wanted to kind of zoom back out and talk about next steps that were recommended and how we can continue kind of improving the ARM and buy-in alongside or in addition to those 5 recommendations. Taken together first, we want to acknowledge that it seems implementing those 5 recommendations in the ARM can make it more transparent and reflective of stakeholder values, and improve buy-in among stakeholders. However, we want to be honest. This 8-month process did not resolve everyone's concerns and solve all the problems,

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which is okay. At the last meeting we asked participants about the level of support in the ARM, even if it recommended female harvest, knowing that that is a really key issue for many. In discussion, we heard that most participant trusted the ARM and its harvest recommendations. They viewed it as an evidence-based peer reviewed framework, and noted that management under the ARM has resulted in a strong increase to horseshoe crabs and a sustainable red knot population.

However, 3 participants opposed using the ARM recommendations, and although these individuals did not explicitly say why in that meeting, participants in previous discussions had expressed the need to take more of a precautionary approach, and to see a thriving ecosystem before female harvest would be acceptable, while others were more concerned about the ARMs underlying science.

Lastly, we think it's also worth noting, another frustration that we heard from multiple participants, actually on the support side of that graph, who mentioned that we collectively have invested a lot of effort into building the ARM, but aren't using the harvest recommendations. They questioned the value of continuing to commit time and resources to the ARM.

Finally, how do we keep improving collaboration and buy-in on top of these 5 recommendations? Well, a few other recommendations were suggested during the process that we wanted to end with. First, on the science side.

The science disagreement keeps coming up, and the group identifies value in dedicating work in sessions on horseshoe crab egg density data and the mechanisms linking the horseshoe crab abundance to red knot outcomes, as well as exploring habitat dynamics, which can better be incorporated in the model.

On education, the group really appreciated the educational sessions that we ran in this process,

and suggested continuing to engage for other stakeholder groups through additional sessions, especially one around uncertainty and predictions in the ARM. On communication the groups wanted more help finding existing documents and opportunities for input into this process.

ASMFC could consider improving advertising these opportunities and documents, as well as new concise plain language products that describe the ARM science, process and rationale for management decisions. This could help groups communicate with constituents, increase everyone's understanding, and also prevent the spread of misinformation, which was cited by some of the participants.

ASMFC could also work with the stakeholders to develop these products collaboratively, since building the public trust is a shared responsibility. With that, we've given you 5 key recommendations for updating the values-based functions in the ARM, as well as some bonus recommendations that came from this process for improving the science, process and communication of the ARM. We just wanted to say thanks again to the stakeholder group for working together towards these recommendations, and thank you all for listening.

The Team and I would be happy to answer any questions, and I think I'm going to turn it over to Caitlin now.

CHAIR REID: Great, thank you very much, you and the team, and all our stakeholders.

CONSIDER INITIATING AN ADDENDUM ON PROPOSED CHANGES

CHAIR REID: I will turn it over to Ms. Starks, she's going to talk us through next steps to it.

MS. CAITLIN STARKS: Considering the outcomes of this process, we being the staff and the planning team that worked on developing this stakeholder process have kind of outlined these next steps for what we see as a logical path forward. Obviously, it

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is the Board's prerogative to decide how to proceed today.

But our recommendation would be to start with charging the ARM Subcommittee to make these recommended changes to the ARM model, and with running that model with the revisions, as well as the model without the revisions to do a side-by-side comparison and make sure everything is working properly. The Delaware Bay Ecosystem Technical Committee could also meet to review those results before bringing that work back to the Board.

Then at that point the Board can initiate an addendum and go through that process to implement the changes in the management program. If the Board were to follow these outlined steps, I think you could expect that addendum to be completed in early 2027, with plenty of time before fall 2027, which is when we would next need to set Delaware Bay specifications for the 2028 fishing year. Because if you recall, we set two years of male only harvest specifications that would go through 2027. That's all I have.

CHAIR REID: Okay, thank you very much, any questions from the people in the room or at the table. Mr. Clark, welcome back.

MR. JOHN CLARK: Thank you for the presentations. I was at the workshop, very interesting. My question I think is mostly for John Sweka, who you said was on the call. I'm just curious, John, if changing these Reward, Utility and Harvest functions, given that minimal level we've been recommending for harvest now, do you see it making much difference to what the recommendations would be?

MR. JOHN SWEKA: To answer your question, John, I think it's a little premature to really say. First, as Caitlin said, we want to make sure that everything is going to run right. I don't foresee any technical issues in making these changes within the modeling framework. But my gut

tells me that it probably won't change the ultimate harvest recommendations very much.

CHAIR REID: Mr. Clark.

MR. CLARK: Yes, if I could just follow up. I guess this one would be to Brian and Katie. Do you think, based on the whole workshop process, that if the recommended harvest came back and was pretty much the same as it is now, that the buy-in for the ARM for stakeholders would still be better, or would they think that, you know I participated in this process and nothing has changed?

MR. CRAWFORD: I think our best guess at that is that second to last slide we showed, where a couple people will be opposed to ARM recommendations, we're assuming that after the updates it would recommend some level of female harvest. Those issues are kind of they seem to go beyond the extent of updating these values-based function.

It's hard to speak for them of how satisfied they would be with the involvement of this process, but I think based on how everyone participated together, I would hope that they would see value in the process we went through, you know kind of the incremental improvement of the ARM representing their values more.

But there is work to be done in digging into the underlying science, and also sort of working with those groups around the scope of the ARM, and what is kind of in and out of scope, and how that relates to how satisfactory they might see some of these options, or some of the recommendations that maybe they wanted but were not implemented, like an additional term for the reward function, for example.

CHAIR REID: All set, John? Mr. Borden, and anybody else.

MR. DAVID V.D. BORDEN: My question is on the slide that is up here, very convenient it went back to it in time. For those that are opposed to the idea, were they opposed for the same reason or different

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reasons? That is one question, then I have a follow up question for Bob Beal.

MR. CRAWFORD: I would say there are multiple reasons. Again, when we did this particular poll at the last meeting we asked but didn't hear their rationale in the moment. But drawing from past conversations during this process, the two reasons are on the slide. Some people just kind of don't trust the recommendations before the underlying science is investigated more, specifically egg density data and its incorporation into the model was brought up by a couple people.

Others, really, it's about, if I can speak for them, it seems to be about their risk tolerance, and they really want to see a thriving ecosystem and high populations of horseshoe crabs and red knots before they would be comfortable with female harvest. At least two reasons, I would say.

MR. BORDEN: My question to Bob is, what was the total cost of the workshop, Bob?

EXECUTIVE DIRECTOR ROBERT E. BEAL: Toni and I were just having that conversation offline. With travel and everything else, it was 70 thousand dollars, maybe, with facilitators and travel and sort of soup to nuts the whole thing. There was a lot of pre-game conversations. There were facilitators and other things to set it up. It was fairly expensive.

MR. BORDEN: My assumption is that doesn't include staff time.

EXECUTIVE DIRECTOR BEAL: Correct.

CHAIR REID: Mr. LaFrance. Anybody else?

MR. ROB LaFRANCE: I guess I had a question about the biomedical preference. It indicated, from what I saw on the screen that there was no preference one way or the other. I guess my question is, could that harvest only be male or only female, or did the calculations come out? I

guess I'm trying to understand how that came out in the final analysis to 2.65 to 1. Did that make it lower or did it make it higher?

MR. CRAWFORD: Katie, do you want to take this one?

MS. O'DONNELL: Yes, I think if I understand the question. The biomedical participants, like we asked this question of all three of those groups, the biomedical stakeholders, the bait fishers and dealers for the purposes of having the discussion. When we kind of separated out the responses by group, it became clear that the biomedical representatives said, in their industry for them they need both males and females. But the value is equal, essentially.

A female is not more valuable than a male, in their context. We then, the 2.65 represents the median value just from the bait fishers and the dealers. Overall, the whole group, the full group agreed to just use their responses, because they have the best understanding of the market, the bait market, which is what this utility function is intended to represent in the ARM Framework. The biomedical values were not actually included in this 2.65.

MR. LaFRANCE: I guess my other point of understanding and I can clarify this is, from their perspective they need both, and that was what was unclear to me.

MS. O'DONNELL: Yes, correct.

CHAIR REID: Anybody else on the Board, anybody but John? Adam, anybody else on line for us. I'll get her in a minute, Ms. Berger, I will get to you but not right now. Go ahead, Mr. Clark.

MR. CLARK: I just had a question about the red knot function. I was just curious as to what the actual red knot population should be now, based on that curve for the full harvest of females. It looked like it was over 100,000. I mean can you get that graph up there that showed the red knot utility function? Yes, that one there. To get to the full female harvest, the population would have to be at a level.

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I'm just curious if it has been at that level any time since we've been doing population estimates of the red knots.

MR. CRAWFORD: I think our current estimates, they are between 40 and 50 thousand, so kind of on the lower end of that figure. There is a bit of kind of an inflection point, and the way we asked this question was intentional, it was kind of in reference to the current population size. We saw people really become unhappy if we go below where we are right now, and then gain utility, gain satisfaction if we increase from where we are right now around that 50 thousand.

I think it's worth noting also, yes, the 40 to 50 thousand, that is kind of the minimal estimate of minimum recovery targets for the Fish and Wildlife Service and that was one of the benchmark abundances that we gave to folks when they filled out the exercise. I think the range encompasses the maximum population that has ever been estimated for any given year, but I would have to look back at what that was. Maybe John knows better.

CHAIR REID: Mr. Sweka.

MR. SWEKA: Yes, John, just to your question. I think everybody needs to keep in mind that this utility function is not a harvest control rule. If red knot were at 150,000 that doesn't mean you can harvest 100% of your allowable horseshoe crab. There is the possibility that even at lower red knot abundances, I mean what this utility function does is it quantifies the happiness of the stakeholders, with respect to the abundance of red knots.

It could very well be the case that we could be at 50 to 75 thousand red knots. But if horseshoe crabs are very, very abundant, you could go into a situation where the ARM Framework would recommend something very close to the maximum female harvest. I think that is something we all need to keep in mind is, utility functions are not a harvest control rule,

that tells you how much you can harvest, given a population size.

CHAIR REID: All set, John.

MR. CLARK: Yes, I understood that. Yes, I just think it would be very difficult to have a full harvest without some of these people seeing the red knots at a very high number.

CHAIR REID: Any other questions from the Board. Anybody in the audience? I'm going to go online to Mr. Hoffmeister, he's our AP Chair. Brett, go ahead.

MR. ALAN BERGENSON: This is Allen Bergenson, I couldn't find my link to get in, so Brett graciously shared the link and I'm in here as Brett 2. Anyway, I just wanted to reflect what Katie said before. The biomedical industry, we don't have any set number, no utility of so many males to so many females, they are all the same to us. That's why we didn't participate in that part, because we felt there was no value into our saying that. It's not 1 to 1; it's just not defined because we don't need that.

CHAIR REID: Okay, thank you, Brett 2. Joanna Berger.

MS. JOANNA BURGER: This is Joanna Burger, and I was on the stakeholder committee, and I think they did a super job reporting on what happened at the meeting. I just want to emphasize the fact that the stakeholder's session as a whole didn't have the same view. We reached consensus, because we were given different alternatives.

We selected sort of the best one. But I think many stakeholders might not believe that we reached a consensus on what would be an acceptable female harvest. Someone asked where the large number of red knots came from, the 150. That partially comes from fact in the 1980s when we first started doing surveys, and I'm old enough to have actually done those first surveys, there was in the order of 100 thousand to 120 thousand.

That is sort of the genesis of where that number came from, and to back up above that. When we're

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thinking about female horseshoe crab harvest, and increasing the population of horseshoe crab, we want to be able to increase the horseshoe crabs, not only to support the current population, but to support what might have been a traditional population. I think the report accurately reflects the difference, and it reflects the fact that some people didn't want to add additional things such as the egg density. We were hoping that this would lead onto more discussions of being able to add those other functions. The report as presented was an excellent representation.

CHAIR REID: Thank you, Ms. Burger. Seeing no other hands; do we have anybody else online? Seeing none; back to the Board. Mr. McKiernan.

MR. DANIEL MCKIERNAN: Just a point of clarification. There was a reference to the current population of females in Delaware Bay at 19 million. I was just hoping to clarify if that is 19 million adults, or is it 19 million females of all ages.

CHAIR REID: Hang on, Mr. Chair, sorry, Dan. I should have called you Mr. Chair in the beginning. John Sweka.

MR. SWEKA: Yes, I can answer that question. It was approximately 19 million adult females, which was comprised of both the primiparous and multiparous crabs. That was our latest population estimates coming from 2024.

MR. MCKIERNAN: Thank you for that. For me, an in-depth discussion about 200,000 extractions seems pretty small and pretty reasonable.

CHAIR REID: Anybody else? Okay, so what is the pleasure of the Board? We've got the slide on the board just to jog your memory and we'll see if anybody has any comments. If not, I am assuming that will be the consent to staff to move in their direction that they are proposing.

Just give us a second. Okay, from the Board. Seeing none; Ms. Starks, are you good?

DISCUSS STATE LEGISLATION ON HORSESHOE CRAB FISHERIES

CHAIR REID: Okay, with that we'll move on to our next item, Ms. Starks.

MS. STARKS: Just to remind everyone why this topic is on the agenda. There was a request from a Board member, and what they wanted to see was a summary of state legislative actions in Connecticut, New York and New Jersey to implement restrictions that horseshoe crab fisheries outside the scope of what is in the Commission's fishery management plan.

I think as most people know, there has been more attention on horseshoe crab management at the state legislative level recently, and there have been some laws passed in those states. I gathered information from each of the states to describe their statutes and regulations, including legal language that has been enacted, regulations the state agency has in addition to the statutes, rules about possession and use of horseshoe crab as bait, and biomedical use, and this information was all compiled into a memo as well in your briefing materials.

I'll just go over the laws and rules related to bait harvest for each state. The recent Connecticut law prohibits hand harvest of horseshoe crab, effective October 1, 2023. But hand harvest may be authorized for scientific or educational purposes, and horseshoe crab may be taken by otter trawl, with a limit of 25 horseshoe crabs a day. In Connecticut, a person may also possess legally acquired dead horseshoe crabs being used for bait.

The recent New York Horseshoe Crab Protection Act phases out the commercial and biomedical harvest of horseshoe crab, reducing the state quota from the current level to 75% this year, 50% in 2027 and 25% in 2028, and then a complete ban taking effect January 1, 2029. Until 2029 the current regulations

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will remain in place. Then in New Jersey the commercial harvest moratorium of horseshoe crab for bait was enacted in 2008. That does allow New Jersey DEP to issue a permit for to take a horseshoe crab or eggs for scientific and educational purposes.

Then with regard to possession and use of horseshoe crab as bait. In Connecticut, it is still legal to possess and use horseshoe crab as bait, but it requires a trawl license, landing license, which allows possession of horseshoe crabs that were legally caught in another state or federal waters, or a shellfish harvesting license.

In New York the recent Act only addresses the take of horseshoe crab, not possession. Those holding a horseshoe crab commercial bait harvesters permit will be still allowed to possess and use horseshoe crab as bait after January 1, 2029. In New Jersey, the state statute allows commercial fishermen to possess and use horseshoe crab as bait.

But they have to provide documentation that the crabs were not harvested in New Jersey, including a receipt or bill of landing with the contact information for the person or company that provided the horseshoe crab, the permit or license number of that person or company and the state and harvest location if possible.

We also asked about if these states had any laws about importing horseshoe crabs that were harvested in other states, and for Connecticut, import of horseshoe crabs from other states is allowed. For New York, those holding the horseshoe crab commercial bait harvesters permit are allowed to possess horseshoe crabs sourced from inside or outside of the state.

Then in New Jersey the statute again only allows possession and use of horseshoe crabs in state if those horseshoe crabs were harvested outside of New Jersey. Then our last slide here is about the rules and laws pertaining to biomedical use of horseshoe crabs. In

Connecticut there is no biomedical horseshoe crab collections occurring at this time, and there haven't been any previously on record in Connecticut. But from what I was able to gather the law is not very clear on whether it is prohibited or not. Then under the recent protection act in New York, biomedical take of horseshoe crabs will also be banned effective January 1, 2029, and until then a biomedical harvest and/or users permit that is issued by New York DEC is required for the take, possession, and sale or purchase of biomedical horseshoe crab.

Then for New Jersey the state actually does allow NJ DEP to issue a permit for the collection of blood from horseshoe crabs for biomedical purposes, provided that those horseshoe crabs are released otherwise unharmed to the same waters where they were collected. That is again an FMP requirement. That is my summary and I can take any questions, or perhaps the states can also help.

CHAIR REID: Any questions? Mr. McKiernan.

MR. McKIERNAN: More of a comment. I would be happy to take the blame for this, or the credit, because there has been legislation filed in my state to do something similar to what is happening in New York. When I read the documentation from the advocates, there is a serious amount of misinformation or incomplete information.

That is why I asked for this to be presented, because for example, New Jersey is portrayed by some of the advocates in Massachusetts as having a prohibition on harvest, when in fact, there is a very viable biomedical fishery. In any state, whether it be New York or if Massachusetts were to go forward and ban biomedical harvest, that would be a huge blow, and result in some unintended consequences with pressure put on other states.

I also want to just tell the Board that we are preparing for a field study this summer to look at the survival of post bled crabs, and we're going to use acoustic tags and an acoustic array to work in both Pleasant Bay and Nantucket Sound. We hope to be able to bring back to this Board some new

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updated information on survival of crabs in that realm.

CHAIR REID: Thank you, Mr. Chair. Mr. Clark.

MR. CLARK: Just curious, I assume New Jersey does not have any sunset provision in their law, but just wondering if Connecticut or New York, if there is anything in the law that would cause them to reevaluate the law in a set period of time.

CHAIR REID: Connecticut, New York.

MS. SHANNA MADSEN: There is no sunset provision in ours, John.

CHAIR REID: Mr. Hornstein.

MR. JESSE HORNSTEIN: Same as Connecticut, there is no sunset as far as I'm aware. Also, I don't believe there has ever been biomedical harvest in New York, just to be clear.

CHAIR REID: Mr. Cimino.

MR. JOE CIMINO: In legislation for New Jersey there is actually biological triggers as well as there is an endangered and nongame species advisory council for the state that also would have to weigh in on approval of allowing harvest again.

CHAIR REID: Anybody else? Mr. McKiernan.

MR. McKIERNAN: Point of clarification to New Jersey. Do you mean bait harvest or any harvest, because I consider biomedical harvest, harvest, even if it's catch and release.

MR. CIMINO: To bring back the bait fishery.

MR. McKIERNAN: It is bait fish you are referring to.

CHAIR REID: Mr. Clark.

MR. CLARK: Yes, me again, Mr. Chair. Yes, I was just curious. I mean as Dan brought up, in these states was there any discussion about the fact that closing the fisheries in their state put more pressure on other states, especially when it is pretty hypocritical to ban harvest of horseshoe crabs in your state, and yet allow your fishermen to use horseshoe crabs as bait, which means they have to be coming from some of the other states that do still have harvest, which puts more pressure there.

CHAIR REID: Mr. Cimino and then Mr. Hyatt.

MR. CIMINO: I'm not going to disagree with John there, but I actually also had a question on, some of the other states like Massachusetts. I know there were issues in South Carolina with the biomedical industry. I'm curious for the pressure that is coming in. Is there any shown tie in to the dependents of a red knot stopover in your state? Has it ever been shown that it is the same kind of situation that the Delaware Bay has for the importance of a red knot stop over. I guess, Dan, to you in particular. Has that case been made to Massachusetts?

MR. McKIERNAN: To that question, Joe. I think there have been observations of red knots in Massachusetts. I think they are more likely to be seen on their southern migration. I don't know of any aggregations of red knots during the spawning period, during the period of late April through early June. It doesn't mean there wasn't a red knot on a beach, but we don't have the kind of numbers that you all have.

CHAIR REID: Mr. Hyatt.

MR. WILLIAM HYATT: John, in answer to your question. Yes, the legislatures who put forth this legislation did have conversations relative to the fact that we would be disallowing harvest in Connecticut, but that they could still reach out of state for crabs. The decision and the justification were based on the fact that stock condition, crab stock condition in Long Island Sound was poor and on a long-term declining trend.

They felt that it was reasonable that in those areas where the stock is deemed healthy and productive, to allow for fishermen to import crabs from those areas. It was given, I would say, full discussion and consideration. Fair or not that is the conclusion that they arrived at.

ADJOURNMENT

CHAIR REID: Are you all set, curious George?
Anybody else? Is there any other business?
Seeing none is there any opposition to
adjourning? Seeing none; thank you very much.

(Whereupon the meeting adjourned at 2:06
p.m. on Tuesday, May 5, 2026)



Atlantic States Marine Fisheries Commission

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MEMORANDUM

TO: Horseshoe Crab Management Board

FROM: Delaware Bay Ecosystem Technical Committee and Adaptive Resource Management Subcommittee

DATE: October 26, 2026

RE: 2025 Survey Results, Recommendations for ARM Revisions, and 2027 Delaware Bay Horseshoe Crab Harvest

The Delaware Bay Ecosystem Technical Committee (DBETC) and Adaptive Resource Management (ARM) Subcommittee (henceforth, the Committees) met jointly on October 5, 2026 to 1) review recent survey data for horseshoe crabs and red knots, 2) review bait harvest specifications for 2027 and make recommendations as necessary, 3) discuss a correction to an error found in the ARM model code, and 4) review modeling updates to the Utility, Reward, and Harvest Policy (URH) functions of the ARM Framework based on the input provided through the stakeholder engagement process conducted earlier this year. The discussions and recommendations of the Committees are summarized in that order below.

1. Review of Annual Survey Data for Horseshoe Crab and Red Knot

Andre Lai (Virginia Tech) presented the results of the 2025 horseshoe crab trawl survey (Lai et al. 2026). The Virginia Tech Trawl survey is designed specifically to characterize the horseshoe crab population in the coastal Delaware Bay Area (DBA) and Lower Delaware Bay (LDB) and has been conducted since 2002. It provides one of the main indices of horseshoe crab abundance used in the ARM Framework. The DBA was previously sampled from 2002 to 2011, and again from 2016 onwards. The LDB was previously sampled from 2010 to 2012, 2016 to 2021, and sampling resumed in 2025.

In the 2025 survey of the DBA, mean catches-per-tow of mature males and females declined from their 2024 levels and are consistent with the mean CPUE recorded in earlier years. Mean catches-per-tow of immature males and females have remained relatively stable since 2016. Mean catch-per-tow of newly mature males decreased from 2024, continuing to decline from their high values in 2021 and 2022 but remaining relatively consistent with CPUE values recorded prior to 2016. Following the revision of the sampling protocol to probe more ambiguous females for eggs, mean catch-per-tow of newly mature females continued to rebound from extremely low values since 2019, reaching their highest recorded value in 2025. There is a decreasing trend in mean prosomal width for mature and newly mature males and females. Based on the 2025 survey, population estimates for the DBA increased significantly for

both immature females and males compared to 2024. The estimated populations decreased from their 2024 values for mature crabs of both sexes, and newly mature males. The estimated population total for newly mature females increased from 2024 values.

In the LDB in 2025, there was an observed increase in stratified mean catch-per-tow for all demographic groups when compared to 2021. Similarly, the population estimates across demographic groups increased compared to 2021.

Jordan Zimmerman (DNREC) presented the results of the 2025 Delaware 30-foot Trawl Survey and Delaware Bay Spawning Survey. In 2025 for the index months of April-July, the geometric mean catch per nautical mile in the trawl survey decreased from 2024 and was slightly below the time series mean (Figure 1). When considering all months (March-December) the index is similar to 2023 and 2024 levels (Figure 2).

In the 2025 Delaware Bay Spawning Survey, sampling was conducted between May 10 and June 27 during 12 nighttime high tides, at 12 beaches in Delaware and 10 in New Jersey. Peak spawning in Delaware occurred May 10-14, and peak spawning in New Jersey occurred June 9-13. The bay-wide index of female spawning activity shows a slightly positive but not significant trend over the time series (1999-2025), while the index of male spawning activity shows a significant increasing trend (Figure 3). The male:female spawning ratio in 2025 was 5:1.

Dani Dyson (NJDEP) shared an update on the NJ Ocean Trawl Survey and noted that there is no data for 2025 due to vessel issues.

Jim Lyons (USGS) presented the results of the 2026 red knot surveys and stopover population estimate (Lyons 2026). The 2026 passage population of red knots in the Delaware Bay was estimated using a Bayesian analysis of a mark-resight model which accounts for population turnover and imperfect detection. The 2026 passage population estimate was 39,534 individuals (95% credible interval: 36,740–42,922). This represents a change of approximately -27% compared to 2025 but is similar to 2022 and 2023 levels. Kat Christie (DNREC) presented additional information on the 2025 Delaware and New Jersey shorebird surveys, noting a recurring trend of the ground counts exceeding aerial counts.

2. Review 2027 Bait Harvest Specifications

Under Addendum VIII (ASMFC 2022b), the 2022 ARM Revision is used to annually produce bait harvest recommendations for male and female horseshoe crabs of Delaware Bay-origin based on the abundance of horseshoe crabs and red knots. In October 2025, the Horseshoe Crab Management Board chose to set male-only harvest specifications of 500,000 males for two years (2026 and 2027) as allowed by Addendum IX (ASMFC 2025). Under Addendum IX, in interim years of multi-year specifications the male-only harvest limit is based on the male:female sex ratio of spawning horseshoe crabs on beaches observed in the bay-wide spawning survey. If the sex ratio is greater than or equal to 3:1, the maximum harvest of 500,000 Delaware Bay origin males is permitted. If the sex ratio is between 3:1 and 2:1, the

maximum allowable male harvest is reduced as the ratio decreases and would be zero if the sex ratio were to decrease to 2:1 or less.

The observed sex ratio in the 2025 bay-wide spawning survey was 5 males to 1 female, so the maximum harvest of 500,000 Delaware Bay origin males is permitted. Thus, the Committees recommend maintaining the 2027 harvest specifications. The allocations implemented for 2026 and 2027 are shown in Table 1.

Table 1. Delaware Bay-origin and total horseshoe crab quota for 2026 and 2027 by state with no female harvest and the 2-to-1 offset. Virginia total quota only refers to the amount that can be harvested east of the COLREGS line

State	Delaware Bay-Origin Quota		Total Quota	
	Male	Female	Male	Female
Delaware	173,014	-	173,014	-
New Jersey	173,014	-	173,014	-
Maryland	132,865	-	255,980	-
Virginia	21,107	-	81,331	-
TOTAL	500,000	0	683,339	0

3. Discuss Correction to ARM Model Code Error

Bryan Nuse (Bird Conservancy of the Rockies) was contracted to develop revisions to the URH functions in the ARM Framework model based on the 2026 stakeholder process input. In the process of this work, an error was identified in the 2021 ARM model code: rather than using annual bait harvest values alone to calculate annual reward when solving for optimal harvest policy parameters, total anthropogenic horseshoe crab mortality (bait harvest, bycatch, and estimated biomedical mortality combined) was used to calculate annual reward. This error ultimately resulted in a reward function different than what was intended by both the modelers and stakeholder groups.

Bryan presented a comparison of simulation results from each of the changes made to the 2021 ARM model, including the error correction. When comparing the results of the corrected 2021 model to the uncorrected 2021 model, the following differences are observed:

- The harvest policy function for male horseshoe crabs is very similar between corrected and uncorrected versions, with a slightly steeper slope in the corrected version. No change is predicted in male harvest levels over the long-term (100-year simulation).
- The harvest policy function for female horseshoe crabs in the corrected version is more likely to recommend female harvest levels closer to the cap, resulting in more predicted female harvest in the long-term.
- The harvest policy for females in the corrected version is more responsive to extremely low abundances of female crabs and comes closer to intersecting 0 at extreme low abundances, but it does increase rapidly as abundance increases.

- The corrected version has a very small effect on the long-term trajectories of red knot and female horseshoe crab abundance, with minor decreases in each (changes of -0.5% and -1.3%, respectively, over a 100-year time horizon).

The Committees acknowledged the need to correct the model code to the intended peer-reviewed methods so that reward is calculated based on bait harvest values only.

4. Review Updates to RUH Functions in the ARM Model

Bryan Nuse presented the revisions to the URH functions in the ARM Framework model. The revisions included the incorporation of three recommendations from the 2026 stakeholder engagement process (Compass 2026):

1. update HSC utility using a female-to male value ratio of 2.65:1.
2. update REKN utility to replace the current curve with the median curve from stakeholder-elicited values from the 2026 workshop.
3. implement a 7,000,000 threshold in female HSC harvest policy function, below which female harvest is 0.

Bryan Nuse implemented these recommendations through revisions to the 2021 ARM Framework model code and reran the model to produce solutions that were compared to the 2021 model solutions. When comparing the results of all three 2026 recommended revisions to the results of the corrected 2021 model, the following differences are observed:

- The predicted long-term trajectory of red knot abundance increases slightly, by 1.3%.
- The long-term trajectory of female horseshoe crab abundance increases by 4.2%.
- There is a 44.3% decrease in predicted female harvest over the long-term, which is influenced by the 7 million abundance threshold for when female harvest would be permitted.

The Committees recommend that the Board consider these model updates for future management. They noted some concern about the threshold creating instability in the female harvest recommendations because the results predict fairly frequent changes between a female harvest recommendation of zero and near the maximum of 210,000 females. However, it was noted that these simulations use data through 2021 only, and the female population estimate has increased since then. Therefore, it is likely that once more recent years of data are incorporated in the next update of the model parameters in 2027, the model will predict fewer switches between zero and a higher female harvest recommendation. The Committees also recommended that the stakeholder group be provided an opportunity to review the results of the model updates.

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- Lyons, J. E. 2026. Stopover Population Estimate and Migration Ecology of Red Knots *C. c. rufa* at Delaware Bay, USA, 2026. Memorandum to the Delaware Bay ARM Working Group, Laurel, Maryland.

Figures

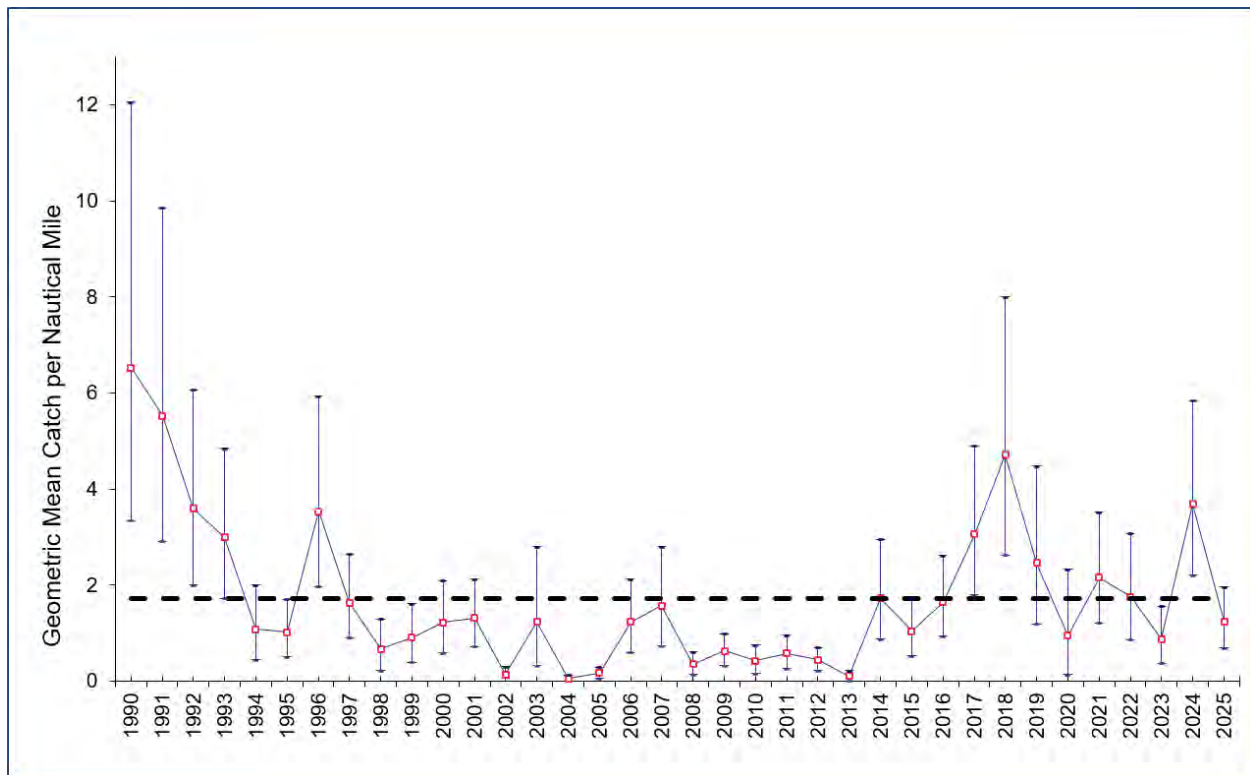


Figure 1. Adult horseshoe crab index from the Delaware 30-foot trawl survey for the months of April-July, 1990-2025.

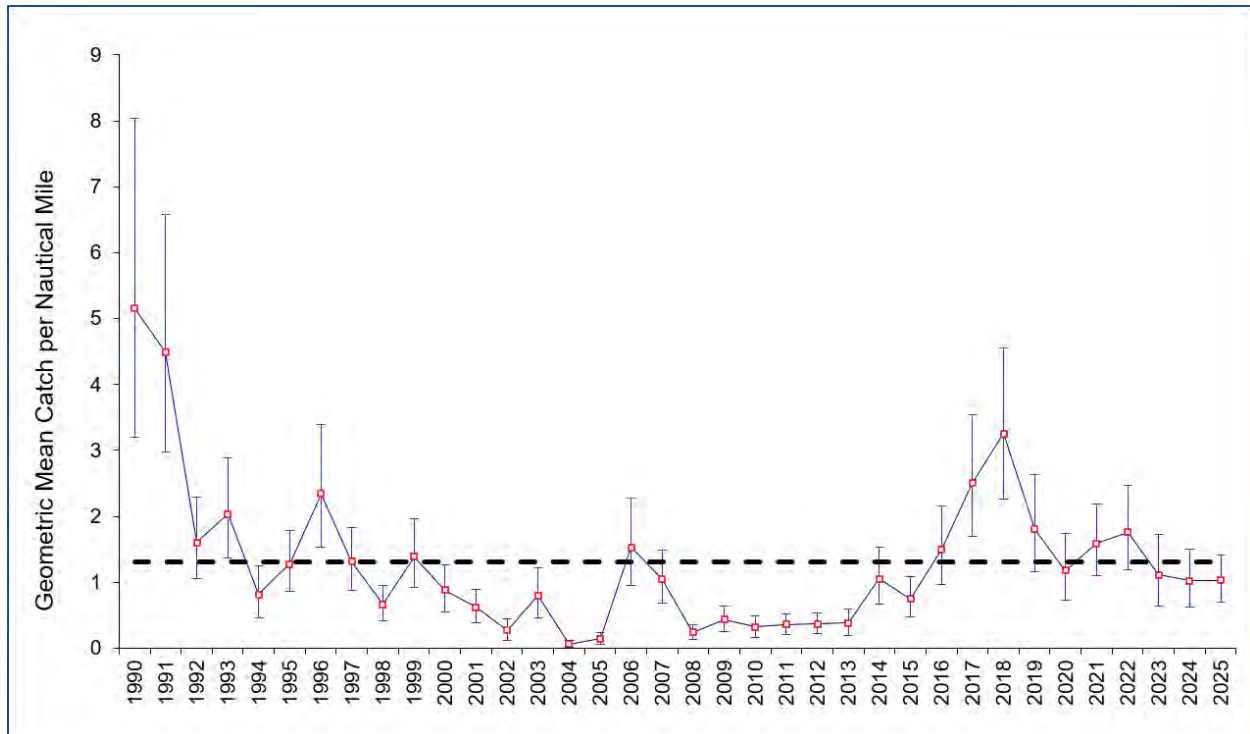


Figure 2. Adult horseshoe crab mean catch per nautical mile in the Delaware 30-foot trawl survey index for all months of (March-December), 1990-2025.

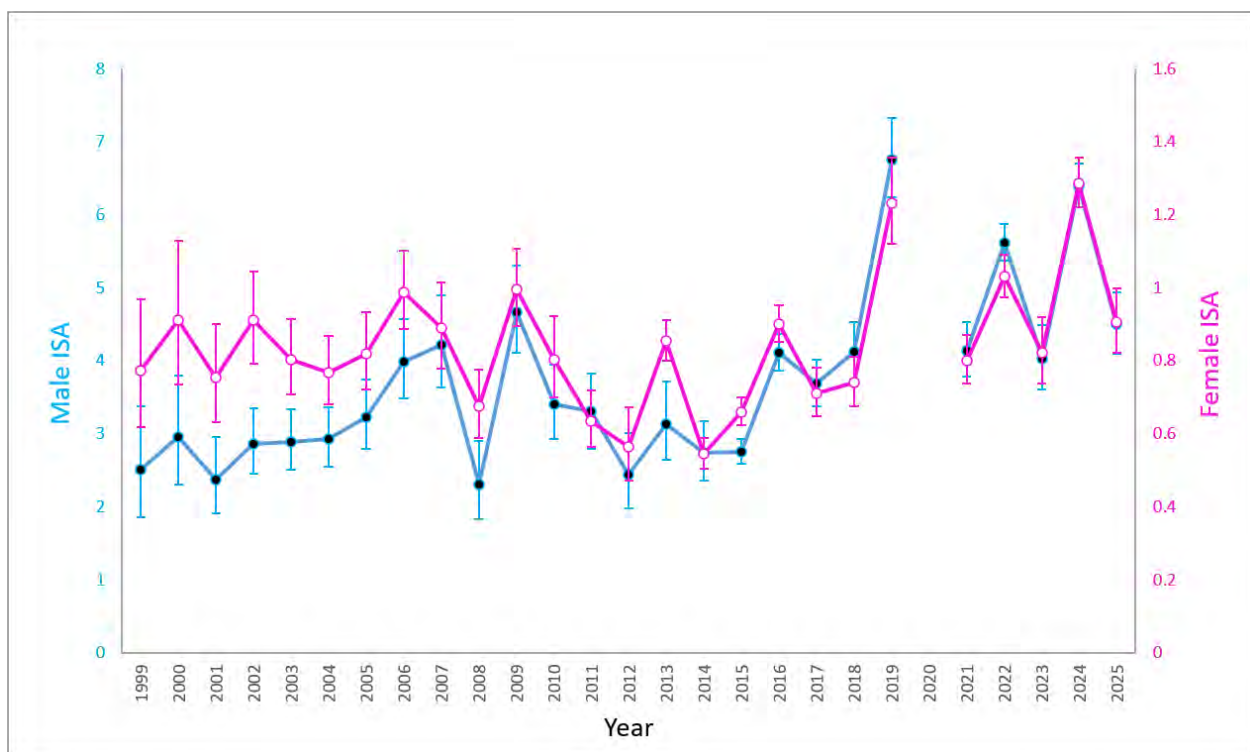


Figure 3. Index of horseshoe crab spawning activity for males and females from the Delaware Bay horseshoe crab spawning survey (baywide), 1999-2025.

**Results of the 2025 Horseshoe Crab Trawl Survey:
Report to the Atlantic States Marine Fisheries Commission Horseshoe Crab and Delaware Bay
Ecology Technical Committees**

Andre Lai, Yan Jiao, and Francesco Ferretti

Department of Fish and Wildlife Conservation
Virginia Polytechnic Institute and State University
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September 15th, 2026

INTRODUCTION

The Atlantic horseshoe crab (*Limulus polyphemus*) fishery along the US East Coast dates back as early as the mid-1800s, where they were used as fertilizer and livestock feed (Kreamer & Michels, 2009; Millard et al., 2015). Today, horseshoe crab flesh is used to bait pots in the conch (*Busycon* spp.), whelk (*Sinistrofulgur* sp.), and American eel (*Anguilla rostrata*) fisheries, while their hemolymph is harvested to produce *Limulus* amebocyte lysate (LAL) for pharmaceutical assays of bacterial endotoxins (ASMFC, 2020; Ding et al., 1997; Hurton et al., 2009; Novitsky, 2009). Delaware Bay hosts the largest spawning population of horseshoe crabs and is internationally recognized as a critical stopover site for various migratory shorebirds of conservation concern like the rufa red knot (*Calidris canutus rufa*) (Mizrahi & Peters, 2009). These birds refuel on horseshoe crab eggs during their northward spring migrations to their Arctic breeding grounds (McGowan et al., 2011; Morrison, 1984; Myers, 1983). To balance commercial harvest with shorebird energy needs, the Atlantic States Marine Fisheries Commission (ASMFC) implemented the Adaptive Resource Management (ARM) framework in 2013, which calculates annual sex-specific harvest limits per state using fishery-independent indices of horseshoe crab and red knot abundances fed into stock assessment models (Anstead et al., 2023; ASMFC, 2009, 2020; McGowan et al., 2015; Sweka et al., 2007).

Since 2003, Virginia Polytechnic State University (hereafter “Virginia Tech”) has conducted an annual trawl survey designed specifically to characterize the horseshoe crab population in the coastal Delaware Bay Area (DBA) and Lower Delaware Bay (LDB). This survey remains one of the main indices of horseshoe crab abundance used in the ARM framework (Anstead et al., 2023; ASMFC, 2009, 2020; Hata & Berkson, 2004; Sweka et al., 2007).

The objectives of the Virginia Tech trawl survey are to (1) determine horseshoe crab relative abundance, (2) describe horseshoe crab population demographics, and (3) track interannual changes in the two aforementioned parameters. Here, we report the results of our Fall 2025 trawl survey. Gear catchability has not been evaluated for these estimates of horseshoe crab abundance, so they should be considered conservative.

METHODS

The Virginia Tech trawl survey is traditionally conducted in two areas (Figure 1). The DBA sampling area extends latitudinally from the northern limit of Atlantic City, NJ (39° 20' N) south to Wachapreague, VA (37° 40' N), and longitudinally from the coastline to 12 nautical miles from shore (Figure 1). The LDB sampling area extends from the bay's mouth to the boundary between Egg Island Point, NJ and Kitts Hummock, DE. The sampling area was stratified based on bottom topography (trough/non-trough) and distance from shore (0-3 nm, inshore; 3-12 nm, offshore), emulating the methodology of the 2001 pilot HSC survey conducted in the DBA (Hata & Berkson, 2004). Troughs are classified as areas of seabed that are >2.4 m deep, <1.8 km wide, and >1.8 km long, as determined from NOAA nautical charts. These charts were georeferenced as a digital map in ArcGIS Pro to design the sampling scheme. The World Geodetic System 1984 coordinate system was used to divide the survey region into 1' latitude-by-1' longitude cells, with the LDB consisting of 196 cells (~528 km²) and the DBA consisting of 1890 cells (~5127 km²).

The DBA was previously sampled from 2002 to 2011, and again from 2016 onwards. The LDB was previously sampled from 2010 to 2012 and 2016 to 2021. We resumed sampling of the LDB in 2025. The surveys were conducted between August 28th and November 20th, 2025. Sampling was conducted aboard a 16.8-m chartered commercial fishing vessel operating out of Ocean City, MD. Trawls were performed using a two-seam flounder trawl with an 18.3-m headrope and 24.4-m footrope, rigged with a Texas Sweep consisting of a 13-mm link chain and a tickler chain. The net body consists of 15.2-cm (6-in) stretched mesh while the codend consists of 14.3-cm (5 5/8-in) stretched mesh. The net was mostly towed along the bottom for 15-minute periods but would occasionally be hauled back early to avoid entanglement with fishing gear (e.g., gill nets and pots), vessel traffic, or if the crew suspected that the net had snagged on something along the bottom. The start and end positions of each tow were recorded when the winches were stopped and when retrieval began, respectively. The bottom water temperature was recorded for each tow, in addition to the beginning and ending trawl depth, bottom salinity, air and surface temperatures, time of day, and general weather conditions. Forty-one tows were conducted in the 2025 DBA survey, while seven tows were conducted in the LDB (Figure 2).

The Virginia Tech trawl survey stratifies the horseshoe crab population into six demographic groups based on sex and maturity. Maturity classifications are immature, newly mature (those that are capable of spawning but have not yet spawned), and mature (those that have previously spawned). Newly mature and mature males are morphologically distinct and are believed to be classifiable without error given the presence and absence, respectively, of the “thumb” on the pedipalps (grasping appendages). However, some error is associated with distinguishing newly mature from immature females. Females over 180 mm in prosomal width that were not obviously mature (females lacking discolored patches and mating scars on their carapaces) or immature (too small or soft-shelled) were probed with an awl to determine the presence or absence of eggs. Females with eggs but without rub marks were considered newly mature while females with both eggs and rub marks were considered mature.

Once the net was retrieved and its contents were dumped on deck, the vessel crew sorted out the horseshoe crabs from any bycatch. Either all individuals or a subsample had their prosomal widths measured and were classified by sex and maturity. Initial sorting classifications were presumed adult males (newly mature and mature), presumed adult females, and all immatures. In the event where a subsample was necessary due to an excessive number of crabs, we retained up to 25 adult males, 25 adult females, and 50 immatures for examination. The remainder were counted separately by their initial sorting classification and released. Characteristics of the examined subsamples were then extrapolated to the counted portions of the catch.

In 2025, we began the additional collection of elasmobranch (skate, ray, and shark) sex, count, and size data. This was done to address the historical lack of documentation for these bycatch species and generate information on their distribution along the Atlantic coast. Around 25 clearnose skates (*Rostroraja*

eglanteria) were randomly selected from the contents of each tow, sexed, and had their disc widths and total lengths measured. Other elasmobranch species were only sexed and counted. We continued to document whelk and summer flounder bycatch in the tows, as in previous years.

In each sex-maturity stratum, the mean catch per 15-minute tow and associated variance were calculated by either assuming a normal-distribution model or a delta-lognormal distribution model (Pennington, 1983). Stratum mean and variance estimates were combined using formulas for a stratified random sampling design (Cochran, 1977). The approximate 95% confidence intervals were calculated using the effective degrees of freedom (Cochran, 1977). Annual means were considered significantly different if 95% confidence intervals did not overlap. Stratified means calculated using the delta-lognormal distribution model are not additive – i.e., means calculated for each demographic group do not sum to the mean calculated using all crabs. Means calculated using the normal distribution model are additive, within rounding errors.

Annual size frequency distributions, in intervals of 5-mm PW, were calculated for each demographic group. Size distributions from all stations within a stratum were pooled (adjusted for tow duration if necessary) for each year to determine relative proportions in each size interval. These proportions were then multiplied by the relative annual stratum mean catch-per-tow to produce a stratum size-frequency distribution. Stratum distributions were then multiplied by the stratum weights and added in the same manner as calculating the stratified mean catch per tow. Areas under the distribution curves represent the stratified mean catch per tow at each size interval.

Within the DBA, the average tow distance for a 15-minute tow was 1.12 kilometers at an average speed of 4.71 kph. No net spread (wing opening) measurement device was used during sampling this year. However, this would be useful to integrate in future surveys. Instead, the net spread was calculated using the net spread regression relationship developed from previous trawl surveys:

$$S = 13.84 - 0.858 \times C \text{ where } S \text{ is net spread in meters and } C \text{ is tow speed in kph}$$

From the 48 tows conducted in 2025, the average net spread was 9.80 meters.

For each tow, catch density (catch/km²) was calculated from the product of tow distance (in km) and estimated net spread (converted from meters to km), assuming that all fishing was done only by the net, and that there was no herding effect from the ground gear (effect of the sweeps in the footrope).

$$\text{catch/km}^2 = \text{catch} / [\text{tow distance (km)} \times \text{net-spread (km)}]$$

Within each stratum, the mean catch per square kilometer and associated variance were calculated assuming a normal-distribution model and a lognormal delta-distribution model. Stratum mean densities and variance estimates were combined to produce a stratified mean density ($\underline{X}_{st}$) using formulas for a stratified random sampling design as with the catch-per-tow estimates described above (Cochran, 1977). Population totals were estimated by multiplying $\underline{X}_{st}$ by survey area (DBA = 5127.1 km²; LDB = 528.4 km²).

$$\text{Population total} = \underline{X}_{st} \times \text{survey area (5127.1 or 528.4 km}^2\text{)}$$

RESULTS

Delaware Bay Area

Mean stratified catch-per-tow of immature females and males increased significantly in 2025 from 2024 but remained consistent with patterns observed since 2016 (Tables 1 and 2; Figure 3). Catch-per-tow of newly mature females continued to show a substantial rebound from pre-2024 levels and reached their highest recorded value following a revision in our sampling protocol that demanded more stringent probing for eggs in ambiguous females. Newly mature males showed a decrease in catch-per-tow, continuing to decline from their higher values in 2021 and 2022 but remaining relatively consistent with catch-per-tow values recorded prior to 2016. Catch-per-tow of mature females and males declined from their 2024 values, becoming more similar to abundance levels seen in earlier years (Tables 1 and 2; Figure 3). Variation increased substantially from 2024 for immature females and immature males, as well as mature males. It increased slightly for newly mature females and mature males. Conversely, variation decreased for mature females.

There continues to be a significant correlation between stratified mean catches of mature males and mature females ($r = 0.94$; $p < 0.001$; $T = 12.14$; $n = 20$) when considering all data since 2002. This is also true for immature males and females ($r = 0.96$; $p < 0.001$; $T = 14.59$; $n = 20$), but not for newly mature individuals ($r = -0.37$; $p = 0.11$; $T = -1.69$; $n = 20$). Previously, there was a significant positive correlation between newly mature individuals from 2002 to 2018. However, this correlation was lost with the addition of data from 2019 and 2022, likely due to the low number of newly mature females trawled in recent years compared to newly mature males. The inclusion of data from years since 2022 did not recover this correlation.

Lower Delaware Bay

2025 marks the first time the Lower Delaware Bay was sampled since 2021, and the data suggests an increase in catch-per-tow across all demographic groups between these two years (Tables 3 and 4; Figure 4). Mean stratified catch-per-tow values for immature females and immature males more than doubled from 2021. Catch-per-tow of newly mature females has been recorded as 0 since 2019, rising to 1.8 in 2025. A similar pattern was observed in newly mature males, having been recorded at 0.1 in 2020 before increasing to 2.2 in 2025. Mature females more than doubled in mean catch-per-tow between 2021 and 2025, while mature males saw a substantial increase. Variation increased slightly from 2021 for immature males and females. It increased for newly mature males from 2020 while increasing slightly for newly mature females from 2018. Conversely, variation decreased for mature females and males between 2021 and 2025, with a much larger decrease observed in the latter.

There is a significant correlation between stratified mean catches of mature males and mature females in the LDB ($r = 0.95$; $p < 0.001$; $T = 13.39$; $n = 10$) when considering all data since 2010. This is also true for immature males and females ($r = 0.99$; $p < 0.001$; $T = 31.09$; $n = 10$), but not for newly mature crabs ($r = 0.38$; $p = 0.10$; $T = 1.73$; $n = 10$).

Size Distributions

Size-frequency distributions remain highly variable (Figures 5 and 6). The substantially higher catch of newly mature females in 2025 led to this demographic group being more prominent within the overall size-frequency distribution than in earlier years. The overall shape and demographic composition of the DBA size-frequency distribution from 2025 is similar to that of 2024.

We had previously reported that mean prosomal widths of crabs in the DBA survey displayed slight but detectable decreases over time (Table 5; Figure 7) (Hallerman & Jiao, 2020; Hata & Hallerman, 2017, 2019). This trend appears to have continued this year within the DBA. The rate of decrease is greatest for newly mature females, followed by mature females, mature males, and finally newly mature males. The decreasing trend is statistically significant for mature and newly mature individuals of both sexes within the DBA (Table 6). The negative correlation between years and mean prosomal width of newly mature and mature individuals remained statistically significant. In the LDB, statistically significant trends in mean prosomal width over time were only observed for mature females and newly mature females (Table 5; Figure 7). The rate of decrease is greater for newly mature females than for mature females (Table 6).

Sex Ratios

Overall, mature males have become increasingly more common than mature females throughout the DBA sampling period, with the mean-catch-per-tow sex ratio (M:F) for mature individuals increasing from 1.61 in 2002 to 5.70 in 2025 with a median of 2.05 across the time series. M:F sex ratios in newly mature crabs have been comparatively more stable over time but still highly variable, ranging from 0.09 in 2003 to 157.89 in 2023, with a median of 1.09 across the time series. This variability is likely caused by low catches of newly mature females in previous years. M:F sex ratios in immature individuals range from 0.44 in 2019 to 1.08 in 2025, with a median of 0.70 across the time series.

M:F sex ratios within the LDB were higher across all maturity groups relative to the DBA. The M:F sex ratio for mature individuals ranges from 2.14 in 2010 to 19.8 in 2020, with a median of 4.53 over the time series – over twice that of the coastal DBA. For newly mature individuals, the M:F sex ratio ranges from 0.38 in 2010 to 5.23 in 2017, with a median of 1.33 across the time series. M:F sex ratios in immature individuals range from 0.63 in 2017 to 1.27 in 2025, with a median of 0.88 across the time series.

Population Estimates

Annual population estimates of immature crabs in the DBA survey mirror trends observed in the catch-per-tow estimates and have been variable over time, with a large peak in 2009 (Tables 7 and 8). Compared to 2024, the estimated mean population total increased significantly for both immature females and males, rising from 6.72 million to 11.37 million and from 5.43 million to 12.39 million individuals respectively. The estimated mean population total decreased from their 2024 values for mature crabs, with mature females dropping from 9.53 million to 7.11 million individuals while mature males fell from 47.72 million to 40.93 million individuals. The estimated mean population totals for newly mature females increased from their 2024 values, rising from 2.89 million to 3.43 million individuals. Conversely, newly mature males decreased in their 2025 population size, falling from 1.72 million to 904 thousand individuals.

The 2025 population estimates for immature crabs in the LDB almost tripled from their 2021 values, with immature females rising from 130 thousand to 315 thousand while immature males increased from 140 thousand to 407 thousand (Tables 9 and 10). Increases were observed in mature crabs as well, with mature females rising from 65 thousand in 2021 to 213 thousand in 2025, while mature males increased from 365 thousand to 588 thousand in the same time period. The populations of newly mature individuals rebounded dramatically from their extremely low values in previous years. Newly mature females were estimated to have a population size of less than a thousand since 2019 before rising to 79 thousand in 2025, while newly mature males rose from 4 thousand in 2020 to 96 thousand in 2025.

On average, 23.1% of the total number of immature females and 25.1% of immature males occurred within Delaware Bay, although the LDB sampling area comprises only 9.3% of the total combined area. Over the whole time series, about 7.4% of the combined population of newly mature females occurred within the

Bay, while 12.2% of newly mature males were in the Bay. About 16.3% of mature females and 21.3% of mature males occurred within the Bay on average.

Effects of the Sampling Period

Sampling occurred from August 28th to November 20th, with most of the trawls being performed in November (20 tows) and August (17 tows), while 11 trawls were performed in September and none in October. This timeframe is similar to those in sampling years prior to 2019, as trawls between 2019 and 2021 were performed earlier in August and September.

The average monthly DBA water temperature in 2025 (20.24 °C) was slightly lower than that in 2024 (21.47 °C), but remained similar to the average water temperatures recorded since 2016 (Table 11; Figure 8). The average LDB water temperature in 2025 (9.71 °C) was much lower than that recorded in previous years (20.50 °C in 2021), although this is likely due to the LDB tows being conducted much later in the year (mean ordinal date of 324 in 2025 compared to 268 in 2021).

In 2024, there was a correlation within the coastal DBA of mean catches-per-tow of immature males and females with both water temperature and ordinal date. With the addition of data from 2025, the correlation between immature female catch-per-tow and water temperature is no longer statistically significant ($p = 0.065$), but the correlation with ordinal date remains significant ($p = 0.035$). Immature male catch-per-tow remains significantly correlated with both water temperature ($p = 0.049$) and ordinal date ($p = 0.030$) (Table 12). Mature female catch-per-tow is significantly correlated with water temperature ($p = 0.045$) but not with ordinal date ($p = 0.118$). Mean catch-per-tow of mature males and newly mature females is not significantly correlated with water temperature or ordinal date. Newly mature male catch-per-tow is not significantly correlated with water temperature ($p = 0.126$) but is significantly correlated with ordinal date ($p = 0.036$).

In the LDB, there is no statistically significant correlation observed between the mean catch-per-tow of any demographic group and water temperature or ordinal date (Table 12).

Bycatch

In addition to horseshoe crabs, these surveys also capture a variety of bycatch species. Detailed documentation on the number of each bycatch species caught and associated size measurements have been historically lacking. The exceptions to this are summer flounder (*Paralichthys dentatus*), knobbed whelk (*Busycon carica*), and channeled whelk (*Busycotypus canaliculatus*). In 2024, we started recording the abundance of elasmobranch bycatch and basic size measurements for the most abundant species, and formally implemented this procedure into the 2025 sampling protocol.

Thirteen different elasmobranch species (5 shark, 3 skate, and 5 ray species) were identified as bycatch during the 2025 horseshoe crab trawl survey (Table 13; Figure 9). Clearnose skates (*Rostroraja eglanteria*) were by far the most encountered bycatch species (frequency of occurrence = 0.91), with 1,121 individuals counted across all tows. The next most frequent elasmobranch species was the bullnose ray (*Myliobatis freminvillei*), with 113 individuals counted across over half the tows (frequency of occurrence = 0.53), followed by the southern stingray (*Hypanus americanus*), with 72 individuals counted across around half the tows (frequency of occurrence = 0.51).

KEY FINDINGS - DBA

1. Mean catches-per-tow of mature males and females declined from their 2024 levels and are consistent with mean CPUE recorded in earlier years. The variances of the mean CPUE for mature males increased substantially for mature males but decreased for mature females.
2. Mean catches-per-tow of immature males and females have remained relatively stable since 2016, and this pattern continued into 2025. Variation increased from 2024 for both immature demographic groups.
3. Mean catch-per-tow of newly mature males decreased from 2024, continuing to decline from their high values in 2021 and 2022 but remaining relatively consistent with CPUE values recorded prior to 2016. Mean catch-per-tow of newly mature females continued to rebound from extremely low values since 2019, reaching their highest recorded value in 2025. This followed a revision in our sampling protocol that demanded more stringent probing for eggs in ambiguous females. Variation increased slightly for newly mature females and males.
4. Mean catches-per-tow of immature males are significantly correlated with both ordinal date and water temperature. Immature female catch-per-tow is now only significantly correlated with ordinal date. Mature female catch-per-tow is significantly correlated with water temperature but not ordinal date. The mean catch-per-tow of mature males and newly mature females are not significantly correlated with either water temperature or ordinal date. Mean catch-per-tow of newly mature males is significantly correlated with ordinal date only.
5. Annual mean prosomal width appears to still be decreasing in mature and newly mature males and females. The rate of decrease is greatest for newly mature females, followed by mature females, mature males, and finally newly mature males.

KEY FINDINGS - LDB

1. Sampling in the LDB resumed in 2025. An increase in stratified mean catch-per-tow was observed across all demographic groups when compared to 2021.
2. Mean catches-per-tow of immature females and males more than doubled from 2021. Variation increased slightly from 2021 for both immature demographic groups.
3. Mean catch-per-tow of newly mature females rose to 1.8 in 2025 from 0 since 2019. Mean catch-per-tow of newly mature males increased to 2.2 in 2025 from 0.1 in 2020. Variation increased for newly mature males from 2020 while increasing slightly for newly mature females from 2018.
4. Mean-catch-per-tow of mature females more than doubled between 2021 and 2025, while mature males saw a substantial increase. Variation decreased for mature females and males between 2021 and 2025, with a much larger decrease observed in the latter.
5. In the LDB, there is no statistically significant correlation observed between the mean catch-per-tow of any demographic group and water temperature or ordinal date.
6. In the LDB, statistically significant decreases in mean prosomal width over time were only observed for mature females and newly mature females.

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FIGURES AND TABLES

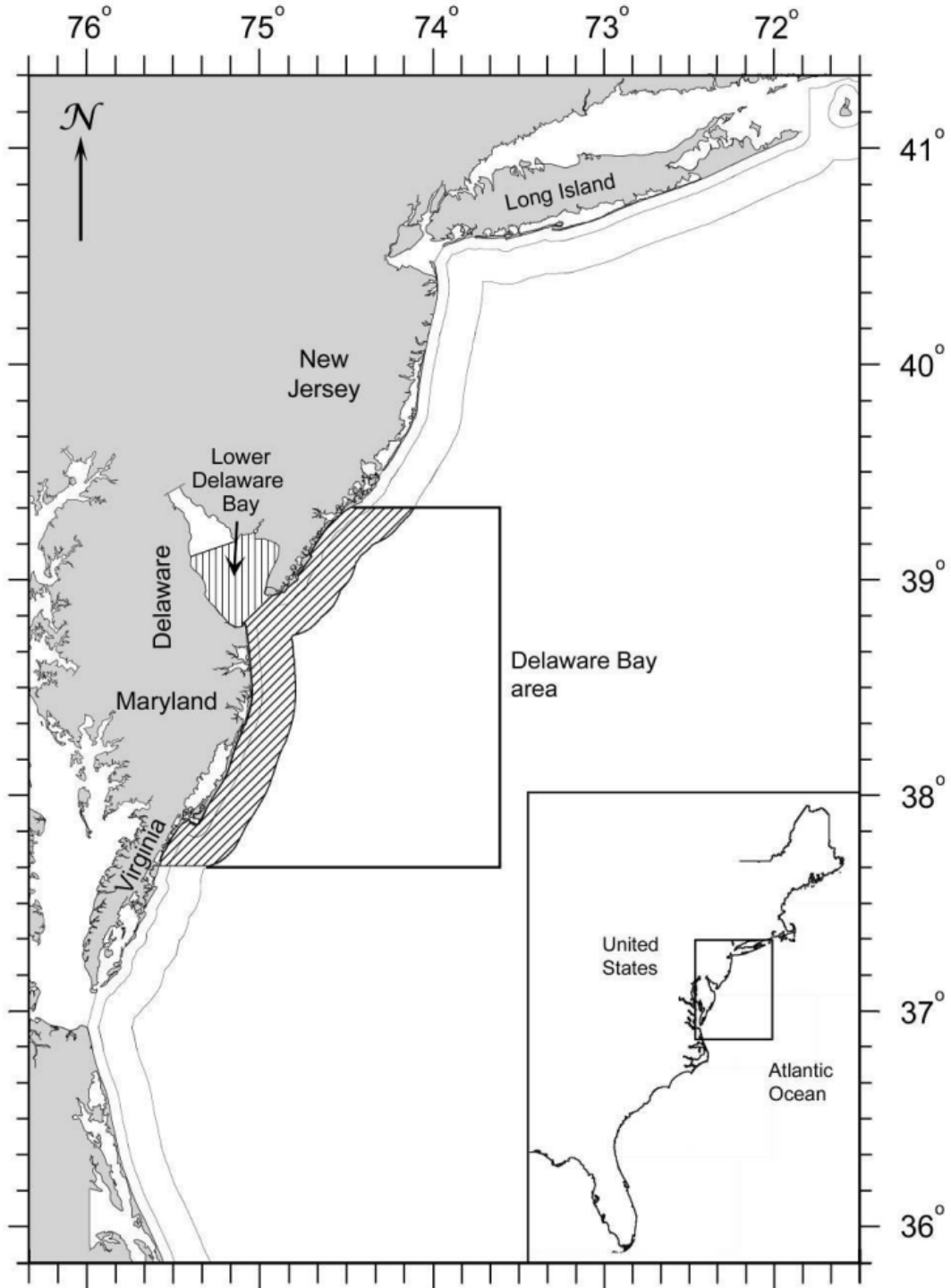


Figure 1. 2025 HSC trawl survey sampling area. The coastal Delaware Bay Area (DBA) and Lower Delaware Bay (LDB) survey areas are indicated. Mean catches between years were compared using stations within the shaded portions of the survey areas.

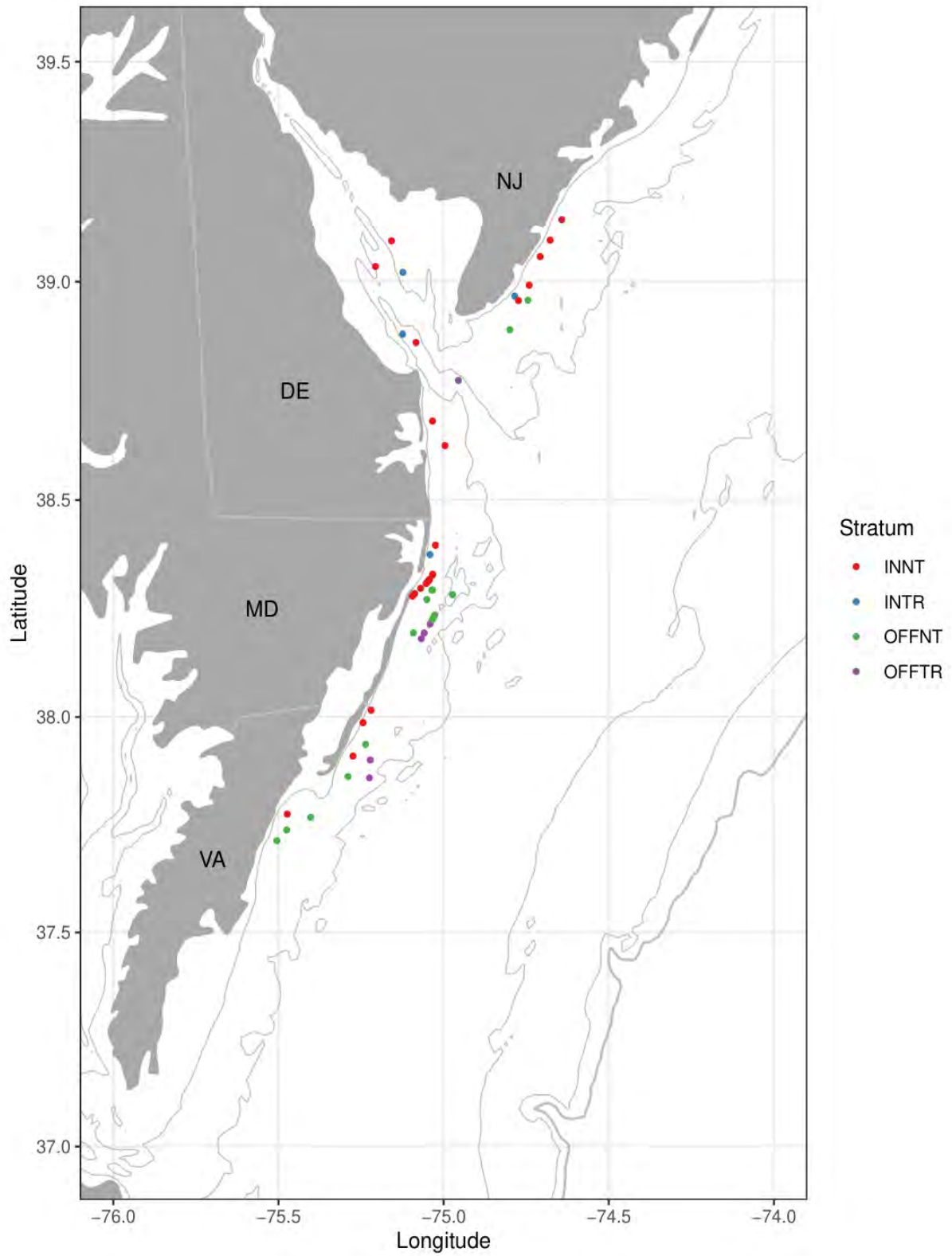


Figure 2. Map of all stations sampled during the 2025 field season. INNT denotes inshore non-trough sites, INTR denotes inshore trough sites, OFFNT denotes offshore non-trough sites, and OFFTR denotes offshore trough sites.

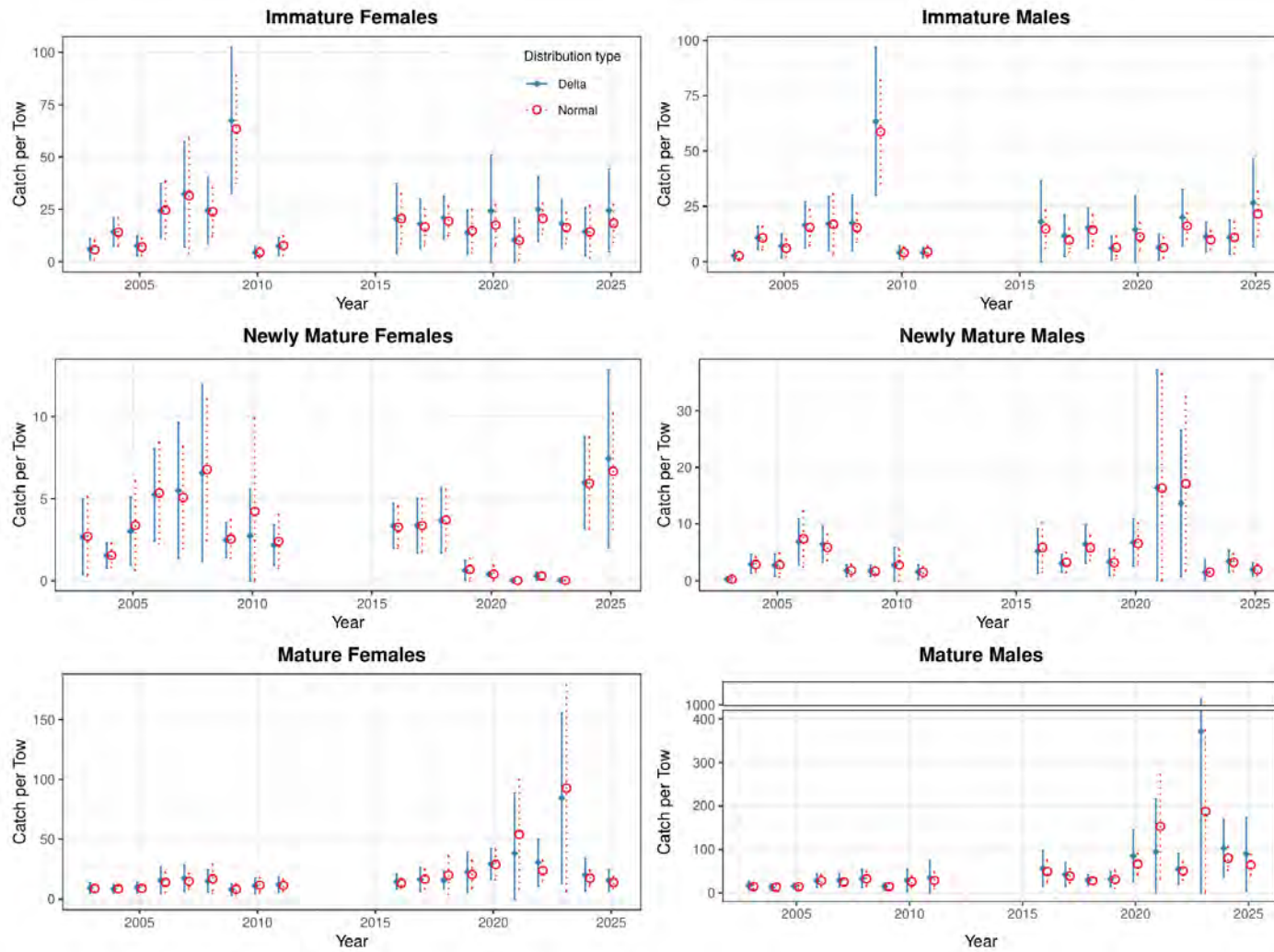


Figure 3. Plots of stratified mean catches per 15-minute tow of horseshoe crabs in the coastal Delaware Bay Area survey by demographic group. Vertical lines indicate 95% confidence intervals. Solid blue symbols and lines indicate the delta distribution model. Open red symbols and dashed lines indicate the normal distribution model. Data are from Tables 1 and 2. Note the differences in the y-axis scales.

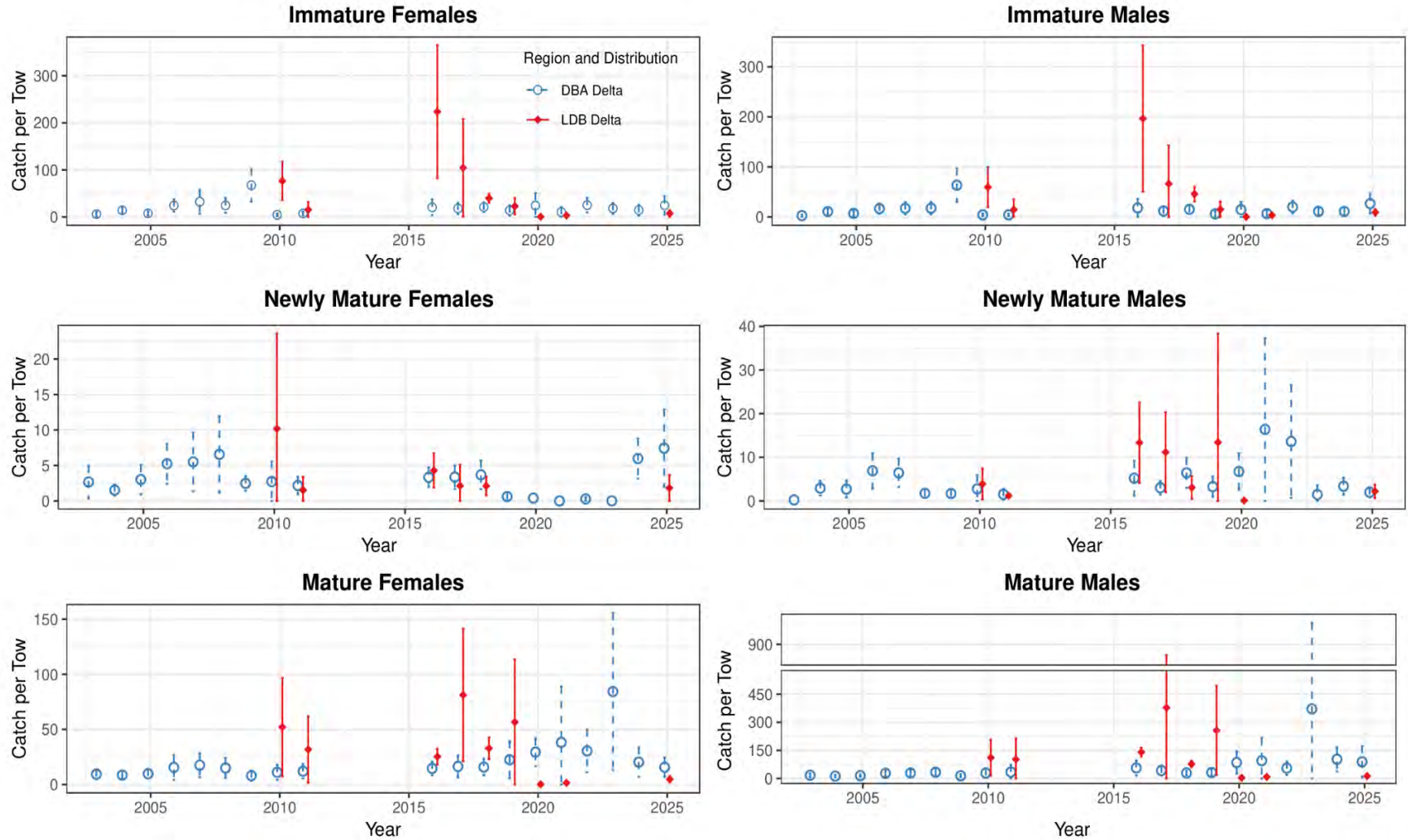


Figure 4. Plots of stratified mean catch per 15-minute tow of horseshoe crabs in the Lower Delaware Bay survey by demographic group, with coastal Delaware Bay Area survey means for comparison. Vertical lines indicate 95% confidence limits. Only the delta distribution model means are presented for comparison. Solid red symbols and lines indicate the Lower Delaware Bay survey. Open blue symbols and dashed lines indicate the coastal Delaware Bay Area survey. Note differences in y-axis scales.

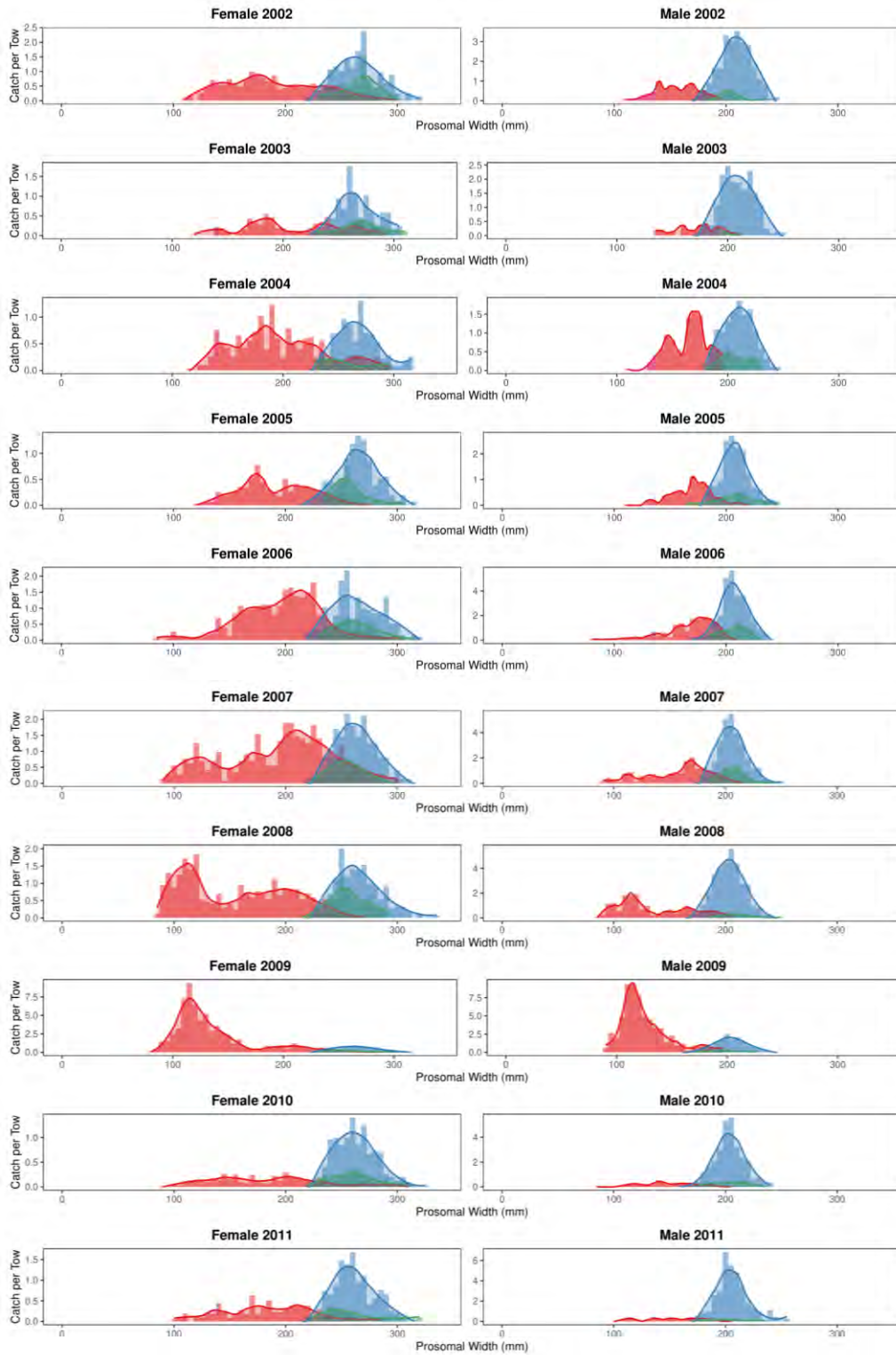


Figure 5. Size frequency distributions of horseshoe crabs by demographic group and year in the coastal Delaware Bay Area trawl survey. Relative frequencies are scaled to equal stratified mean catch-per-tow in Table 1 when summed. Red represents immatures, green represents newly matures, and blue represents matures.

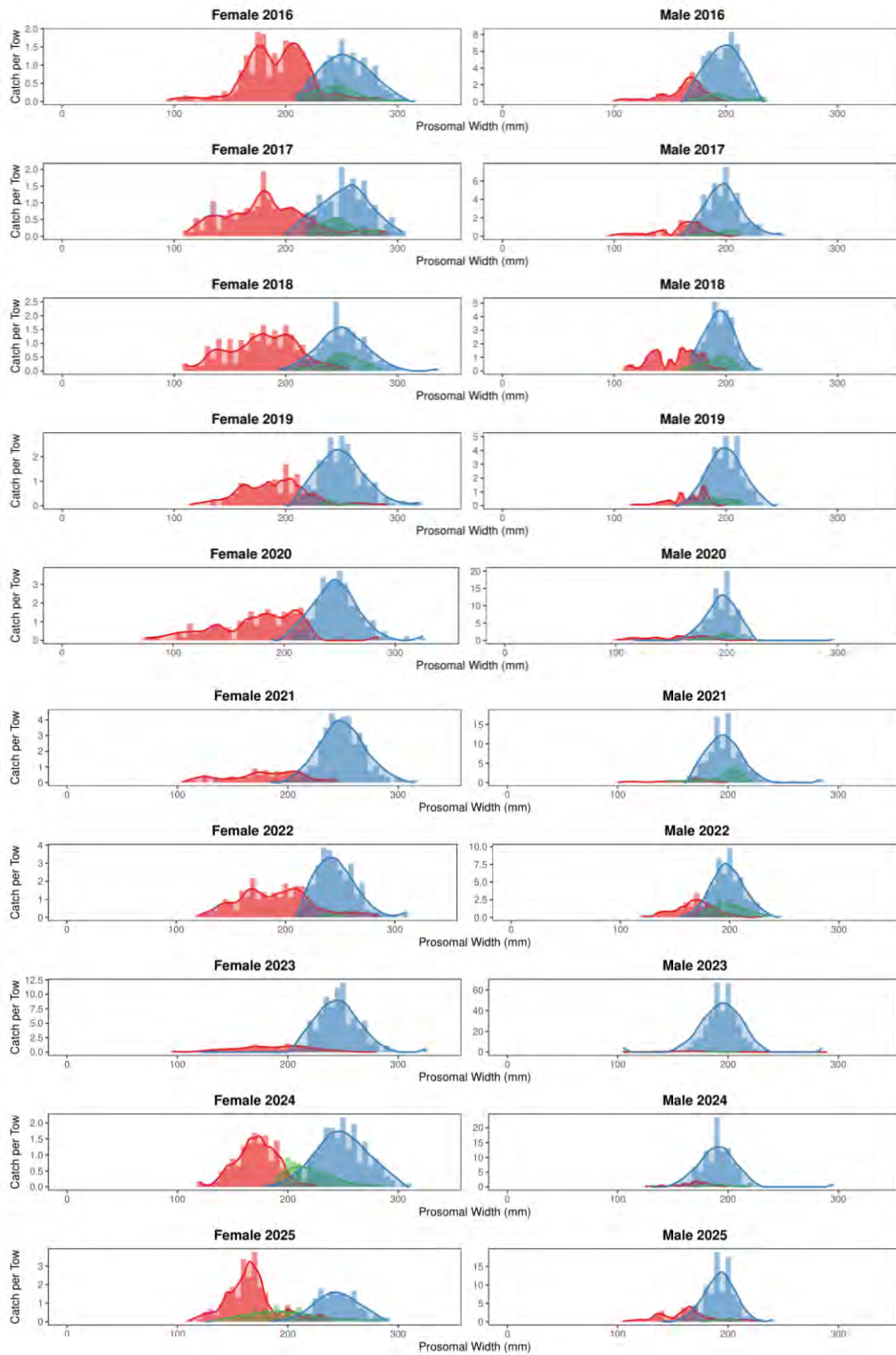


Figure 5. continued.

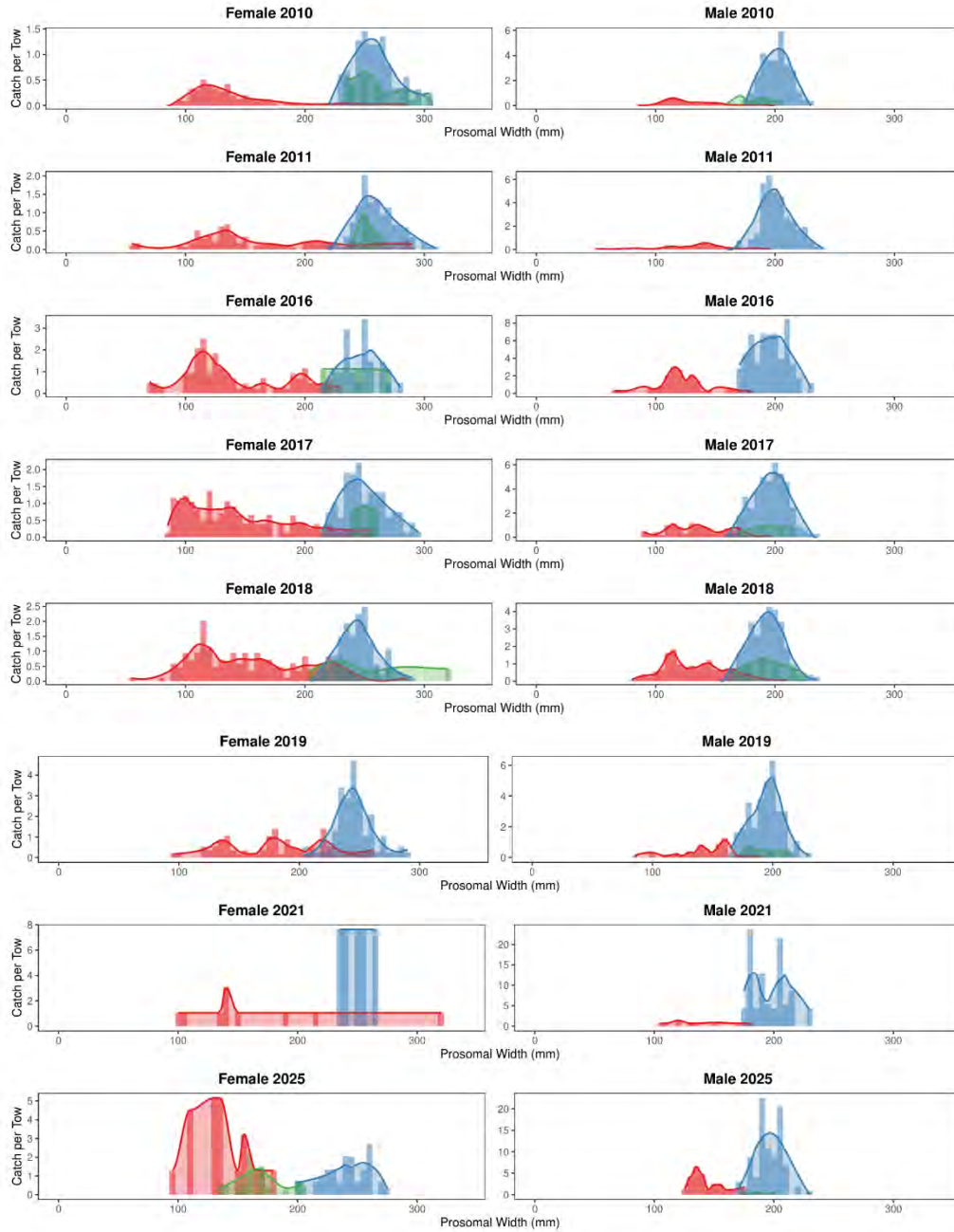


Figure 6. Relative size frequency distributions of horseshoe crabs by demographic group and year in the Lower Delaware Bay trawl survey. Relative frequencies are scaled to equal stratified mean catch-per-tow in Table 3 when summed.

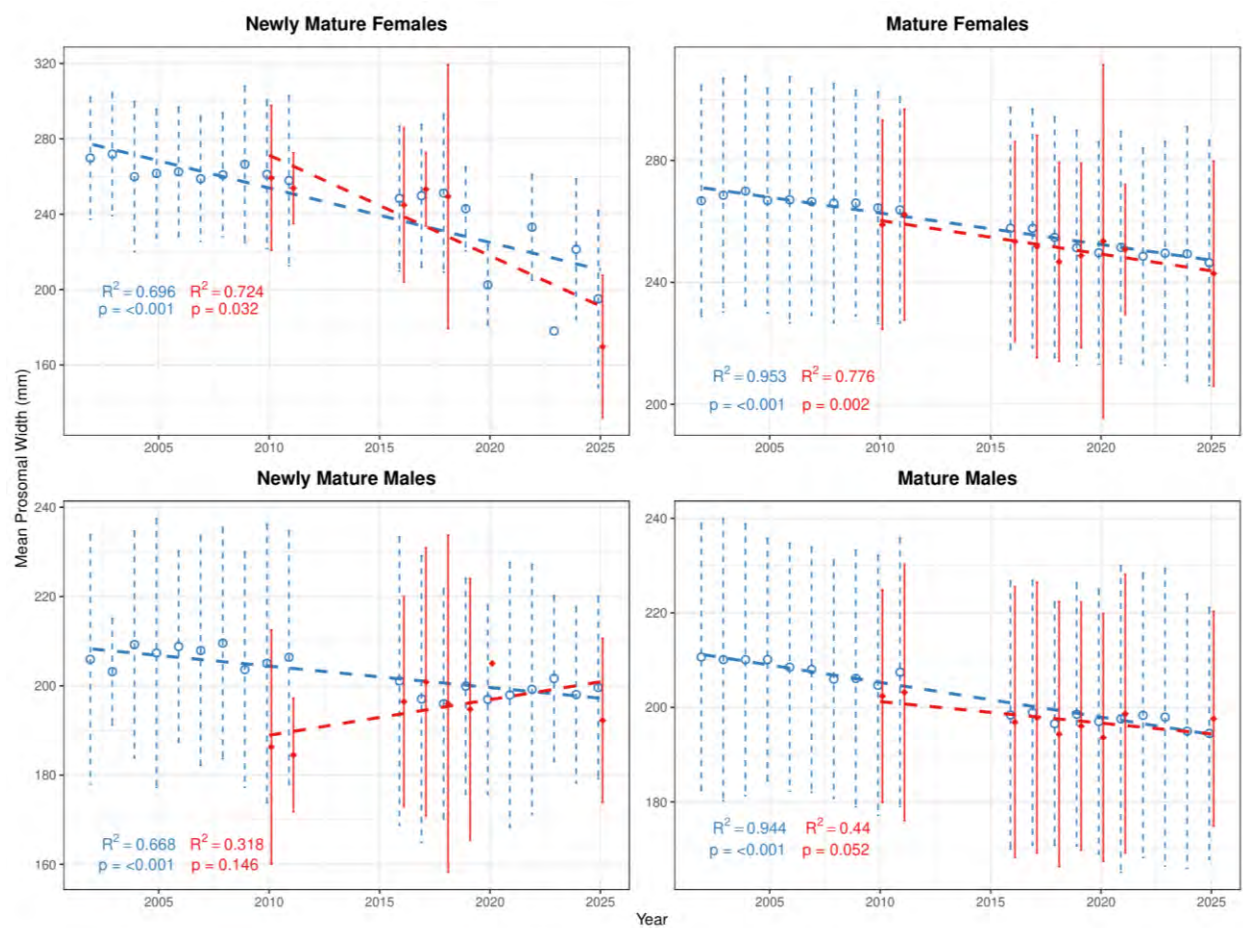


Figure 7. Mean prosomal widths (mm) (± 2 standard deviations) of mature and newly mature female and male horseshoe crabs in the Delaware Bay Area (blue symbols and lines) and Lower Delaware Bay (red symbols and lines) surveys.

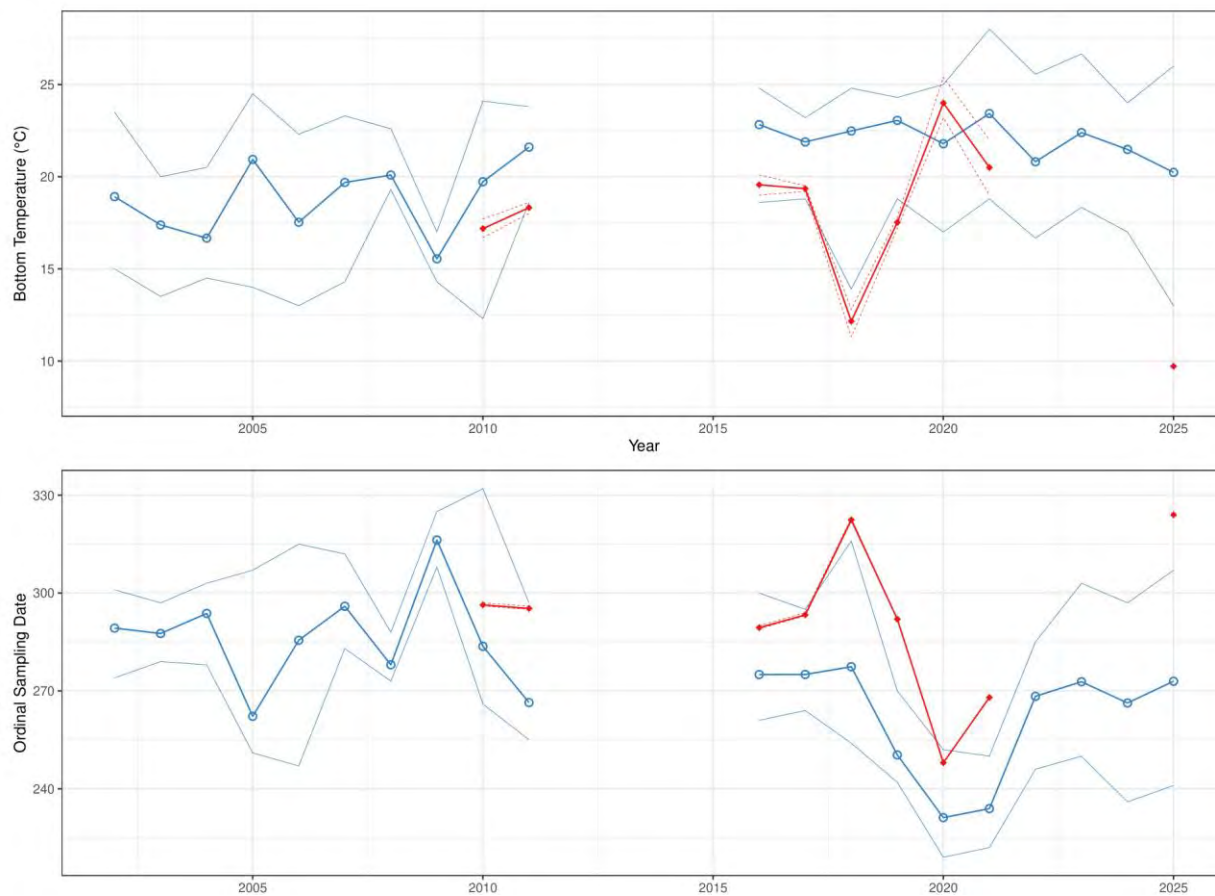


Figure 8. Plots of bottom water temperatures and ordinal sampling dates (days since January 1st) in the coastal Delaware Bay Area and Lower Delaware Bay trawl surveys. Open symbols and blue lines indicate coastal Delaware Bay Area. Solid symbols and red lines indicate Lower Delaware Bay. Points indicate mean values. Thinner lines indicate maximum and minimum values.

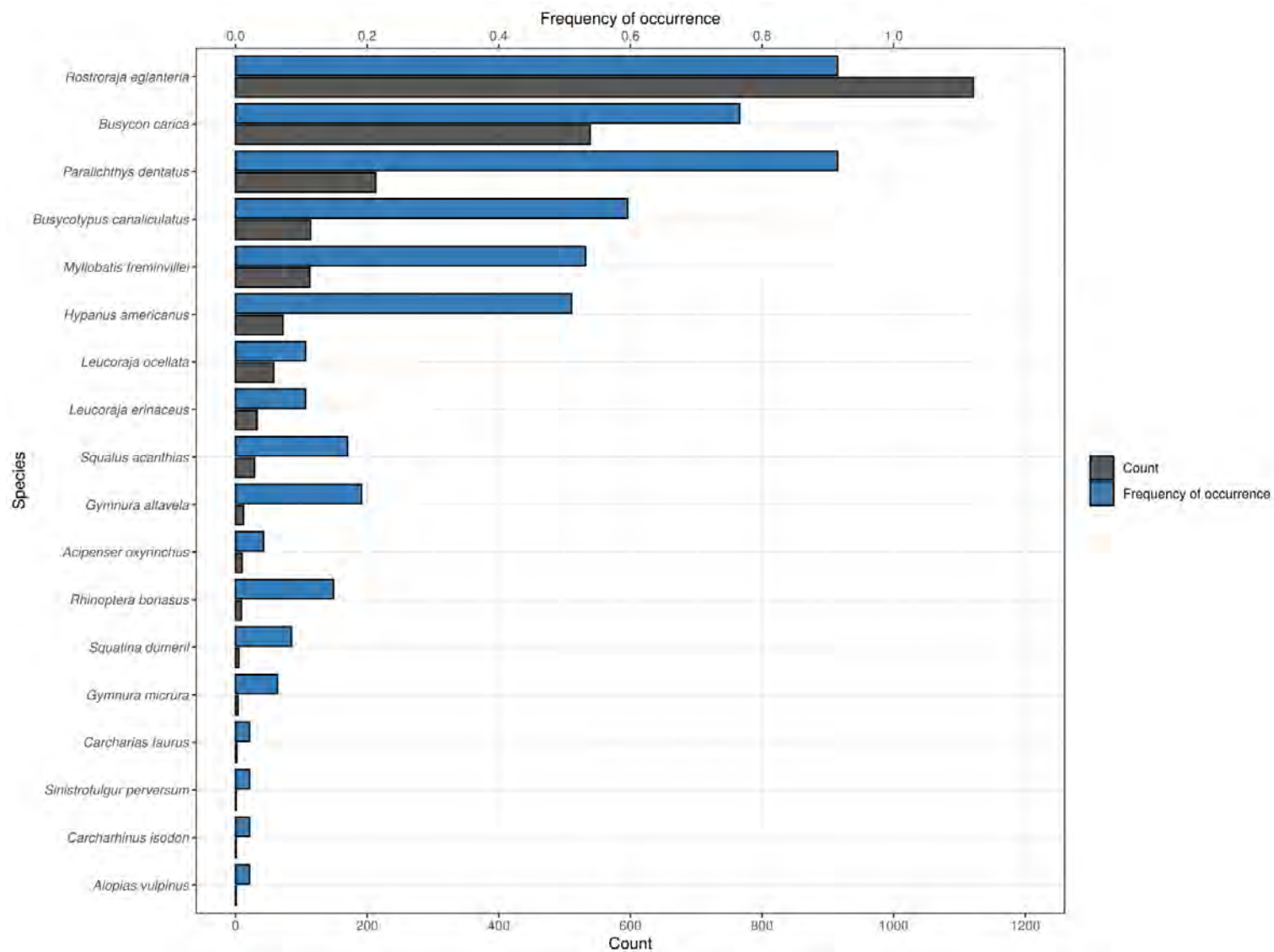


Figure 9. Frequency of occurrence and count of all bycatch species caught during the 2025 field season. Frequency of occurrence (number of tows with species/total number of tows performed) is indicated with blue bars while count is indicated with dark grey bars. Note differences in x-axis scales.

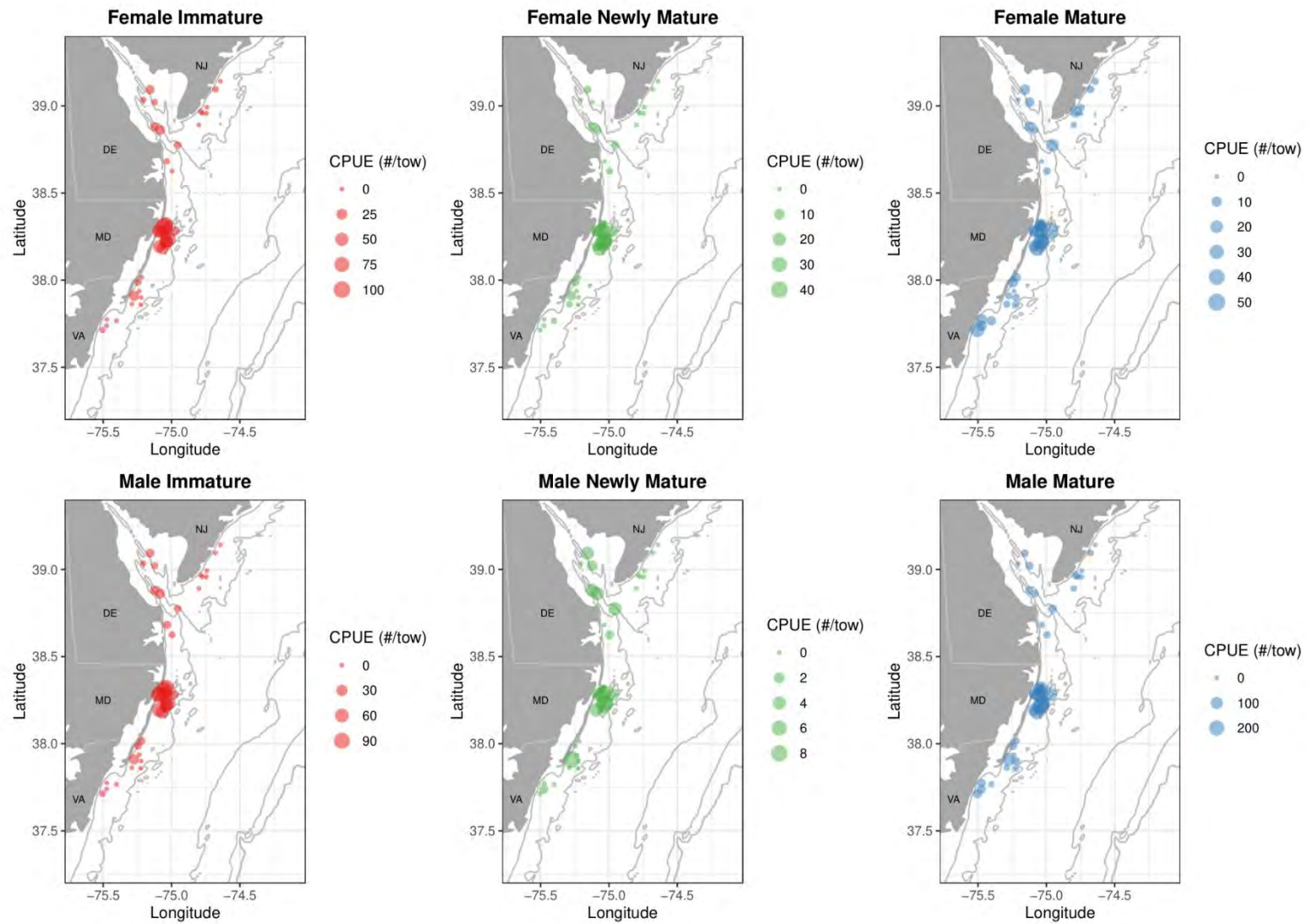


Figure 10. Geographical distribution of stratified mean catch-per-tow by demographic group in 2025. Larger circles indicate higher catch-per-tow values.

Table 1. Stratified mean catch-per-tow of horseshoe crabs in the coastal Delaware Bay Area survey, 2002-2025, with the mean, standard deviation (sd), and coefficient of variation (CV), calculated using the delta distribution model by demographic group. Also included are the upper and lower 95% confidence limits (UCL, LCL).

YEAR	MEAN	UCL	LCL	CV	SD	YEAR	MEAN	UCL	LCL	CV	SD
Immature Females						Immature Males					
2002	21.9	36.1	7.6	0.31	6.8	2002	12.6	21.4	3.9	0.33	4.2
2003	10.5	20.4	0.7	0.43	4.6	2003	5.4	9.9	0.9	0.39	2.1
2004	17.9	27.2	8.6	0.25	4.5	2004	15.7	25.0	6.4	0.29	4.5
2005	12.7	19.9	5.5	0.28	3.5	2005	11.9	20.0	3.8	0.33	3.9
2006	29.5	42.8	16.3	0.21	6.3	2006	21.6	33.9	9.2	0.25	5.4
2007	29.6	59.4	0.0	0.41	12.2	2007	19.5	39.6	0.0	0.42	8.2
2008	25.3	43.7	6.9	0.33	8.3	2008	18.0	32.4	3.6	0.35	6.3
2009	90.2	167.4	12.9	0.39	35.5	2009	69.0	109.7	28.3	0.29	19.8
2010	9.0	11.9	6.1	0.16	1.4	2010	6.1	9.5	2.8	0.27	1.6
2011	11.4	15.9	6.9	0.19	2.2	2011	6.9	10.1	3.7	0.23	1.6
2016	25.8	45.1	6.5	0.36	9.2	2016	20.0	36.6	3.5	0.39	7.9
2017	17.9	25.4	10.4	0.19	3.4	2017	12.3	20.5	4.2	0.27	3.3
2018	22.5	31.2	13.9	0.18	4.1	2018	16.5	24.4	8.7	0.22	3.7
2019	8.0	12.7	3.2	0.3	2.4	2019	3.5	6.0	1.0	0.35	1.2
2020	25.3	51.9	0.1	0.6	15.2	2020	16.0	31.3	0.8	0.56	9.1
2021	10.4	19.8	1.1	0.52	5.5	2021	6.4	11.5	1.3	0.46	3.0
2022	24.6	38.5	10.8	0.33	8.1	2022	19.3	30.8	7.7	0.36	6.9
2023	14.4	22.6	6.1	0.31	4.5	2023	9.7	15.3	4.0	0.32	3.1
2024	14.8	26.5	3.1	0.44	6.5	2024	11.9	20.2	3.7	0.38	4.56
2025	24.5	44.2	4.8	0.46	11.2	2025	26.6	46.4	6.8	0.42	11.3
Mature Females						Mature Males					
2002	11.4	18.5	4.2	0.3	3.4	2002	26.6	39.7	13.4	0.24	6.3
2003	7.7	11.7	3.7	0.25	1.9	2003	18.4	29.6	7.3	0.28	5.2
2004	5.9	8.6	3.3	0.21	1.3	2004	11.4	17.1	5.7	0.24	2.8
2005	7.2	11.4	3.0	0.27	2.0	2005	13.2	19.1	7.3	0.21	2.8
2006	15.3	33.8	0.0	0.44	6.7	2006	36.2	60.9	11.4	0.28	10.1
2007	16.9	27.5	6.2	0.3	5.1	2007	34.3	54.4	14.3	0.28	9.7
2008	14.4	23.3	5.4	0.29	4.2	2008	33.5	57.2	9.8	0.33	11.2
2009	6.7	11.2	2.3	0.32	2.1	2009	14.1	22.8	5.3	0.30	4.2
2010	11.8	17.3	6.3	0.22	2.6	2010	31.5	49.2	13.8	0.27	8.6
2011	12.3	17.1	7.6	0.18	2.2	2011	36.0	69.8	2.2	0.41	14.7
2016	13.5	19.5	7.6	0.21	2.9	2016	49.2	83.1	15.2	0.29	14.3
2017	16.9	24.8	9.0	0.23	3.9	2017	48.9	74.0	23.9	0.25	12.2
2018	16.8	23.7	9.9	0.2	3.3	2018	35.7	48.9	22.5	0.17	6.2
2019	11.6	18.7	4.5	0.3	3.5	2019	20.0	33.3	6.8	0.33	6.6
2020	29.6	41.2	18.1	0.23	6.9	2020	87.0	139.4	34.5	0.36	31.1
2021	38.2	86.5	0.0	0.72	27.4	2021	95.0	207.8	0.0	0.67	64.1
2022	28.2	42.3	14.1	0.29	8.3	2022	50.0	79.1	20.9	0.34	17.2
2023	73.4	149.0	0.0	0.56	41.3	2023	320.0	881.0	0.0	0.95	302.0
2024	21.0	34.5	7.6	0.35	7.4	2024	105.5	170.9	40.0	0.34	36.1
2025	15.7	24.5	6.9	0.32	5.0	2025	89.4	173.4	5.6	0.53	47.6
Newly Mature Females						Newly Mature Males					
2002	3.6	5.6	1.6	0.26	0.9	2002	1.3	2	0.5	0.28	0.4
2003	1.8	3.8	0.0	0.49	0.9	2003	0.2	0.5	0.0	0.84	0.2
2004	0.8	1.3	0.3	0.3	0.2	2004	1.8	2.6	1	0.21	0.4
2005	1.1	1.7	0.5	0.28	0.3	2005	1.3	2.3	0.4	0.33	0.4
2006	4.6	7.8	1.5	0.3	1.4	2006	7.1	11.6	2.6	0.36	2.7
2007	5.1	9.3	0.9	0.39	2.0	2007	6.7	10.6	2.8	0.28	1.9
2008	6.0	11.8	0.2	0.44	2.7	2008	1.8	2.9	0.6	0.32	0.6
2009	2.0	3.1	0.9	0.26	0.5	2009	1.7	2.8	0.5	0.34	0.6
2010	3.0	6.8	0.0	0.59	1.8	2010	3.2	7.0	0.0	0.55	1.8
2011	2.0	3.3	0.7	0.31	0.6	2011	1.9	3.4	0.4	0.37	0.7
2016	3.5	5.2	1.9	0.23	0.8	2016	5.9	11	0.7	0.42	2.5
2017	3.5	5.5	1.6	0.27	0.9	2017	3.6	5.8	1.5	0.29	1.0
2018	3.9	6.3	1.4	0.3	1.2	2018	7.5	11.9	3.1	0.27	2.1

Table 1. continued.

YEAR	MEAN	UCL	LCL	CV	SD	YEAR	MEAN	UCL	LCL	CV	SD
Newly Mature Females						Newly Mature Males					
2019	0.5	1.0	0.0	0.46	0.2	2019	2.8	4.6	1.0	0.32	0.9
2020	0.3	0.8	0.0	0.85	0.3	2020	7.0	11.0	2.9	0.35	2.4
2021	0.0	NA	NA	NA	NA	2021	16.4	37.3	0.0	0.69	11.3
2022	0.3	0.5	0.1	0.5	0.1	2022	13.8	26.0	1.7	0.52	7.2
2023	0.0	NA	NA	NA	NA	2023	0.1	0.3	0.0	0.76	0.1
2024	6.4	9.3	3.5	0.25	1.6	2024	3.8	5.8	1.7	0.31	1.2
2025	7.4	12.9	2.0	0.41	3.1	2025	2.0	3.1	0.8	0.33	0.7

Table 2. Stratified mean catch-per-tow of horseshoe crabs in the coastal Delaware Bay Area survey, 2002-2025, with the mean, standard deviation (sd), and coefficient of variation (CV), calculated using the normal distribution model by demographic group. Also included are the estimated upper and lower 95% confidence limits (UCL, LCL).

YEAR	MEAN	UCL	LCL	CV	SD	YEAR	MEAN	UCL	LCL	CV	SD
Immature Females						Immature Males					
2002	19.1	27.6	10.5	0.22	4.1	2002	11.7	18.3	5.0	0.27	3.2
2003	9.5	15.9	3.0	0.32	3.1	2003	4.9	8.1	1.8	0.30	1.5
2004	17.0	24.5	9.5	0.21	3.6	2004	14.0	20.3	7.6	0.22	3.1
2005	11.5	17.0	6.1	0.23	2.6	2005	10.6	16.7	4.4	0.28	2.9
2006	31.1	46.9	15.3	0.24	7.5	2006	21.5	32.0	11.1	0.23	5.0
2007	29.8	59.6	0.0	0.41	12.2	2007	20.5	43.2	0.0	0.45	9.3
2008	24.6	38.9	10.3	0.27	6.6	2008	15.9	24.2	7.6	0.24	3.8
2009	63.1	93.8	32.4	0.24	14.9	2009	61.0	89.8	32.1	0.23	14.0
2010	9.4	13.0	5.7	0.19	1.8	2010	6.4	10.1	2.6	0.29	1.8
2011	12.2	18.5	6.0	0.25	3.0	2011	7.3	11.2	3.3	0.26	1.9
2016	25.1	41.1	9.0	0.31	7.7	2016	18.1	29.9	6.3	0.31	5.7
2017	19.1	28.7	9.6	0.24	4.6	2017	12.4	19.3	5.5	0.26	3.3
2018	22.5	30.6	14.5	0.17	3.8	2018	17.2	25.9	8.6	0.24	4.1
2019	13.7	21.9	5.5	0.3	4.1	2019	6.6	11.1	2.0	0.34	2.2
2020	18.8	35.4	8.7	0.32	6.0	2020	12.7	24.0	4.7	0.37	4.8
2021	10.1	19.2	1.5	0.50	5.1	2021	6.4	11.0	1.8	0.42	2.7
2022	20.7	27.2	14.2	0.18	3.8	2022	16.0	21.4	10.7	0.20	3.2
2023	13.2	18.9	7.5	0.24	3.2	2023	8.4	12.1	4.8	0.25	2.1
2024	14.9	27.4	2.4	0.45	6.9	2024	11.8	19.3	4.3	0.35	4.2
2025	18.4	27.4	9.3	0.28	5.2	2025	21.6	31.8	11.4	0.27	5.9
Mature Females						Mature Males					
2002	11.0	17.0	4.9	0.26	2.8	2002	24.6	34.4	14.8	0.19	4.7
2003	7.5	10.9	4.1	0.22	1.6	2003	17.0	24.7	9.4	0.21	3.6
2004	6.0	8.3	3.7	0.19	1.1	2004	12.6	20.2	5.1	0.29	3.6
2005	6.8	10.0	3.5	0.22	1.5	2005	12.3	16.7	7.8	0.17	2.1
2006	13.5	24.2	2.7	0.31	4.2	2006	32.8	49.5	16.1	0.22	7.4
2007	14.2	21.3	7.1	0.24	3.4	2007	28.4	39.9	16.8	0.20	5.6
2008	16.5	31.0	2.0	0.41	6.8	2008	32.7	53.7	11.7	0.31	10.0
2009	7.3	12.3	2.2	0.33	2.4	2009	14.2	22.9	5.5	0.29	4.1
2010	12.7	19.7	5.7	0.26	3.3	2010	32.5	50.9	14.1	0.27	8.8
2011	12.6	18.1	7.2	0.2	2.6	2011	35.4	61.4	9.5	0.32	11.5
2016	12.8	17.4	8.2	0.17	2.2	2016	53.9	90.0	17.8	0.30	16.2
2017	18.2	28.0	8.4	0.26	4.8	2017	47.2	69.3	25.1	0.23	10.8
2018	21.1	39.6	2.5	0.41	8.7	2018	34.9	44.9	24.9	0.14	4.8
2019	18.7	28.4	9.0	0.26	4.8	2019	19.7	31.0	8.4	0.28	5.6
2020	29.4	41.8	17.3	0.25	7.2	2020	68.8	111.7	44.1	0.21	14.7
2021	54.0	85.3	6.8	0.50	26.8	2021	152.6	215.5	30.0	0.46	69.7
2022	24.3	31.5	17.1	0.18	4.3	2022	47.8	64.7	31.0	0.21	9.9
2023	79.8	167.0	0.0	0.59	47.2	2023	170.0	360.0	0.0	0.60	102.0
2024	18.2	24.7	11.7	0.20	3.6	2024	82.7	110.0	55.4	0.18	15.1
2025	13.8	18.8	8.8	0.21	2.8	2025	64.1	88.8	39.5	0.22	14.1
Newly Mature Females						Newly Mature Males					
2002	3.5	5.3	1.7	0.24	0.9	2002	1.3	2.2	0.4	0.31	0.4
2003	1.8	3.6	0.1	0.45	0.8	2003	0.2	0.5	0.0	0.84	0.2
2004	0.8	1.4	0.3	0.33	0.3	2004	1.8	2.6	1.0	0.21	0.4
2005	1.2	2.1	0.3	0.35	0.4	2005	1.3	2.1	0.5	0.29	0.4
2006	4.8	8.2	1.4	0.33	1.6	2006	7.5	13.2	1.8	0.36	2.7
2007	4.6	7.7	1.5	0.32	1.5	2007	6.1	9.1	3.2	0.23	1.4
2008	6.3	11.3	1.3	0.37	2.3	2008	1.8	3.1	0.5	0.34	0.6
2009	2.0	3.1	0.9	0.26	0.5	2009	1.6	2.6	0.6	0.30	0.5
2010	4.0	10.3	0.0	0.74	3.0	2010	3.3	7.2	0.0	0.56	1.9
2011	2.2	3.9	0.5	0.38	0.8	2011	1.9	3.5	0.4	0.38	0.7
2016	3.5	5.1	1.9	0.22	0.8	2016	6.6	12.6	0.6	0.43	2.9
2017	3.6	5.5	1.6	0.27	1.0	2017	3.8	6.4	1.3	0.32	1.2
2018	3.9	6.2	1.6	0.28	1.1	2018	6.9	10.0	3.9	0.21	1.5

Table 2. continued.

YEAR	MEAN	UCL	LCL	CV	SD	YEAR	MEAN	UCL	LCL	CV	SD
Newly Mature Females						Newly Mature Males					
2019	0.6	1.2	0.0	0.48	0.3	2019	3.5	5.5	1.5	0.29	1.0
2020	0.3	0.8	0.0	0.84	0.3	2020	6.9	10.6	3.3	0.31	2.1
2021	0.0	NA	NA	NA	0.0	2021	16.3	37.4	0.0	0.69	11.3
2022	0.3	0.5	0.04	0.46	0.1	2022	16.2	28.6	3.8	0.45	7.2
2023	0.0	NA	NA	NA	NA	2023	0.1	0.3	0.0	0.76	0.1
2024	6.4	9.3	3.5	0.25	1.6	2024	3.8	5.5	2.0	0.27	1.0
2025	6.7	10.2	3.1	0.30	2.0	2025	1.9	2.9	0.9	0.29	0.6

Table 3. Stratified mean catch-per-tow of horseshoe crabs in the Lower Delaware Bay survey area in 2010-2025, with the mean, standard deviation (sd), and coefficient of variation (CV), calculated using the delta distribution model, by demographic group. Also included are the estimated upper and lower 95% confidence limits (UCL, LCL).

YEAR	MEAN	UCL	LCL	CV	SD	YEAR	MEAN	UCL	LCL	CV	SD
Immature Females						Immature Males					
2010	79.7	122.2	37.3	0.21	16.5	2010	61.2	105.5	16.9	0.30	18.1
2011	19.7	45.2	0.0	0.47	9.2	2011	20.2	50.7	0.0	0.55	11.0
2012	164.3	311.8	16.9	0.32	53.1	2012	192.6	548.4	0.0	0.43	82.7
2016	196	335.5	56.6	0.29	57.0	2016	184.2	322.9	45.5	0.32	58.7
2017	96.7	210.0	0.0	0.46	44.1	2017	62.9	137.6	0.0	0.46	29.0
2018	47.2	56.2	38.1	0.08	3.8	2018	55.1	71.8	38.4	0.12	6.8
2019	9.5	24.3	0.0	0.60	5.7	2019	5.7	15.8	0.0	0.70	4.0
2020	0.3	0.8	0.0	0.97	0.3	2020	0.2	0.6	0.0	0.97	0.2
2021	3.1	NA	NA	0.99	3.1	2021	3.3	NA	NA	0.78	2.6
2022	NA	NA	NA	NA	NA	2022	NA	NA	NA	NA	NA
2023	NA	NA	NA	NA	NA	2023	NA	NA	NA	NA	NA
2024	NA	NA	NA	NA	NA	2024	NA	NA	NA	NA	NA
2025	7.3	14.6	0.0	0.49	3.6	2025	9.3	15.9	2.7	0.4	3.3
Mature Females						Mature Males					
2010	48.8	98.9	0.0	0.4	19.5	2010	130.3	242.6	18.1	0.34	43.7
2011	30.3	60.4	0.2	0.36	10.8	2011	110.2	249	0.0	0.45	50.0
2012	19.1	51.6	0.0	0.4	7.6	2012	66.8	141.1	0.0	0.35	23.3
2016	26.3	33.9	18.7	0.12	3.2	2016	161.7	192.5	131.0	0.08	13.3
2017	80.6	167.1	0.0	0.39	31.1	2017	362.7	868.5	0.0	0.50	182.2
2018	36.2	46.6	25.8	0.12	4.3	2018	94.3	117.9	70.7	0.11	10.0
2019	20.8	54.7	0.0	0.63	13.2	2019	100.4	254	0.0	0.59	59.7
2020	0.2	0.5	0.0	0.97	0.2	2020	4.1	8.8	0.0	0.67	2.7
2021	1.6	NA	NA	0.99	1.5	2021	8.7	NA	NA	0.72	6.3
2022	NA	NA	NA	NA	NA	2022	NA	NA	NA	NA	NA
2023	NA	NA	NA	NA	NA	2023	NA	NA	NA	NA	NA
2024	NA	NA	NA	NA	NA	2024	NA	NA	NA	NA	NA
2025	4.8	7.5	2.2	0.3	1.2	2025	13.3	18.3	8.4	0.17	2.3
Newly Mature Females						Newly Mature Males					
2010	9.7	25.8	0.0	0.64	6.2	2010	4.4	9.5	0.0	0.46	2.0
2011	1.4	3.8	0.0	0.58	0.8	2011	1.4	4.9	0.0	0.94	1.3
2012	1.0	4.4	0.0	0.76	0.8	2012	6.1	14.2	0.0	0.48	2.9
2016	4.6	8.0	1.1	0.31	1.4	2016	16.2	29.0	3.5	0.3	5.0
2017	2.1	5.9	0.0	0.65	1.4	2017	12.4	27.6	0.0	0.44	5.4
2018	2.3	4.4	0.2	0.35	0.8	2018	3.6	7.6	0.0	0.44	1.6
2019	0.0	0.0	0.0	NA	0.0	2019	8.0	22.3	0.0	0.7	5.6
2020	0.0	0.0	0.0	NA	0.0	2020	0.1	0.3	0.0	0.97	0.1
2021	0.0	NA	NA	NA	0.0	2021	0.0	NA	NA	NA	0.0
2022	NA	NA	NA	NA	NA	2022	NA	NA	NA	NA	NA
2023	NA	NA	NA	NA	NA	2023	NA	NA	NA	NA	NA
2024	NA	NA	NA	NA	NA	2024	NA	NA	NA	NA	NA
2025	1.8	3.7	0.0	0.5	0.9	2025	2.2	3.8	0.7	0.3	0.8

Table 4. Stratified mean catch-per-tow of horseshoe crabs in the Lower Delaware Bay survey area in 2010-2025, with the mean, standard deviation (sd), and coefficient of variation (CV), calculated using the normal distribution model by demographic group. Also included are the estimated upper and lower 95% confidence limits (UCL, LCL).

YEAR	MEAN	UCL	LCL	CV	SD	YEAR	MEAN	UCL	LCL	CV	SD
Immature Females						Immature Males					
2010	79.5	116.5	42.6	0.19	15.1	2010	60.4	95.7	25.1	0.25	15.3
2011	21.3	54.2	0.0	0.55	11.8	2011	21.5	57.2	0.0	0.60	12.9
2012	165.5	287.6	43.4	0.30	49.9	2012	183.9	360.1	7.8	0.34	63.4
2016	186.5	284.7	88.3	0.22	40.1	2016	167.9	249.7	86.0	0.21	34.6
2017	90.8	176.0	5.6	0.37	33.2	2017	58.2	109	7.5	0.36	20.7
2018	47.1	55.6	38.6	0.08	3.6	2018	54.9	69.6	40.2	0.11	6.2
2019	16.0	30.4	1.5	0.35	5.6	2019	10.7	21.7	0.0	0.40	4.3
2020	0.3	0.8	0.0	0.97	0.3	2020	0.2	0.6	0.0	0.97	0.2
2021	3.1	NA	NA	NA	NA	2021	3.3	NA	NA	NA	NA
2022	NA	NA	NA	NA	NA	2022	NA	NA	NA	NA	NA
2023	NA	NA	NA	NA	NA	2023	NA	NA	NA	NA	NA
2024	NA	NA	NA	NA	NA	2024	NA	NA	NA	NA	NA
2025	7.1	13.3	1.0	0.4	3.0	2025	9.0	14.4	3.5	0.3	2.7
Mature Females						Mature Males					
2010	49.1	99.8	0.0	0.40	19.7	2010	128.0	227.9	28.2	0.3	38.9
2011	28.6	49.9	7.4	0.27	7.7	2011	100.3	187.7	13.0	0.31	31.5
2012	18.7	46.2	0.0	0.34	6.4	2012	65.3	111.7	18.8	0.28	18.1
2016	26.2	33.4	19.0	0.11	3.0	2016	161.8	192.4	131.1	0.08	13.3
2017	80.5	165	0.0	0.38	30.4	2017	303.4	531.7	75.2	0.27	82.2
2018	36.2	47.2	25.1	0.12	4.3	2018	94.7	120.3	69.0	0.11	10.8
2019	29.3	54.8	3.8	0.34	9.9	2019	49.9	90	9.9	0.31	15.6
2020	0.2	0.5	0.0	0.97	0.2	2020	4.1	8.8	0.0	0.67	2.7
2021	1.6	NA	NA	NA	NA	2021	8.7	NA	NA	NA	NA
2022	NA	NA	NA	NA	NA	2022	NA	NA	NA	NA	NA
2023	NA	NA	NA	NA	NA	2023	NA	NA	NA	NA	NA
2024	NA	NA	NA	NA	NA	2024	NA	NA	NA	NA	NA
2025	4.9	7.8	2.0	0.3	1.4	2025	13.2	17.8	8.7	0.2	2.1
Newly Mature Females						Newly Mature Males					
2010	9.6	24.9	0.0	0.62	5.9	2010	4.3	9.1	0.0	0.43	1.9
2011	1.4	3.8	0.0	0.58	0.8	2011	1.4	4.9	0.0	0.94	1.3
2012	1.0	4.4	0.0	0.76	0.8	2012	6.1	14.1	0.0	0.47	2.9
2016	4.5	8.0	1.1	0.3	1.3	2016	16	27.2	4.9	0.27	4.3
2017	2.1	5.9	0.0	0.65	1.4	2017	12.4	25.7	0.0	0.42	5.2
2018	2.3	4.3	0.3	0.34	0.8	2018	3.6	7.6	0.0	0.44	1.6
2019	0.0	0.0	0.0	NA	0.0	2019	8.5	22.9	0.0	0.66	5.6
2020	0.0	0.0	0.0	NA	0.0	2020	0.1	0.3	0.0	0.97	0.1
2021	0.0	NA	NA	NA	0.0	2021	0.0	NA	NA	NA	0.0
2022	NA	NA	NA	NA	NA	2022	NA	NA	NA	NA	NA
2023	NA	NA	NA	NA	NA	2023	NA	NA	NA	NA	NA
2024	NA	NA	NA	NA	NA	2024	NA	NA	NA	NA	NA
2025	1.8	3.9	0.0	0.5	0.8	2025	2.2	3.6	0.8	0.3	0.7

Table 5. Results of correlation analyses of mean prosomal width (mm) and survey year for mature and newly mature males and females from the Delaware Bay Area and Lower Delaware Bay surveys. Statistics presented are the number of years included: *n*; *T*-score; probability, *p*; and correlation coefficient, *r*. A negative correlation coefficient indicates a decreasing regression slope.

Maturity Group	n	T	p	r
Delaware Bay Area 2002 - 2025				
Mature females	20	-19.20	<0.001	-0.976
Newly mature females	20	-6.24	<0.001	-0.834
Mature males	20	-17.38	<0.001	-0.971
Newly mature males	20	-6.02	<0.001	-0.818
Lower Delaware Bay 2010 - 2025				
Mature females	10	-4.92	0.002	-0.881
Newly mature females	10	-3.24	0.032	-0.851
Mature males	10	-2.34	0.052	-0.663
Newly mature males	10	1.67	0.146	0.564

Table 6. Results of linear regression analyses of mean prosomal width (mm) and survey year for mature and newly mature males and females from the Delaware Bay Area and Lower Delaware Bay surveys. Statistics presented are regression slope, m , and probability, p .

Maturity Group	m	p
Delaware Bay Area 2002 - 2025		
Mature females	-1.03	<0.001
Newly mature females	-2.89	<0.001
Mature males	-0.73	<0.001
Newly mature males	-0.48	<0.001
Lower Delaware Bay 2010 - 2025		
Mature females	-1.10	0.002
Newly mature females	-5.34	0.032
Mature males	-0.46	0.052
Newly mature males	0.80	0.146

Table 7. Estimated population (in thousands) of horseshoe crabs in the coastal Delaware Bay Area survey, 2002-2025, with the mean, standard deviation (sd), and coefficient of variation (CV), calculated using the delta distribution model by demographic group. Also included are the estimated upper and lower 95% confidence limits (UCL, LCL).

YEAR	MEAN	UCL	LCL	CV	SD	YEAR	MEAN	UCL	LCL	CV	SD
Immature Females						Immature Males					
2002	9470	15665	3275	0.31	2936	2002	5483	9284	1683	0.33	1809
2003	4585	8848	321	0.43	1972	2003	2303	4217	390	0.39	898
2004	7774	11770	3778	0.25	1944	2004	6810	10895	2725	0.29	1975
2005	5630	8856	2404	0.28	1576	2005	5260	8839	1681	0.33	1736
2006	12928	18691	7164	0.21	2715	2006	9327	14554	4100	0.24	2238
2007	13684	27486	0	0.41	5610	2007	8966	18246	0	0.42	3766
2008	10933	18650	3216	0.32	3499	2008	7841	13917	1766	0.35	2744
2009	39032	72868	5197	0.39	15222	2009	29864	47269	12460	0.28	8362
2010	3954	5220	2688	0.16	633	2010	2686	4144	1229	0.26	698
2011	4965	6945	2985	0.2	993	2011	3092	4547	1637	0.23	711
2016	11699	20462	2935	0.36	4212	2016	9102	16649	1555	0.39	3550
2017	7505	10708	4302	0.19	1426	2017	5091	8465	1717	0.27	1375
2018	10173	14285	6061	0.19	1933	2018	7507	11173	3842	0.23	1727
2019	3397	5516	1279	0.31	1053	2019	1487	2614	360	0.38	565
2020	9475	19779	0	0.65	6159	2020	5925	11967	0	0.61	3614
2021	4174	7947	400	0.53	2218	2021	2574	4634	513	0.47	1199
2022	9930	15493	4366	0.33	3282	2022	7652	12192	3112	0.35	2686
2023	8228	14206	2250	0.39	3238	2023	5313	8835	1792	0.36	1910
2024	6724	12105	1343	0.44	2966	2024	5432	9227	1638	0.39	2094
2025	11369	20552	2186	0.46	5237	2025	12387	21753	3022	0.43	5334
Mature Females						Mature Males					
2002	4959	8084	1834	0.3	1488	2002	11584	17335	5834	0.24	2780
2003	3379	5160	1599	0.25	845	2003	8069	13029	3110	0.29	2340
2004	2735	4043	1426	0.23	629	2004	5150	7788	2511	0.25	1288
2005	3138	4942	1333	0.27	847	2005	5844	8461	3228	0.22	1286
2006	6611	14330	0	0.42	2777	2006	15825	26060	5589	0.27	4273
2007	7746	12704	2789	0.31	2401	2007	15795	25104	6487	0.28	4423
2008	6311	10202	2419	0.29	1830	2008	14647	24995	4299	0.33	4834
2009	2975	4971	979	0.32	952	2009	6240	10197	2283	0.3	1872
2010	5178	7616	2740	0.23	1191	2010	13963	21910	6015	0.28	3910
2011	5290	7282	3297	0.18	952	2011	15060	29000	1120	0.4	6024
2016	6024	8635	3413	0.21	1265	2016	21941	37216	6665	0.29	6363
2017	7185	10525	3844	0.23	1653	2017	20664	31208	10119	0.25	5166
2018	7326	10520	4131	0.21	1538	2018	15749	21880	9619	0.18	2835
2019	5110	8454	1767	0.32	1635	2019	8924	15202	2646	0.35	3108
2020	10803	15359	6247	0.25	2706	2020	31546	51050	12042	0.36	11583
2021	15498	35873	0	0.75	11,568	2021	38538	85949	0	0.7	26925
2022	11421	17179	5662	0.30	3380	2022	19921	31447	8395	0.34	6806
2023	59866	138341	0	0.71	42480	2023	245346	716731	0	1.03	253925
2024	9534	15559	3509	0.35	3316	2024	47719	76968	18470	0.34	16153
2025	7112	11078	3146	0.32	2262	2025	40933	79370	2495	0.53	21803
Newly Mature Females						Newly Mature Males					
2002	1537	2400	675	0.26	400	2002	548	869	227	0.28	153
2003	794	1633	0	0.49	389	2003	78	221	0	0.84	66
2004	358	575	141	0.29	104	2004	789	1127	451	0.21	166
2005	479	753	206	0.27	129	2005	597	1002	191	0.33	197
2006	2051	3509	594	0.31	636	2006	3113	5113	1113	0.31	965
2007	2373	4339	408	0.4	949	2007	3129	4972	1287	0.28	876
2008	2571	4984	158	0.43	1106	2008	757	1254	261	0.31	235
2009	885	1361	410	0.26	230	2009	725	1240	210	0.34	247
2010	1338	2990	0	0.59	789	2010	1422	3070	0	0.55	782
2011	845	1360	331	0.3	254	2011	749	1335	164	0.36	270
2016	1608	2357	860	0.23	370	2016	2608	4884	331	0.42	1095
2017	1480	2274	687	0.26	385	2017	1523	2392	654	0.28	426
2018	1773	2923	622	0.31	550	2018	3341	5367	1316	0.29	969

Table 7. continued.

YEAR	MEAN	UCL	LCL	CV	SD	YEAR	MEAN	UCL	LCL	CV	SD
Newly Mature Females						Newly Mature Males					
2019	0.6	1.2	0.0	0.48	0.3	2019	3.5	5.5	1.5	0.29	1.0
2020	0.3	0.8	0.0	0.84	0.3	2020	6.9	10.6	3.3	0.31	2.1
2021	0	NA	NA	NA	NA	2021	6333	14328	0	0.68	4309
2022	115	207	23	0.46	53	2022	5487	10293	681	0.52	2,835
2023	0	NA	NA	NA	NA	2023	55	131	0	0.77	42
2024	2893	4193	1593	0.25	723	2024	1716	2658	775	0.31	527
2025	3433	5957	909	0.42	1428	2025	904	1439	369	0.34	306

Table 8. Estimated population (in thousands) of horseshoe crabs in the coastal Delaware Bay Area survey, 2002-2025, with the mean, standard deviation (sd), and coefficient of variation (CV), calculated using the normal distribution model by demographic group. Also included are the estimated upper and lower 95% confidence limits (UCL, LCL).

YEAR	MEAN	UCL	LCL	CV	SD	YEAR	MEAN	UCL	LCL	CV	SD
Immature Females						Immature Males					
2002	8222	11875	4568	0.21	1727	2002	5076	7998	2155	0.28	1421
2003	4089	6860	1317	0.32	1308	2003	2114	3462	766	0.3	634
2004	7376	10616	4135	0.21	1549	2004	6033	8786	3281	0.22	1327
2005	5104	7521	2687	0.23	1174	2005	4673	7414	1932	0.28	1308
2006	13714	20988	6439	0.25	3429	2006	9378	13971	4786	0.23	2157
2007	13692	27335	48	0.41	5614	2007	9350	19735	0	0.45	4208
2008	10595	16578	4612	0.26	2755	2008	6897	10443	3350	0.23	1586
2009	27375	40519	14232	0.23	6296	2009	26435	38730	14140	0.23	6080
2010	4102	5706	2497	0.19	779	2010	2781	4423	1139	0.29	806
2011	5426	8433	2420	0.27	1465	2011	3301	5219	1382	0.28	924
2016	11292	18441	4144	0.3	3388	2016	8185	13512	2858	0.31	2537
2017	7948	11818	4077	0.23	1828	2017	5082	7829	2335	0.26	1321
2018	10115	13839	6391	0.18	1821	2018	7768	11653	3882	0.24	1864
2019	14855	15027	14682	0.33	4902	2019	66	236	0	1.27	84
2020	6832	10559	3106	0.32	2213	2020	4610	7540	1679	0.38	1740
2021	4053	7670	436	0.51	2064	2021	2548	4389	707	0.42	1074
2022	8328	11016	5639	0.19	1580	2022	6359	8461	4257	0.20	1243
2023	7702	12775	2629	0.36	2770	2023	4510	6819	2202	0.29	1296
2024	6838	12683	993	0.47	3207	2024	5429	8926	1932	0.36	1941
2025	8538	12837	4239	0.29	2462	2025	10060	14880	5239	0.27	2765
Mature Females						Mature Males					
2002	4779	7431	2128	0.26	1243	2002	10711	14972	6450	0.19	2035
2003	3308	4851	1764	0.22	728	2003	7454	10827	4082	0.21	1565
2004	2767	3919	1615	0.20	553	2004	5586	8875	2297	0.28	1564
2005	2957	4323	1592	0.22	651	2005	5408	7322	3494	0.17	919
2006	5867	10517	1218	0.31	1819	2006	14461	21734	7188	0.23	3326
2007	6553	9864	3243	0.25	1638	2007	13100	18506	7694	0.20	2620
2008	7172	13336	1008	0.4	2869	2008	14244	23240	5247	0.30	4273
2009	3230	5523	936	0.33	1066	2009	6319	10255	2383	0.29	1833
2010	5588	8698	2478	0.26	1453	2010	14396	22600	6192	0.27	3887
2011	5388	7629	3147	0.20	1078	2011	14858	25890	3825	0.33	4903
2016	5735	7770	3700	0.17	975	2016	24017	40197	7837	0.30	7205
2017	7785	12033	3537	0.27	2102	2017	19985	29245	10724	0.23	4597
2018	9463	18463	464	0.44	4164	2018	15264	19849	10680	0.15	2290
2019	6420	6506	6334	0.32	2054	2019	11660	11824	11497	0.37	4314
2020	10927	16014	5840	0.28	3021	2020	25200	34983	15416	0.23	5810
2021	21766	40665	2867	0.49	10750	2021	61879	109880	13877	0.45	27576
2022	9839	12836	6842	0.18	1770	2022	19032	25588	12475	0.20	3859
2023	69076	167547	29396	0.77	52990	2023	148824	362850	0	0.77	115167
2024	8308	11332	5283	0.20	1666	2024	37699	50225	25173	0.18	6942
2025	6222	8381	4064	0.20	1227	2025	29315	40715	17916	0.22	6514
Newly Mature Females						Newly Mature Males					
2002	1509	2278	741	0.24	362	2002	561	925	196	0.31	174
2003	787	1547	26	0.45	354	2003	78	222	0	0.84	66
2004	367	613	120	0.32	117	2004	786	1120	452	0.20	157
2005	531	908	154	0.34	181	2005	580	927	233	0.29	168
2006	2122	3705	540	0.33	700	2006	3377	6076	678	0.38	1283
2007	2129	3584	674	0.33	703	2007	2841	4214	1468	0.23	653
2008	2697	4780	613	0.36	971	2008	776	1315	237	0.33	256
2009	883	1366	399	0.26	230	2009	708	1157	259	0.31	219
2010	1770	4532	0	0.74	1310	2010	1464	3180	0	0.56	820
2011	882	1495	269	0.34	300	2011	766	1343	190	0.36	276
2016	1583	2304	863	0.22	348	2016	2939	5588	290	0.43	1264
2017	0.00	NA	NA	NA	NA	2017	1590	2623	557	0.32	509
2018	1780	2866	695	0.29	516	2018	3064	4466	1663	0.22	674

Table 8. continued.

YEAR	MEAN	UCL	LCL	CV	SD	YEAR	MEAN	UCL	LCL	CV	SD
Newly Mature Females						Newly Mature Males					
2019	77	225	0	0.94	73	2019	112	267	0	0.68	77
2020	134	330	0	0.87	117	2020	2430	3676	1184	0.30	740
2021	0	NA	NA	NA	NA	2021	6308	14299	0	0.68	4307
2022	115	212	18	0.46	53	2022	6370	11143	1597	0.44	2795
2023	0	NA	NA	NA	NA	2023	55	131	0	0.77	42
2024	2924	4262	1587	0.26	751	2024	1725	2529	921	0.27	469
2025	3085	4758	1413	0.31	954	2025	874	1340	408	0.30	263

Table 9. Estimated population (in thousands) of horseshoe crabs in the Lower Delaware Bay survey area in 2010-2025, with the mean, standard deviation (sd), and coefficient of variation (CV), calculated using the delta distribution model by demographic group. Also included are the estimated upper and lower 95% confidence limits (UCL, LCL).

YEAR	MEAN	UCL	LCL	CV	SD	YEAR	MEAN	UCL	LCL	CV	SD
Immature Females						Immature Males					
2010	3510	5199	1822	0.2	702	2010	2632	4476	788	0.29	763
2011	870	1931	0	0.44	383	2011	881	2160	0	0.52	458
2012	8021	15084	958	0.32	2567	2012	9381	21965	0	0.42	3940
2016	9046	15558	2534	0.29	2623	2016	8429	14813	2044	0.32	2697
2017	4536	10029	0	0.47	2132	2017	2920	6458	0	0.47	1372
2018	2211	2803	1619	0.1	221	2018	2597	3516	1678	0.15	390
2019	525	1278	0	0.56	294	2019	308	816	0	0.64	197
2020	12	33	0	0.97	12	2020	8	22	0	0.97	8
2021	130	NA	NA	0.99	129	2021	140	NA	NA	0.78	109
2022	NA	NA	NA	NA	NA	2022	NA	NA	NA	NA	NA
2023	NA	NA	NA	NA	NA	2023	NA	NA	NA	NA	NA
2024	NA	NA	NA	NA	NA	2024	NA	NA	NA	NA	NA
2025	315	622	8	0.48	151	2025	407	691	124	0.35	140
Mature Females						Mature Males					
2010	2117	4260	0	0.39	826	2010	5657	10247	1067	0.32	1810
2011	1348	2599	96	0.33	445	2011	4829	10570	0	0.43	2076
2012	938	2522	0	0.39	366	2012	3263	6864	0	0.35	1142
2016	1274	1710	837	0.15	191	2016	7735	9709	5761	0.1	774
2017	3674	7501	0	0.38	1396	2017	16794	40517	0	0.51	8565
2018	1771	2588	953	0.18	319	2018	4616	6600	2631	0.18	831
2019	1148	3011	0	0.63	723	2019	5746	14583	0	0.6	3448
2020	7	19	0	0.97	7	2020	152	332	0	0.68	103
2021	65	NA	NA	0.99	64	2021	365	NA	NA	0.72	262
2022	NA	NA	NA	NA	NA	2022	NA	NA	NA	NA	NA
2023	NA	NA	NA	NA	NA	2023	NA	NA	NA	NA	NA
2024	NA	NA	NA	NA	NA	2024	NA	NA	NA	NA	NA
2025	213	332	94	0.26	56	2025	588	802	373	0.17	101
Newly Mature Females						Newly Mature Males					
2010	414	1087	0	0.63	261	2010	187	409	0	0.46	86
2011	65	170	0	0.58	38	2011	58	208	0	0.94	55
2012	50	214	0	0.76	38	2012	301	710	0	0.49	147
2016	206	357	55	0.3	62	2016	727	1268	186	0.29	211
2017	88	249	0	0.66	58	2017	542	1100	0	0.40	217
2018	115	220	9	0.36	41	2018	148	290	7	0.40	59
2019	0	0	0	NA	0	2019	361	1022	0	0.71	257
2020	0	0	0	NA	0	2020	4	11	0	0.97	4
2021	0	NA	NA	NA	NA	2021	0	NA	NA	NA	NA
2022	NA	NA	NA	NA	NA	2022	NA	NA	NA	NA	NA
2023	NA	NA	NA	NA	NA	2023	NA	NA	NA	NA	NA
2024	NA	NA	NA	NA	NA	2024	NA	NA	NA	NA	NA
2025	79	156	1	0.46	36	2025	96	161	30	0.34	32

Table 10. Estimated population (in thousands) of horseshoe crabs in the Lower Delaware Bay survey area in 2010-2025, with the mean, standard deviation (sd), and coefficient of variation (CV), calculated using the normal distribution model by demographic group. Also included are the estimated upper and lower 95% confidence limits (UCL, LCL).

YEAR	MEAN	UCL	LCL	CV	SD	YEAR	MEAN	UCL	LCL	CV	SD
Immature Females						Immature Males					
2010	3503	5155	1851	0.18	631	2010	2588	4056	1120	0.24	621
2011	938	2311	0	0.53	497	2011	935	2437	0	0.58	542
2012	8125	14222	2027	0.31	2519	2012	9023	17690	356	0.35	3158
2016	8618	13190	4046	0.22	1896	2016	7725	11638	3812	0.21	1622
2017	4325	8829	0	0.41	1773	2017	2731	5408	53	0.38	1038
2018	2209	2780	1638	0.10	221	2018	2595	3529	1661	0.15	389
2019	852	868	836	0.01	9	2019	566	566	566	0.00	0
2020	12	33	0	0.97	12	2020	8	22	0	0.97	8
2021	130	NA	NA	0	0	2021	140	NA	NA	0.00	0
2022	NA	NA	NA	NA	NA	2022	NA	NA	NA	NA	NA
2023	NA	NA	NA	NA	NA	2023	NA	NA	NA	NA	NA
2024	NA	NA	NA	NA	NA	2024	NA	NA	NA	NA	NA
2025	307	565	50	0.42	128	2025	392	615	169	0.28	110
Mature Females						Mature Males					
2010	2124	4340	0	0.41	871	2010	5600	9916	1285	0.30	1680
2011	1290	2239	340	0.27	348	2011	4479	8332	625	0.31	1388
2012	915	2242	0	0.34	311	2012	3188	5456	921	0.28	893
2016	1264	1647	880	0.13	164	2016	7727	9570	5883	0.10	773
2017	3654	7307	2	0.36	1315	2017	13805	23702	3908	0.26	3589
2018	1782	2666	898	0.19	339	2018	4647	6901	2393	0.19	883
2019	1932	1948	1916	0	0	2019	8356	8356	8356	0.00	0
2020	7	19	0	0.97	7	2020	152	332	0	0.68	103
2021	65	NA	NA	0	0	2021	365	NA	NA	0.00	0
2022	NA	NA	NA	NA	NA	2022	NA	NA	NA	NA	NA
2023	NA	NA	NA	NA	NA	2023	NA	NA	NA	NA	NA
2024	NA	NA	NA	NA	NA	2024	NA	NA	NA	NA	NA
2025	216	166	85	0.29	62	2025	585	782	388	0.16	93
Newly Mature Females						Newly Mature Males					
2010	418	1097	0	0.63	263	2010	185	391	0	0.43	80
2011	65	170	0	0.58	38	2011	58	208	0	0.94	55
2012	50	214	0	0.76	38	2012	302	719	0	0.50	151
2016	205	355	55	0.28	57	2016	716	1176	256	0.25	179
2017	88	249	0	0.66	58	2017	541	1090	0	0.40	216
2018	114	226	3	0.35	40	2018	149	296	1	0.41	61
2019	0	0	0	NA	0	2019	401	408	394	0.00	3
2020	0	0	0	NA	0	2020	4	11	0	0.97	4
2021	0	NA	NA	NA	NA	2021	0	NA	NA	NA	NA
2022	NA	NA	NA	NA	NA	2022	NA	NA	NA	NA	NA
2023	NA	NA	NA	NA	NA	2023	NA	NA	NA	NA	NA
2024	NA	NA	NA	NA	NA	2024	NA	NA	NA	NA	NA
2025	78	347	0	0.46	36	2025	94	153	35	0.31	29

Table 11. Mean, minimum (min), and maximum (max) bottom water temperature (°C) and ordinal sampling date (numerical calendar date from January 1st) for survey collections in the Delaware Bay Area and Lower Delaware Bay. For reference, September 1st is ordinal date 243 in non-leap years.

	Water Temperature			Ordinal Date		
	mean	min	max	mean	min	max
Delaware Bay Area						
2002	19.33	15	23.5	277.41	273	300
2003	17.41	13.5	20	286.60	278	296
2004	16.67	14.5	20.5	292.74	277	302
2005	20.94	14	24.5	261.23	250	306
2006	17.53	13	22.3	284.53	246	314
2007	19.69	14.3	23.3	294.96	282	311
2008	20.09	19.3	22.6	277.02	272	287
2009	15.54	14.3	17	315.24	307	324
2010	19.72	12.3	24.1	282.68	265	331
2011	21.60	18.6	23.8	265.44	254	296
2012	18.47	18.1	18.8	292.92	289	298
2016	22.82	18.6	24.8	274.02	260	299
2017	21.89	18.8	23.2	274.05	263	294
2018	22.48	13.9	24.8	276.41	253	315
2019	23.05	18.8	24.3	250.38	242	270
2020	21.79	17	25	231.15	219	252
2021	23.25	18.8	28	233.44	222	250
2022	21.18	16.7	25.6	265.42	245	285
2023	22.54	18.3	26.7	270.02	248	302
2024	21.47	17	24	262.17	235	297
2025	20.24	13	26	272.97	241	307
Lower Delaware Bay						
2010	17.18	16.7	17.7	295.36	295	296
2011	18.32	18	18.6	294.27	294	295
2012	17.96	17.9	18	299.00	299	299
2016	19.56	19	20.1	288.40	288	289
2017	19.35	19.2	19.5	292.30	292	293
2018	12.16	11.3	12.8	321.44	321	322
2019	17.50	17.2	17.8	292.00	292	292
2020	24.00	23.2	25.4	248.00	248	248
2021	20.50	19	22	268.00	268	268
2022	NA	NA	NA	NA	NA	NA
2023	NA	NA	NA	NA	NA	NA
2024	NA	NA	NA	NA	NA	NA

Table 11. continued.

		<u>Water Temperature</u>			<u>Ordinal Date</u>		
		mean	min	max	mean	min	max
Lower Delaware Bay							
	2025	9.71	8	11	324.00	324	324

Table 12. Correlations between annual mean catches-per-tow of horseshoe crabs with mean bottom water temperature and ordinal sampling date in the Delaware Bay Area survey and the Lower Delaware Bay survey, by demographic group. The Delaware Bay Area surveys included 20 years, and the Lower Delaware Bay surveys included 10 years. Statistics presented include correlation coefficient, *r*; *T*-score; and probability, *p*. Data are from Tables 1, 3, and 10.

	Water Temperature			Ordinal Date		
Delaware Bay Area 2002 - 2025	<i>r</i>	<i>T</i>	<i>p</i>	<i>r</i>	<i>T</i>	<i>P</i>
Immature females	-0.421	-1.97	0.065	0.473	2.28	0.035
Immature males	-0.445	-2.11	0.049	0.485	2.35	0.030
Mature females	0.454	2.16	0.045	-0.361	-1.64	0.118
Mature males	0.386	1.77	0.093	-0.245	-1.07	0.298
Newly mature females	-0.263	-1.16	0.263	0.416	1.94	0.068
Newly mature males	0.354	1.61	0.126	-0.472	-2.27	0.036
Lower Delaware Bay 2010 - 2025						
Immature females	0.136	0.36	0.727	0.091	0.24	0.816
Immature males	0.084	0.22	0.830	0.124	0.33	0.751
Mature females	-0.021	-0.05	0.958	0.277	0.76	0.471
Mature males	0.111	0.29	0.777	0.138	0.37	0.724
Newly mature females	0.253	0.52	0.629	-0.345	-0.74	0.503
Newly mature males	0.163	0.40	0.700	0.011	0.03	0.979

Table 13. Count and frequency of occurrence (number of tows with species/total number of tows performed) of all bycatch species caught during the 2025 field season.

SCIENTIFIC NAME	COMMON NAME	COUNT	FREQ. OF OCCURRENCE
<i>Rostroraja eglanteria</i>	Clearnose Skate	1121	0.91
<i>Busycon carica</i>	Knobbed Whelk	539	0.77
<i>Paralichthys dentatus</i>	Summer Flounder	213	0.91
<i>Busycotypus canaliculatus</i>	Channeled Whelk	114	0.60
<i>Myliobatis freminvillei</i>	Bullnose Ray	113	0.53
<i>Hypanus americanus</i>	Southern Stingray	72	0.51
<i>Leucoraja ocellata</i>	Winter skate	58	0.11
<i>Leucoraja erinaceus</i>	Little skate	33	0.11
<i>Squalus acanthias</i>	Spiny dogfish	29	0.17
<i>Gymnura altavela</i>	Spiny Butterfly Ray	12	0.19
<i>Acipenser oxyrinchus</i>	Atlantic Sturgeon	10	0.04
<i>Rhinoptera bonasus</i>	Cownose Ray	9	0.15
<i>Squatina dumeril</i>	Atlantic Angel Shark	5	0.09
<i>Gymnura micrura</i>	Smooth Butterfly Ray	4	0.06
<i>Carcharias taurus</i>	Sand Tiger Shark	2	0.02
<i>Sinistrofulgur perversum</i>	Lightning Whelk	1	0.02
<i>Alopias vulpinus</i>	Common Thresher Shark	1	0.02
<i>Carcharhinus isodon</i>	Finetooth Shark	1	0.02

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Stopover Population Estimate and Migration Ecology of Red Knots *C. c. rufa* at Delaware Bay, USA, 2026

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Abstract

Red Knots (*Calidris canutus rufa*) rely on Atlantic horseshoe crab (*Limulus polyphemus*) eggs to refuel during migratory stopover at Delaware Bay. Intensive harvest of horseshoe crabs in the 1990s contributed to declines in Red Knot numbers. In 2013, the Atlantic States Marine Fisheries Commission adopted an Adaptive Resource Management (ARM) framework to balance sustainable horseshoe crab harvest with ecosystem integrity and Red Knot recovery, requiring annual stopover population estimates. We estimated the 2026 passage population of Red Knots at Delaware Bay using a Bayesian analysis of a Jolly–Seber mark–resight model which accounts for population turnover and imperfect detection. The 2026 passage population was 39,534 individuals (95% credible interval: 36,740–42,922), a change of approximately -27% compared to 2025 but similar to passage population estimates in 2022 and 2023. These findings provide meaningful input for the ARM framework, supporting sustainable harvest of horseshoe crabs while maintaining adequate foraging opportunities for Red Knots and other shorebirds.

Parts of the Introduction, Methods, and Appendices were originally published in Lyons (2024) and are summarized herein.

1 Introduction

The northward migration of Red Knots (*Calidris canutus rufa*) in the mid-Atlantic region coincides with the onset of spawning of horseshoe crabs (*Limulus polyphemus*). Red Knots stop at the Delaware Bay to feed on horseshoe crab eggs, which are an important food

resource for Red Knots and other shorebirds because they have a high energy content and are easily digestible (Karpanty et al., 2006, Haramis et al., 2007).

Horseshoe crabs have been harvested since at least 1990 for use as bait in American eel (*Anguilla rostrata*) and whelk (*Busycotypus canaliculatus* and *Busycon carica*) fisheries (Kreamer and Michels, 2009). The number of horseshoe crabs harvested increased throughout the 1990s, peaked in the late 1990s, and then declined in the early 2000s. In the 1990s and early 2000s the estimated number of Red Knots counted during aerial surveys of Delaware Bay declined from ~50,000 to ~13,000 (Niles et al., 2008). Avian conservation biologists hypothesized that unregulated harvest of horseshoe crabs in Delaware Bay during the 1990s reduced food availability for migratory shorebirds. This shortage limited their ability to refuel during stopover, thereby potentially compromising migration performance, breeding success, and annual survival (Baker et al., 2004, McGowan, Hines, et al., 2011).

The Atlantic States Marine Fisheries Commission (ASMFC) has managed the horseshoe crab harvest in the Delaware Bay region since 1998 and in 2012 adopted an Adaptive Resource Management (ARM) framework that was created to explicitly incorporate shorebird objectives in horseshoe crab harvest management (McGowan, Smith, et al., 2015). The ARM framework was designed to constrain the harvest so that the number of spawning horseshoe crabs would not limit the number of Red Knots stopping at Delaware Bay during migration. To achieve multiple objectives simultaneously, the ARM framework requires an estimate each year of both the horseshoe crab population and the Red Knot stopover population (McGowan, Lyons, and Smith, 2015).

The goal of this study was to estimate the stopover population size in 2026 using mark-resight data on individually marked birds and a Jolly-Seber model for open populations (Jolly, 1965, Seber, 1965), as we have each year since 2011 to support the ARM framework, and evaluate timing of arrivals, departures, and stopover duration at Delaware Bay in 2026.

2 Methods

2.1 Field methods

Red Knots have been individually marked at Delaware Bay and other regions across the Western Hemisphere (e.g., parts of Argentina, Brazil, Canada, Chile) since 2003 with field-readable leg flags engraved with unique three-character alphanumeric codes (Clark et al., 2005). Mark-resight data consisting of individual resightings of flagged birds and counts of marked and unmarked birds were collected during northward migration in 2026 on the

Table 1: Dates for mark-resight survey periods (3-day sampling occasions) for Red Knot (*C. c. rufa*) population analysis at Delaware Bay in 2026. The same sampling periods have been used at Delaware Bay since 2011.

Survey period	Dates	Survey period	Dates
1	8–10 May	6	23–25 May
2	11–13 May	7	26–28 May
3	14–16 May	8	29–31 May
4	17–19 May	9	1–3 June
5	20–22 May		

Delaware and New Jersey shores of Delaware Bay following established protocols (Lyons, 2016). These methods have been consistently applied at Delaware Bay since 2011.

Surveys were conducted on 20 beaches (Appendix A) during May and early June 2026 (Table 1). Each beach was surveyed at least once in every three-day sampling period (Lyons, 2016). During surveys, agency staff and volunteers searched for flagged birds, recording the engraved alphanumeric codes. During resighting surveys, observers also periodically employed scan sampling techniques to estimate the marked–unmarked ratio. In each scan, a random portion of a Red Knot flock was examined, and observers recorded (1) the number of individually flagged birds and (2) the total number of birds checked for flags (Lyons, 2016). Survey data are available from Delaware Division of Fish and Wildlife and New Jersey Department of Environmental Protection.

2.2 Statistical methods

For analysis with the Jolly-Seber (JS) model, the migration season at Delaware Bay was divided into 9 three-day sampling periods (Table 1). Three days was chosen as the time step for the mark-resight model given the time required to complete a circuit of all 20 beaches. Multiple observations of a flagged individual within any of these sampling periods were combined into one observation per period and formatted as encounter histories for mark-recapture modeling (Williams, Nichols, and Conroy, 2002). A summary of the 2026 mark–resight data is provided in Appendix B.

Stopover population size was estimated using methods outlined in Lyons et al. (2016). Specifically, we used the superpopulation framework of Crosbie and Manly (1985) and Schwarz and Arnason (1996) for the JS model (Jolly, 1965; Seber, 1965), which is an open population model accounting for turnover of individuals during migration and imperfect detection during surveys. The superpopulation is defined as all birds present in the study

area on at least one sampling occasion (Nichols and Kaiser, 1999).

The Jolly–Seber (JS) model includes parameters for recruitment (β), survival (ϕ), and capture probability (p). In the context of estimating populations of migratory birds at a stopover site, these parameters correspond to the probability of arrival at the study area (β), probability of remaining from time t to $t + 1$ (ϕ), and resighting probability (p). Stopover departure is defined as $1 - \phi$, the probability that a bird present at time t departs the study area before $t + 1$. Resighting probability was modeled as a function of flag color because some colors are harder to read than others (Appendix C); specifically, we fit a separate detection probability for dark green flags because these can have lower detection probability than light green flags (Tucker, McGowan, Nuse, et al., 2023). Arrival, departure, and resighting parameters are biologically meaningful at Delaware Bay because they capture the dynamic nature of migration, where birds arrive and depart continuously, remain for varying durations, and are resighted with imperfect detection, allowing estimation of the total number of Red Knots using the stopover (superpopulation).

We used a Bayesian analysis of a state-space formulation of the JS model (Royle and Dorazio, 2008; Kéry and Schaub, 2012; Lyons et al., 2016) in which abundance estimates were derived in two steps. First, the number of birds with leg flags was estimated using encounter histories. Second, this abundance estimate was adjusted for unmarked birds using the proportion of flagged individuals (Lyons et al., 2016). The flagged proportion was estimated from the scan sample data using a binomial model, implemented as a generalized linear mixed model with a random effect for sampling period to account for temporal variation in arrival of flagged birds and additions of newly-flagged individuals during the migration season. Additional methodological details are provided in Lyons et al. (2016) and Appendix C.

The JS model has several key assumptions, including homogeneous probabilities of arrival, stopover departure, and resighting among individuals; that marks are not lost or misrecorded; that sampling is effectively instantaneous relative to the interval between occasions; that emigration from the study area is permanent; that individual fates are independent of one another; and that marked-to-unmarked ratio data are representative of the population (i.e., individuals in the scan samples are randomly selected from the population). To help meet the assumption that individual identities of flagged birds were recorded without error, resighting data were validated against physical capture and flag-deployment records in the <http://www.bandedbirds.org/> repository. Resightings without a corresponding record of prior physical capture and flag deployment were excluded from analyses as false-positive (misread) errors. An exception was made for resightings of orange flags, which were retained without validation because capture records from Argentina and Uruguay—where orange flags are used

under the Pan American Shorebird Program (Howes, Béraud, and Drolet-Gratton, 2016)—are generally not available in the repository. Thus, validation against capture data was applied when such data were available but could not be applied uniformly across all countries. A second type of false positive error is also possible. Some of the resightings in our dataset may be flags that were deployed prior to 2026 but were not in fact present at Delaware Bay in 2026. It is not possible to identify this second type of false positive with banding data validation or other quality assurance/quality control methods (Tucker, McGowan, Robinson, et al., 2019). See Lyons (2016) for discussion of all model assumptions.

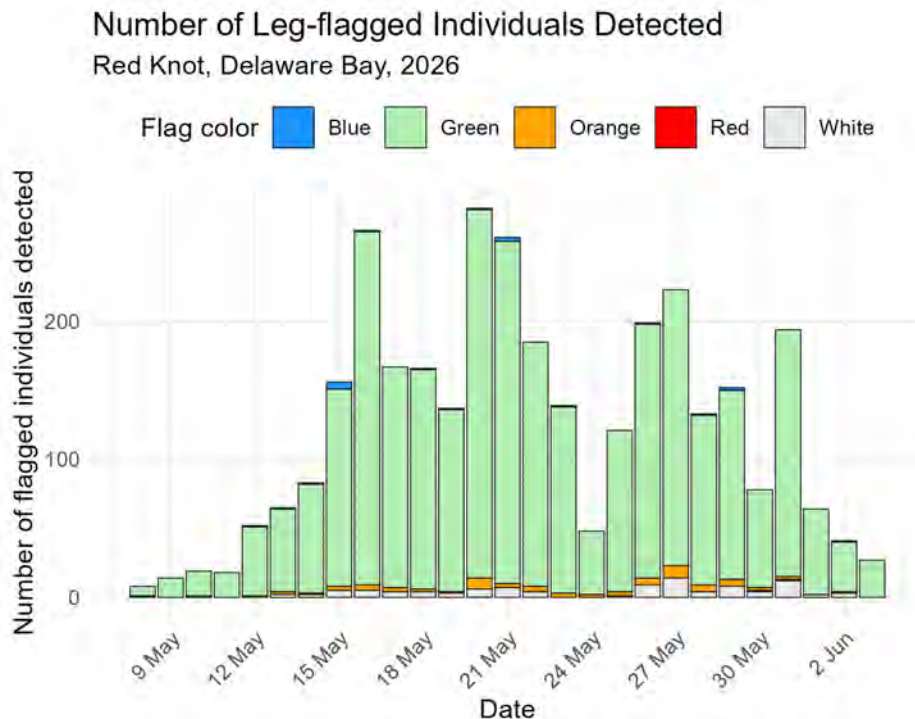


Figure 1: Number of unique leg-flags (individuals) detected each day in 2026. Colors correspond to countries in the Western Hemisphere according to the Pan American Shorebird Program (Howes, Béraud, and Drolet-Gratton, 2016): blue = Brazil and Paraguay; green = USA; orange = Argentina and Uruguay; red = Chile; white = Canada.

Stopover duration is an important reflection of turnover and key aspect of stopover dynamics. We estimated stopover duration in 2026 using the approach described by Lyons et al. (2016) and Lok et al. (2019), which takes advantage of the state-space formulation of the Jolly–Seber model. In the state-space formulation, a latent parameter indicates the number of time steps that each individual remains in the study area, i.e., stopover duration. Lyons et al. (2016) originally calculated duration based only on individuals that were resighted at least once. Lok et al. (2019) improved this approach by extending the calculation to all individuals,

including those never observed, estimated to be present for at least one sampling period.

3 Results

3.1 Mark-resight surveys

Field observers in 2026 collected a total of 3,525 flag resightings between 8 May and 3 June 2026. Among this total, 227 resightings lacked a corresponding banding record, for an overall misread error of 6.4%. After discarding resightings that could not be verified, there were 3,298 valid resightings representing a total of 1,641 individual birds that were recorded at least once between 8 May and 3 June 2026. These individuals had been captured and flagged in five to seven different countries (Fig. 1). The number of individuals detected in 2026 ($n = 1,641$) was 29% higher than the number detected in 2025 ($n = 1,276$) and the highest since 2019. On average, each flagged individual was resighted 2.0 times and the maximum number of times resighted was 14.

The mean flagged proportion across all 3-day periods was 6.1% (95% CI: 4.5%–8.2%) (Fig. D1). The flagged proportion fluctuated between 4–6% for much of the season but was greater in the last two sampling intervals (8–12%; Fig. D1). The 2026 mean flagged proportion was slightly higher than 2024–2025, but remains substantially lower than during 2011–2020, when the flagged proportion was estimated to be closer to 10% (Fig. 3).

3.2 Superpopulation estimate and migration ecology in 2026

The passage population size estimate for 2026 was 39,534 (95% CI: 36,740–42,922; Table 2). The time-specific stopover population estimates peaked at 17,150 on 21 May.

Arrivals peaked on 15 May, then continued at a lower, fairly steady rate through 21 May; by 21 May 2026, 67% of the stopover population had arrived (Fig. 2a). A brief lull around 24 May was followed by a second, later wave of arrivals, with ~20% of the stopover population arriving in the 3-day period centered on 27 May.

Departure probability remained relatively low (~22%) through 21 May, then rose steadily from 18 May through the end of the month, reflecting increasing rates of departure from the stopover site in each successive sampling period (Fig. 2b).

Mean stopover duration in 2026 was 7.14 days (95% CI: 6.86–7.47). This is somewhat lower than recent years (8.6–12.1 days during 2019–2025).

The mean probability of resighting in 2026 was 54% (95% CI: 34–76%), the highest mean

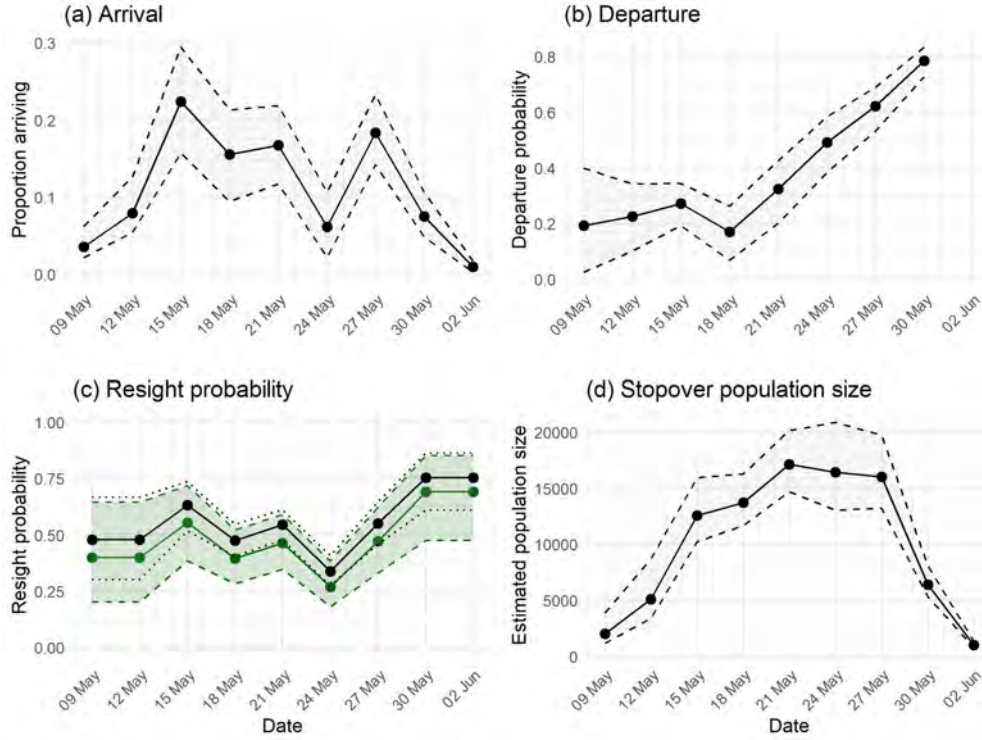


Figure 2: Jolly-Seber model parameter estimates from a mark-resight study of Red Knots (*C. c. rufa*) at Delaware Bay in 2026: (a) proportion of stopover population arriving at Delaware Bay, (b) stopover departure probability, (c) probability of resighting, and (d) time-specific population size estimates. Dates on the x-axis indicate the mid-point of three-day sampling occasions (Table 1). Dashed lines and shading indicate a 95% Bayesian credible interval. The model included two parameters for probability of resighting (c), one for dark green flags and one for other flag colors combined.

probability of resighting since 2014 (Fig. 4). Across the sampling occasions in 2026, resighting probability ranged from approximately 34% to 76% (Fig. 2c). The probability of resighting for dark green flags in 2026 was significantly different from other flags (slope: -0.322, 95% CI: -0.543 to -0.098; Fig. 2c).

4 Discussion

In 2026, the passage population was estimated at 39,534 Red Knots, approximately 27% lower than 2025. Overlapping credible intervals with recent years indicate no clear directional trend, but rather interannual variability within the long-term range. Producing this annual estimate meets a core goal of the study—providing the ARM framework with up-to-date population inputs to evaluate whether current horseshoe crab harvest strategies maintain

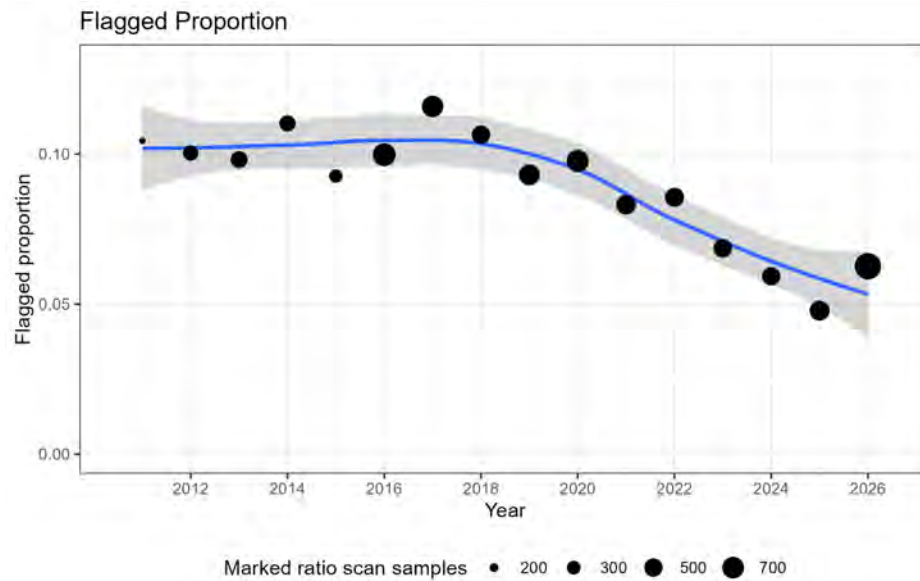


Figure 3: Flagged proportion of Red Knots observed during mark-resight studies at Delaware Bay, 2011–2026, defined as the proportion of birds in scan samples bearing field-readable flags. The blue line shows the LOESS-smoothed trend, and the shaded area represents the 95% confidence interval around the fitted trend.

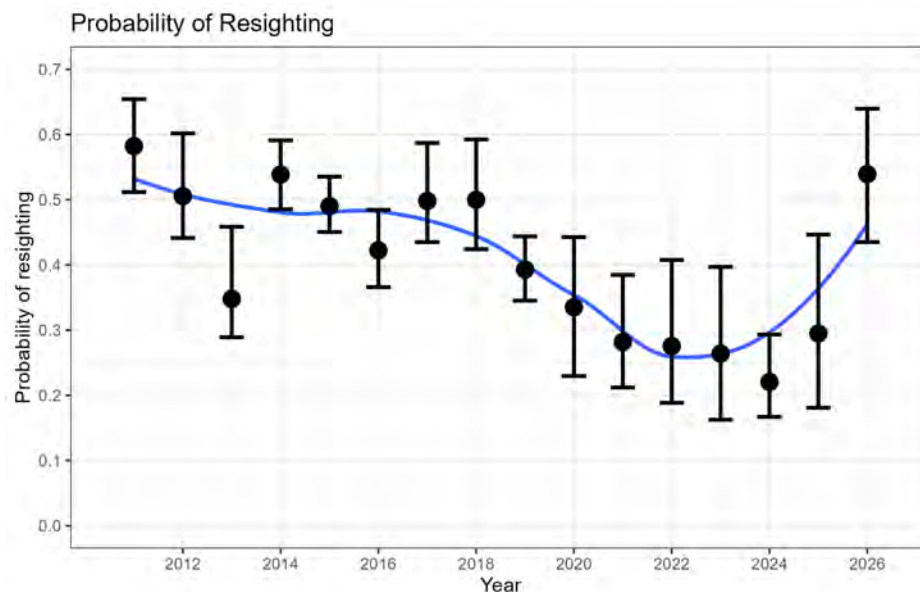


Figure 4: Probability of resighting in mark-resight studies of Red Knots at Delaware Bay, 2011–2026. The blue line shows the LOESS-smoothed trend, and the error bars represent the 95% credible interval around each annual estimate.

Table 2: Red Knot (*C. c. rufa*) stopover (passage) population estimated using mark-resight methods during northward migration at Delaware Bay. The mark-resight estimate of stopover (passage) population, N^* , accounts for population turnover during migration. CI = Bayesian credible interval and CV = coefficient of variation.

Year	Stopover population (N^*)	95% CI N^*	CV
2011	43,570	(40,880–46,570)	0.03
2012	44,100	(41,860–46,790)	0.03
2013	48,955	(39,119–63,130)	0.12
2014	44,010	(41,900–46,310)	0.03
2015	60,727	(55,568–68,732)	0.06
2016	47,254	(44,873–50,574)	0.03
2017	49,405	(46,368–53,109)	0.03
2018	45,221	(42,568–49,508)	0.04
2019	45,133	(42,269–48,393)	0.03
2020	40,444	(33,627–49,966)	0.10
2021	42,271	(35,948–55,210)	0.11
2022	39,800	(35,013–51,355)	0.10
2023	39,361	(33,724–47,556)	0.09
2024	46,127	(39,286–57,799)	0.11
2025	54,044	(47,926–61,928)	0.07
2026	39,534	(36,740–42,922)	0.04

adequate foraging opportunities for knots at Delaware Bay.

By simultaneously estimating arrival and departure schedules, resight probability, and passage abundance, the Jolly–Seber framework delivers integrated, decision-relevant measures of Delaware Bay stopover dynamics. These outputs provide a rigorous basis for adjusting crab harvest within the ARM framework. Mark-resight-derived stopover metrics translate monitoring data into policy-relevant evidence needed to sustain the Delaware Bay stopover and the *rufa* Red Knot population.

Acknowledgments

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Appendix

A Study Area

Table A1: Locations around Delaware Bay, USA, where mark-resight surveys were conducted to estimate Red Knot (*C. c. rufa*) stopover population size during northward migration in 2026. DE = Delaware; NJ = New Jersey; NWR = National Wildlife Refuge. Beach names reflect locally used survey locations. Official geographic names were verified against the U.S. Geological Survey Geographic Names Information System (GNIS) where available. *Locations without GNIS-recognized beach names are identified using locally used names and precise latitude/longitude coordinates.

State	Beach	Longitude	Latitude
DE	Port Mahon	-75.4021	39.1831
DE	Pickering Beach	-75.4087	39.1377
DE	Kitts Hummock	-75.4048	39.1130
DE	Ted Harvey Wildlife Area	-75.4019	39.0864
DE	North Bowers*	-75.3973	39.0630
DE	Brockenbridge*	-75.3638	39.0359
DE	Mispillion Harbor	-75.3131	38.9519
DE	Slaughter Beach	-75.3146	38.9282
DE	Fowlers Beach*	-75.2633	38.8766
DE	Prime Hook NWR	-75.2467	38.8604
NJ	Gandys*/Money Island	-75.2417	39.2767
NJ	Fortescue	-75.1675	39.2233
NJ	North Reeds*	-74.8908	39.1228
NJ	South Reeds*	-74.8922	39.1138
NJ	Cooks*	-74.8941	39.1082
NJ	Kimbles*	-74.8948	39.1049
NJ	Bay Cove*	-74.8965	39.1008
NJ	Pierces Point	-74.9013	39.0897
NJ	Villas and Norburys*	-74.9298	39.0449

B Mark-resight Data Summary

Table B1: Summary (m-array) of Red Knot (*C. c. rufa*) mark-resight data from Delaware Bay, USA, 2026. Releases is the number of flags detected at each sample. NR = never resighted.

Sample	Dates	Releases	Next resighted at sample								
			2	3	4	5	6	7	8	9	NR
1	8-10 May	23	14	3	0	0	0	0	0	0	6
2	11-13 May	85		48	3	4	1	0	1	0	28
3	14-16 May	415			124	54	13	12	4	0	208
4	17-19 May	313				145	15	11	7	1	134
5	20-22 May	470					118	31	10	1	310
6	23-25 May	240						55	9	1	175
7	26-28 May	307							76	1	230
8	29-31 May	269								41	228

C Statistical Methods to Estimate Stopover Population Size Using Mark-Resight Data and Counts of Marked Birds

We converted the observations of marked Red Knots into encounter histories, one for each bird, and analyzed the encounter histories with a Jolly-Seber (JS) model (Jolly, 1965; Seber, 1965). The JS model includes parameters for recruitment (β), survival (ϕ), and capture (p) probabilities; in the context of a mark-resight study at a migration stopover site, these parameters are interpreted as probability of arrival to the study area, stopover persistence, and resighting, respectively. Stopover persistence is defined as the probability that a bird present at time t remains at the study area until time $t + 1$.

The Crosbie and Manly (1985) and Schwarz and Arnason (1996) formulation of the JS model also includes a parameter for superpopulation size, which in our approach to mark-resight inferences for stopover populations is an estimate of the marked (leg-flagged) population size.

We chose to use three-day periods, rather than days, as the sampling interval for the JS model given logistical constraints on complete sampling of the study area; multiple observations of the same individual in a given three-day period were combined for analysis. A summary

(m-array) of the mark-resight data is presented in Appendix B.

We made inference from a fully time-dependent model; arrival, persistence, and resight probabilities were allowed to vary with sampling period $[\beta_t, \phi_t, p_t]$. In this model, we set $p_1 = p_2$ and $p_{K-1} = p_K$ (where K is the number of samples) because not all parameters are estimable in the fully time-dependent model (Jolly, 1965).

We followed the methods of Royle and Dorazio (2008, Chapter 10) and Kéry and Schaub (2012, Chapter 10) to fit the JS model using the restricted occupancy formulation. Royle and Dorazio (2008) use a state-space formulation of the JS model with parameter-expanded data augmentation. For parameter-expanded data augmentation, we augmented the observed encounter histories with all-zero encounter histories ($n = 2,000$) representing potential recruits that were not detected (Royle and Dorazio, 2012).

According to the Pan American Shorebird Program (Howes, Béraud, and Drolet-Gratton, 2016), researchers in the U.S. deploy green engraved leg flags. In 2014, researchers switched from using light green flags to dark green flags, which many observers found more difficult to read in the field, as shown by Tucker, McGowan, Nuse, et al. (2023). Therefore we modeled two detection probabilities, one for dark green flags and one for all other flag colors:

$$\text{logit}(p_{it}) = \beta_0 + \beta_1 \times DG_i \quad (\text{C1})$$

where β_0 is the logit of the average resighting probability of all non-dark-green flags, β_1 is the effect of dark green flag color on resighting probability, and $DG = 1$ for dark green flags and 0 otherwise.

We followed Lyons et al. (2016) to combine the JS model with a binomial model for the counts of marked and unmarked birds in an integrated Bayesian analysis. Briefly, the counts of marked birds (m_s) in the scan samples are modeled as a binomial random variable:

$$m_s \sim \text{Binomial}(C_s, \pi) \quad (\text{C2})$$

where m_s is the number of marked birds in scan sample s , C_s is the number of birds checked for marks in scan sample s , and π is the proportion of the population that is marked. Total stopover population size $\hat{N}^*$ is estimated using

$$\hat{N}^* = \frac{\hat{M}^*}{\hat{\pi}} \quad (\text{C3})$$

where $\hat{M}^*$ is the estimate of marked birds from the JS model and $\hat{\pi}$ is the proportion of the population that is marked (from Eq. C2). Estimates of marked subpopulation sizes at each resighting occasion t , $\hat{M}_t^*$, are available as derived parameters in the analysis. An estimate of population size at each mark-resight sampling occasion, $\hat{N}_t^*$, is calculated using $\hat{M}_t^*$ and $\hat{\pi}$ as in equation C3.

To better account for the random nature of the arrival of marked birds and addition of new marks during the season, we used a time-specific model for proportion with marks in place of equation C2 above:

$$m_{s,t} \sim \text{Binomial}(C_{s,t}, \pi_t) \quad (\text{C4})$$

for $s = 1, \dots, n_{\text{samples}}$ and $t = 1, \dots, n_{\text{occasions}}$

$$\text{logit}(\pi_t) = \alpha + \delta_t \quad (\text{C5})$$

$$\delta_t \sim \text{Normal}(0, \sigma_{\text{occasions}}^2) \quad (\text{C6})$$

where π_t is the time-specific proportion of the population that is marked, and δ_t is a random effect for time of sample s . Total stopover population size $\hat{N}^*$ was estimated by summing time-specific arrivals of marked birds to the stopover (B_t) and expanding to include unmarked birds using estimates of proportion marked:

$$\hat{N}^* = \sum_t \frac{\hat{B}_t}{\hat{\pi}_t} \quad (\text{C7})$$

Time-specific arrivals of marked birds are estimated from the JS model using $\hat{B}_t = \hat{M}_t^* \cdot \beta_t$, where β_t is the estimated fraction of the population arriving at time t .

D Marked-ratio Scan Samples

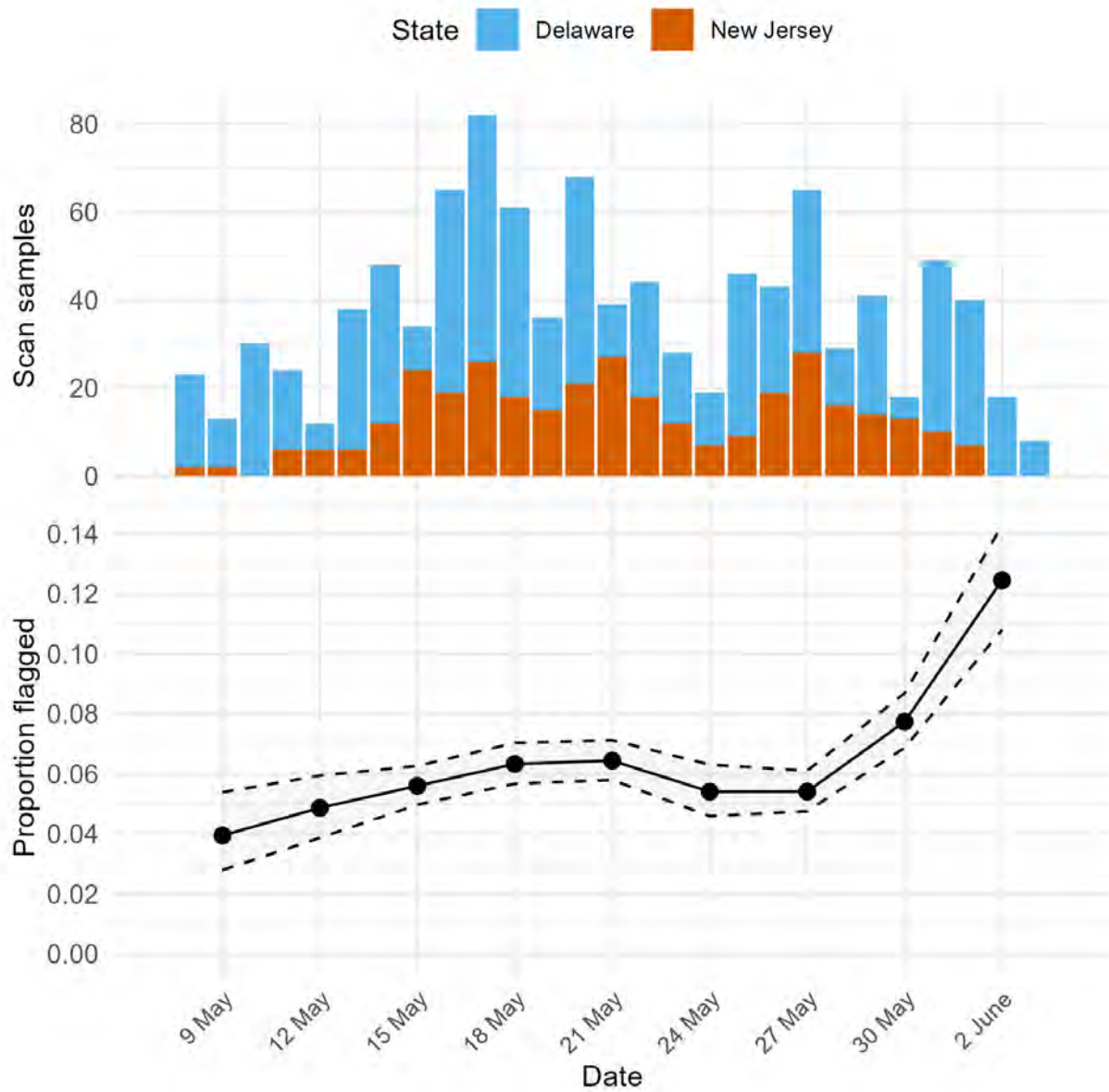


Figure D1: (top) Number of marked-ratio scan samples ($n = 590$) collected at Delaware Bay in 2026 by field crews in Delaware (blue, $n = 327$ scan samples) and New Jersey (orange, $n = 263$ scan samples). (bottom) Estimated proportion of the Red Knot (*C. c. rufa*) stopover population at Delaware Bay carrying leg flags in 2026 (overall average and 95% Bayesian credible interval: 0.045 [0.034, 0.055]). The marked proportion was estimated from marked-ratio scan samples for each three-day sampling period (Table 1) and the generalized linear mixed model described in Appendix C. Solid and dashed lines are estimated median proportion marked and 95% Bayesian credible interval, respectively.

Update to the horseshoe crab adaptive resource management (ARM) decision model following the January, 2026 stakeholder workshop

Bryan L. Nuse

Bird Conservancy of the Rockies

26 Oct 2026

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1 Introduction

During 2020-2022, The Atlantic States Marine Fisheries Commission (ASMFC) supported a revision of its Adaptive Resource Management (ARM) framework (McGowan et al., 2015, 2020) for producing recommended bait harvest limits for horseshoe crabs (*Limulus polyphemus*; HSC) of Delaware Bay origin (ASMFC, 2022). The ARM represents an extension of a Structured Decision Making program that accommodates multiple, periodic decisions (an approach generally referred to as Adaptive Management; (Williams et al., 2002)), and is fairly unique in that it incorporates information about a second taxon, a federally Threatened shorebird, the red knot (*Calidris canutus rufa*; REKN). The birds rely on HSC eggs as a food resource during a spring stopover period in May, as they travel from South America to the breeding grounds in the Canadian Arctic (Baker et al., 2020). The goal of the ARM is to make annual harvest recommendations that will maximize the probability both of a sustainable HSC harvest and a healthy REKN population over the next century.

The decision model that underlies the ARM is composed of two basic parts. The first is a set of population projection models, which are used to simulate HSC and REKN populations into the future. The second is a set of mathematical expressions that reflect stakeholder values, and are used to construct an objective function (called the reward function, in the ARM). The two parts, representing scientific findings on the one hand and stakeholder values on the other, are used together to find HSC harvest levels that will maximize the future reward from the system. The resulting solution takes the form of two harvest functions, one for male HSC harvest, one for females. In a given year, population sizes for male HSC, female HSC and REKN are estimated from monitoring data; these estimates are plugged into the optimal harvest functions to obtain the recommended harvest.

The revised ARM was designed such that the same monitoring data used to obtain the recommended harvest from the harvest functions each year can also be used to update parameters in the population projection models used in the ARM. This periodic updating of parameter values is critical to the ARM program because it allows the system model to ‘learn’ about how HSC and REKN populations behave, and how REKNs rely on HSC abundance.

Equally important to maintaining the ARM is the process of periodically allowing for updates to the stakeholder-informed components of the decision model. In January, 2026, ASMFC convened a group of stakeholders in Ocean City, Maryland to engage in a workshop, the primary aim of which was to assess whether and how updates should be made to three important values-based parts of the ARM (Compass, 2026). These were 1) the utility functions for both HSC and REKN, 2) the overall form of the reward function, and 3) the form of the harvest functions for male and female HSCs (Figure 1.1). The stakeholder group recommended adjustments to both the utility functions and the harvest function for female HSCs, but not to the reward function.

The aim of the work reported here was to understand the consequences of those changes for the ARM model’s behavior and harvest recommendations. Solutions to the decision model were thus obtained both before and after implementing the stakeholders’ recommended changes. Population estimates and other parameters informed by scientific data remained exactly the same as in model runs that appear in the original report for the revised ARM (ASMFC, 2022).

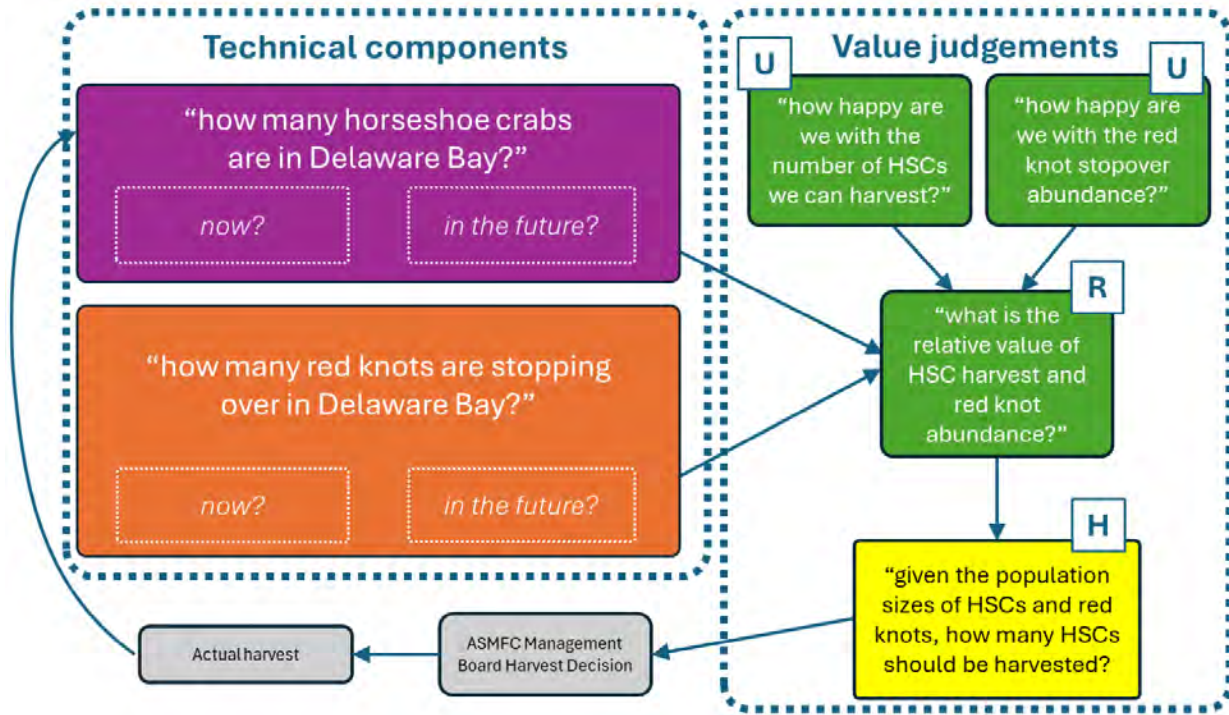


Figure 1.1: Simplified diagram of the ARM decision model, with the ‘scientific’ components that are informed by ecological data grouped under the heading *Technical components*, and the stakeholder-informed parts grouped under the heading *Value judgements*. The latter are labeled as: *U*, utility function (one each for red knots and horseshoe crabs); *R*, reward function; *H*, harvest policy functions.

During the course of this planned exercise, an error in the 2021 model code was discovered. This report describes first the nature of that error and the consequences of its correction. The planned adjustments following the January, 2026 workshop are then described along with their effects on ARM outcomes. In each section, results from a set of model runs are provided and interpreted; these were cumulative in the sense that a single adjustment was made for each run, and each run included all the adjustments that came before it. Because the coding error was deemed critical to correct, it was fixed before the stakeholders’ changes were added.

2 Error correction

During the course of implementing changes to the ARM decision model code based on the January, 2026 workshop outcomes, an error was found in an important component of the model, the reward function. This error resulted from confusion over the two ways in which the term *harvest* is used in the ARM framework:

1. the bait harvest (what is usually meant by ‘harvest’ in the ARM framework)
2. the total anthropogenic HSC mortality, including contributions from:
 - a) bait harvest
 - b) a ‘background harvest’ consisting of mortality from handling as bycatch and use by the biomedical industry

In the horseshoe crab simulation model embedded within the ARM decision model, #2 is used; to calculate the reward for a given year, only #1 should be considered. The 2021 ARM Revision code used # 2 to calculate the reward, rather than # 1. In other words, the 2021 ARM Revision was optimized using an objective function based on bait *plus* background harvest. This is incorrect and conflicts with the intention and understanding of the ARM modeling group and all other contributors to the design of the ARM framework (stakeholders, ARM Subcommittee, Delaware Bay Ecosystem Technical Committee, etc.).

2.1 Methods

To understand the implications for model behavior and the solution, the optimization procedure was conducted first on the uncorrected 2021 ARM Revision model (labeled *Rev2021*), then on the corrected version (labeled *errFix*). Except for the code correction, these model runs relied on exactly the same codebase, and used the same parameter values and input data.

2.2 Results

Figures 2.1–2.6 compare the outcomes from the *Rev2021* and *errFix* model runs. Plots are shown side-by-side for easier comparison.

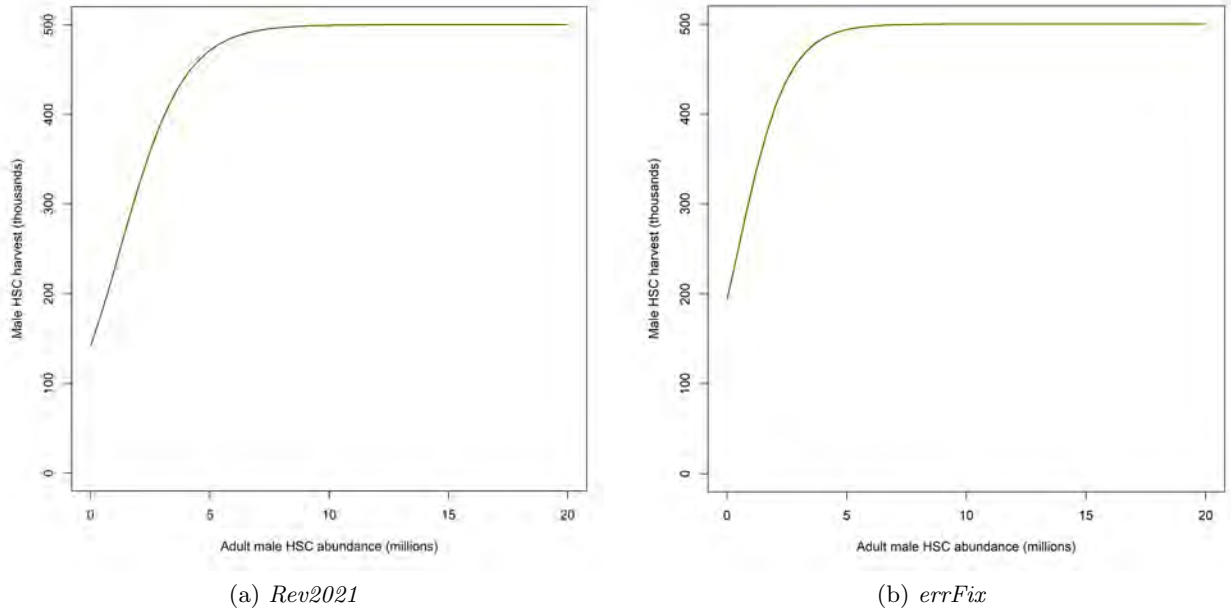


Figure 2.1: Male harvest policy function from (a) the uncorrected 2021 ARM Revision (*Rev2021*) model, and (b) the corrected version (*errFix*).

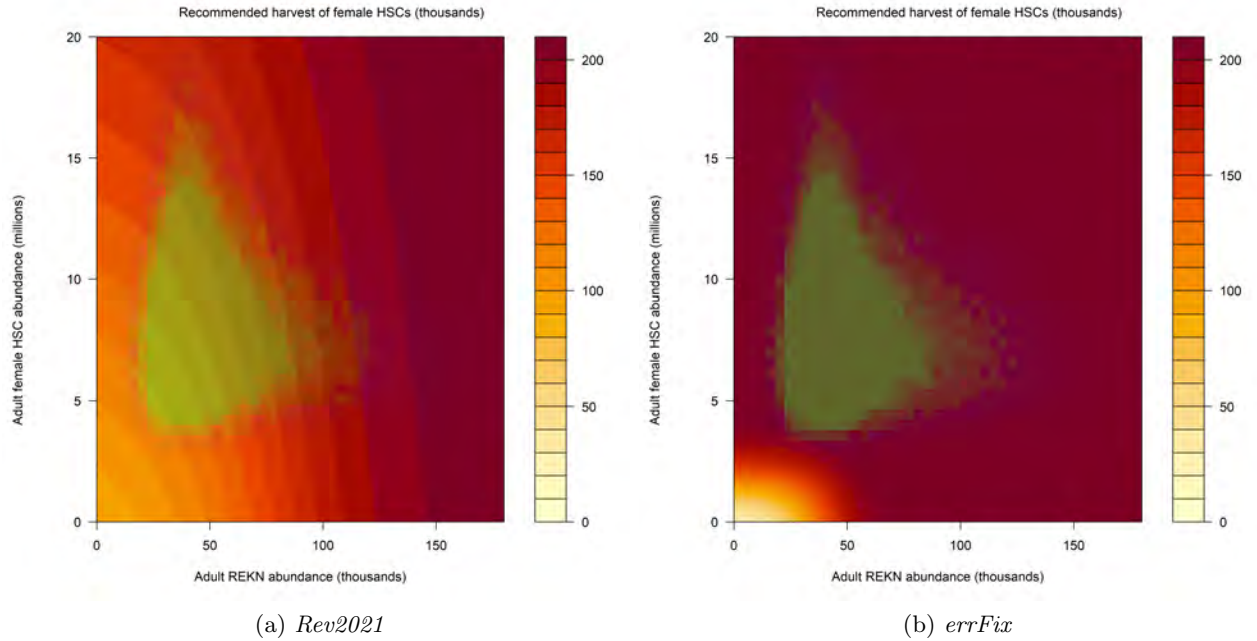


Figure 2.2: Female harvest policy function from (a) the uncorrected 2021 ARM Revision (*Rev2021*) model, and (b) the corrected version (*errFix*). The green and blue ‘blob’ region shows where the system is projected to be (i.e., in terms of female HSC and REKN abundance) in **years 1–10** of the 100-year time horizon. The green cells collectively contain 75% of the observations, the blue an additional 20%.

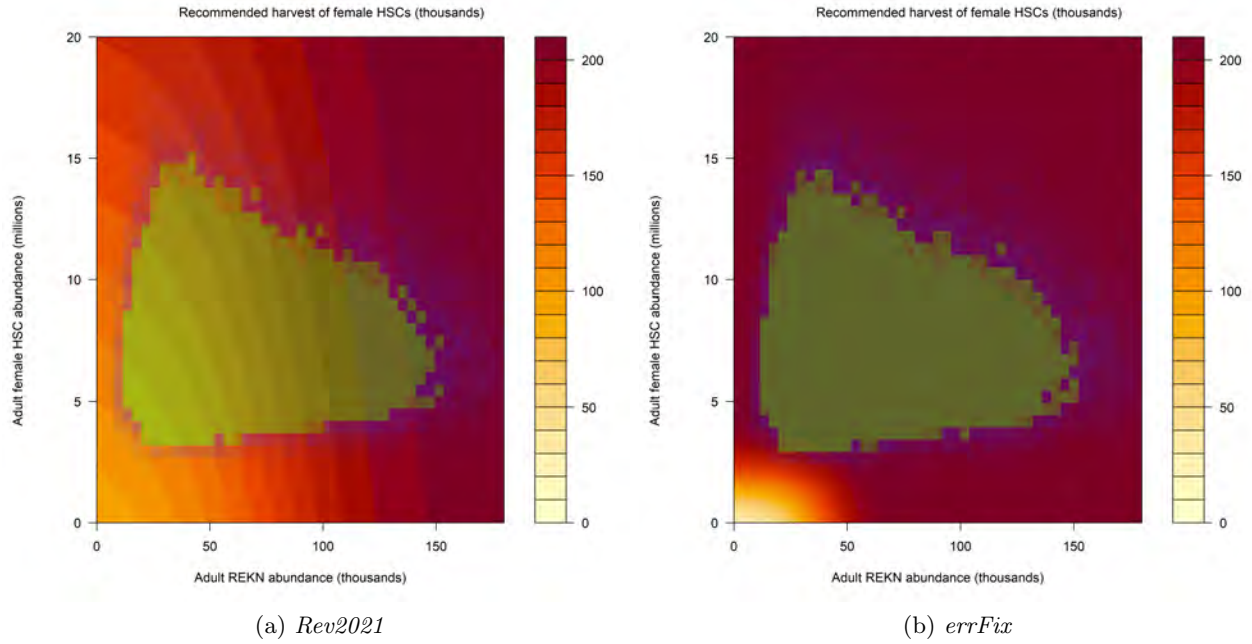


Figure 2.3: Female harvest policy function from (a) the uncorrected 2021 ARM Revision (*Rev2021*) model, and (b) the corrected version (*errFix*). The green and blue ‘blob’ region shows where the system is projected to be (i.e., in terms of female HSC and REKN abundance) in **years 11–20** of the 100-year time horizon. The green cells collectively contain 75% of the observations, the blue an additional 20%.

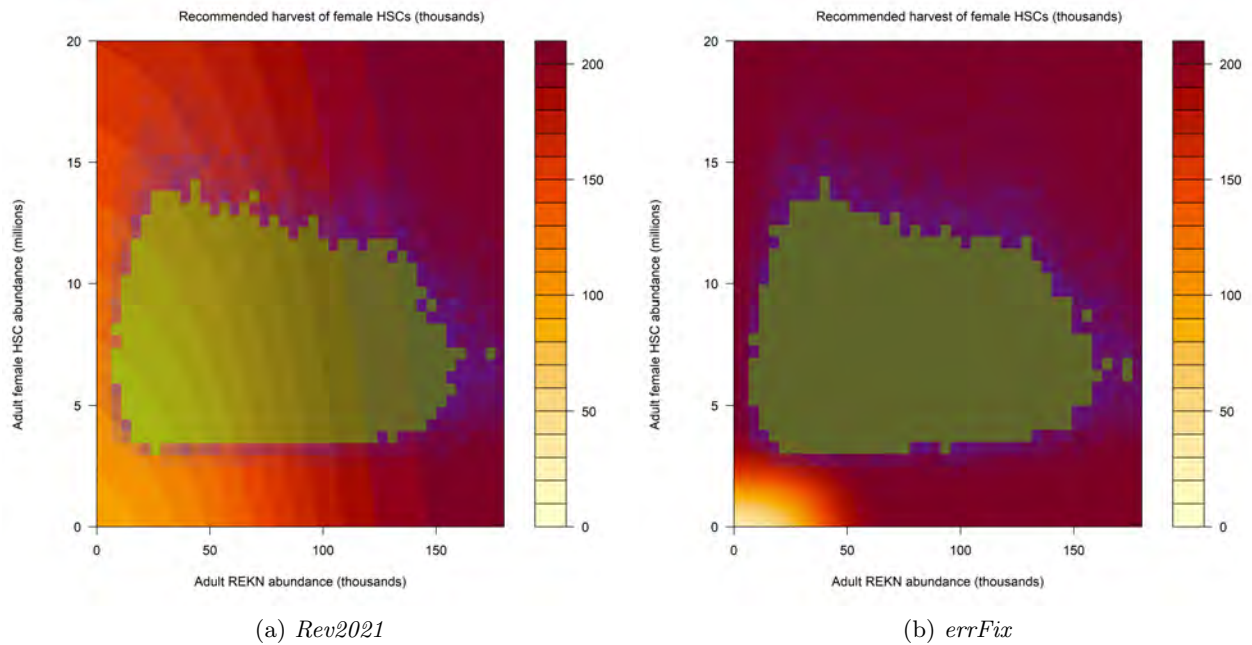


Figure 2.4: Female harvest policy function from (a) the uncorrected 2021 ARM Revision (*Rev2021*) model, and (b) the corrected version (*errFix*). The green and blue ‘blob’ region shows where the system is projected to be (i.e., in terms of female HSC and REKN abundance) in **years 21–30** of the 100-year time horizon. The green cells collectively contain 75% of the observations, the blue an additional 20%.

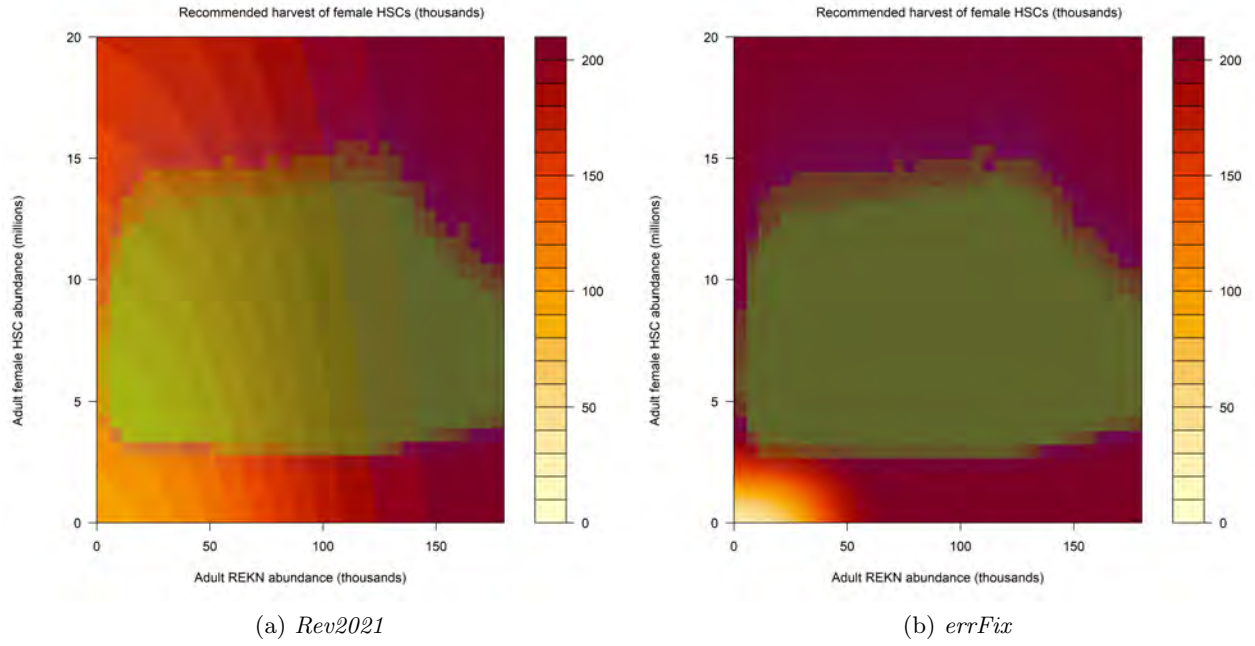


Figure 2.5: Female harvest policy function from (a) the uncorrected 2021 ARM Revision (*Rev2021*) model, and (b) the corrected version (*errFix*). The green and blue ‘blob’ region shows where the system is projected to be (i.e., in terms of female HSC and REKN abundance) in **years 31–100** of the 100-year time horizon. The green cells collectively contain 75% of the observations, the blue an additional 20%.

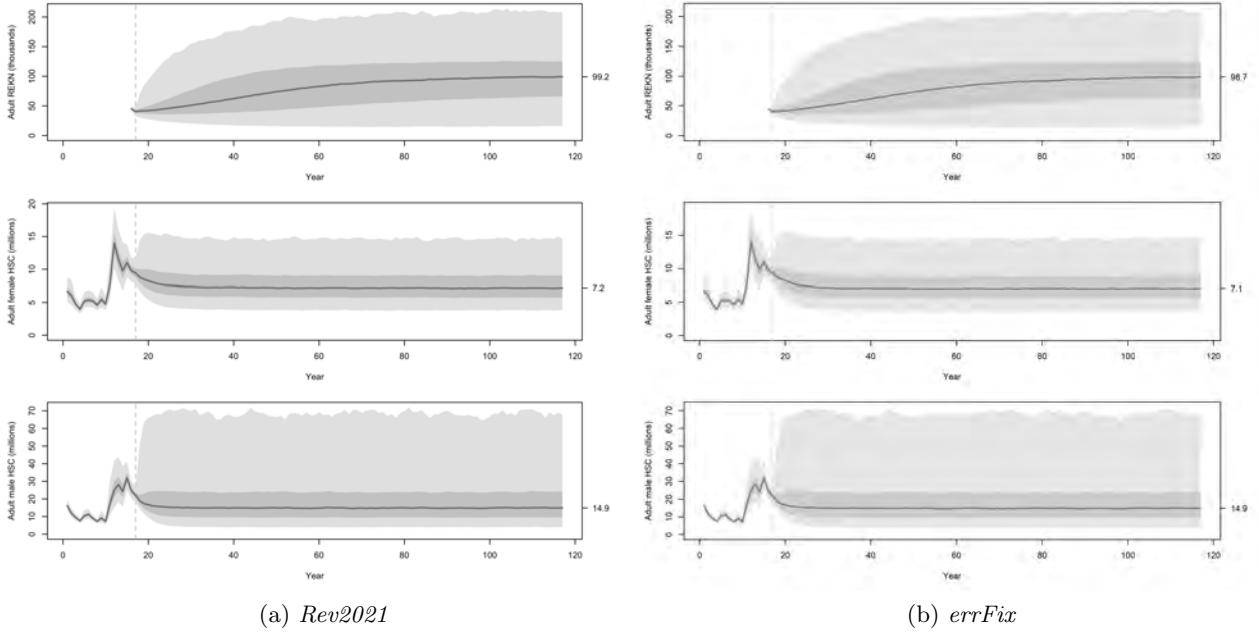


Figure 2.6: Female harvest policy function Projected population abundances from (a) the uncorrected 2021 ARM Revision (*Rev2021*) model, and (b) the corrected version (*errFix*). In each figure, top plot shows red knots; center, female horseshoe crabs; bottom, male horseshoe crabs. Dashed vertical line in each plot shows where observed data series ends and simulated values begin. Trajectory line is the median of all simulated values; light gray envelopes mark the 2.5% and 97.5% percentiles; dark gray are 50% to 75%. Values shown in the right margin are the median values at year 100.

Table 2.1: Expected values in simulation year 100 of several population and management metrics, for each of the uncorrected 2021 ARM Revision (*Rev2021*) and corrected (*errFix*) model runs, along with percent change in each metric (at year 100) between the runs. Symbols: N^k , red knot abundance; N^f , female horseshoe crab abundance; N^m , male horseshoe crab abundance; H^f , female horseshoe crab harvest; H^m , male horseshoe crab harvest; ϕ^k , red knot survival; ρ^k , red knot recruitment.

Model run	Expected value, year 100						
	N^k	N^f	N^m	H^f	H^m	ϕ^k	ρ^k
<i>Rev2021</i>	9.92e4	7.2e6	1.49e7	1.805e5	5e5	0.93	0.05
<i>errFix</i>	9.87e4	7.1e6	1.49e7	2.1e5	5e5	0.93	0.05
Percent change	-0.5	-1.3	0	+16.3	0	0	0

2.3 Discussion

Correcting the error in the 2021 ARM reward function resulted in a substantial change in the shape of the female harvest policy surface (Figures 2.2–2.5). In particular, the slope of the surface along both the female horseshoe crab and red knot axes is steeper. This allows the surface to approach

zero harvest as these two abundances near zero; and causes it to rise more quickly to the harvest cap of 210,000 female crabs along both axes. Consequently, this maximum harvest is recommended over more of the region projected to be occupied by the system (green-and-blue ‘blob’ in Figures 2.2–2.5), and this results in a greater total harvest over the time horizon and at year 100 (Table 2.1).

However, although the projected female harvest at year 100 is 16.3% higher under the corrected model (Table 2.1), the percent change in expected red knot and female horseshoe crab abundance at year 100 are only -0.5% and -1.3% respectively. So a substantial increase in total female harvest is predicted to result in a relatively small change in population sizes. This is likely because the harvest cap of 210,000 is relatively small compared to the projected long-run abundance of female crabs, which is greater than 7 million.

Although the comparison of the uncorrected and corrected versions of 2021 ARM Revision has been presented here, it is important to note that it is crucial to use only the corrected version henceforth.

3 Outcomes from January 2026 workshop

3.1 Review of recommendations

Workshop participants chose to recommend alterations to three values-based components of the ARM: the horseshoe crab and red knot utility functions, and the female horseshoe crab harvest policy function (Figure 1.1). Stakeholders chose to retain the 2021 version of the reward function, so its functional form was not altered here. However, because the utility functions are used in the reward function, changing the utility functions does affect the reward function directly, which can in turn affect the optimal solution because it shows how value (economic and otherwise) is derived from the state of the ecological system.

The third change, to the functional form of the female HSC harvest policy function, imposes a threshold below which no female harvest will occur. This acts more like a constraint on the model, limiting the universe of system states over which it is possible to derive value (i.e., reward).

3.1.1 Horseshoe crab utility function

In the 2021 Revised ARM, the horseshoe crab utility, $u_t^h \in [0, 1]$, represents relative economic value, expressed as the ratio of the harvest in year t (H_t^m for males, H_t^f for females) to the maximum possible harvest as determined by the harvest caps placed on male ($H_{\max}^m$) and female ($H_{\max}^f$) harvest:

$$u_t^h = \frac{2 \times H_t^f + H_t^m}{2 \times H_{\max}^f + H_{\max}^m}. \quad (3.1)$$

Based on stakeholder input during the development of the original ARM framework, female horseshoe crabs were considered to have twice the economic value of males for bait harvest (ASMFC, 2009) and this relative valuation was retained in the 2021 Revision (ASMFC, 2022). Thus, in both the numerator and denominator of Equation 3.1 the term representing female harvest is doubled.

During the 2026 workshop, stakeholders determined that this relative valuation of harvested male and female HSCs should be adjusted such that one female has the value of 2.65 males. The utility function was therefore adjusted to

$$u_t^h = \frac{2.65 \times H_t^f + H_t^m}{2.65 \times H_{\max}^f + H_{\max}^m}. \quad (3.2)$$

3.1.2 Red knot utility function

Under the 2021 Revised ARM the red knot utility function used a threshold value (81,900 knots) that was established during development of the Original ARM, and the function ramped up from 0 to a value of 1 at this threshold (Figure 3.1). The ramp began at $0.9 \times 81,900 = 73,710$ knots.

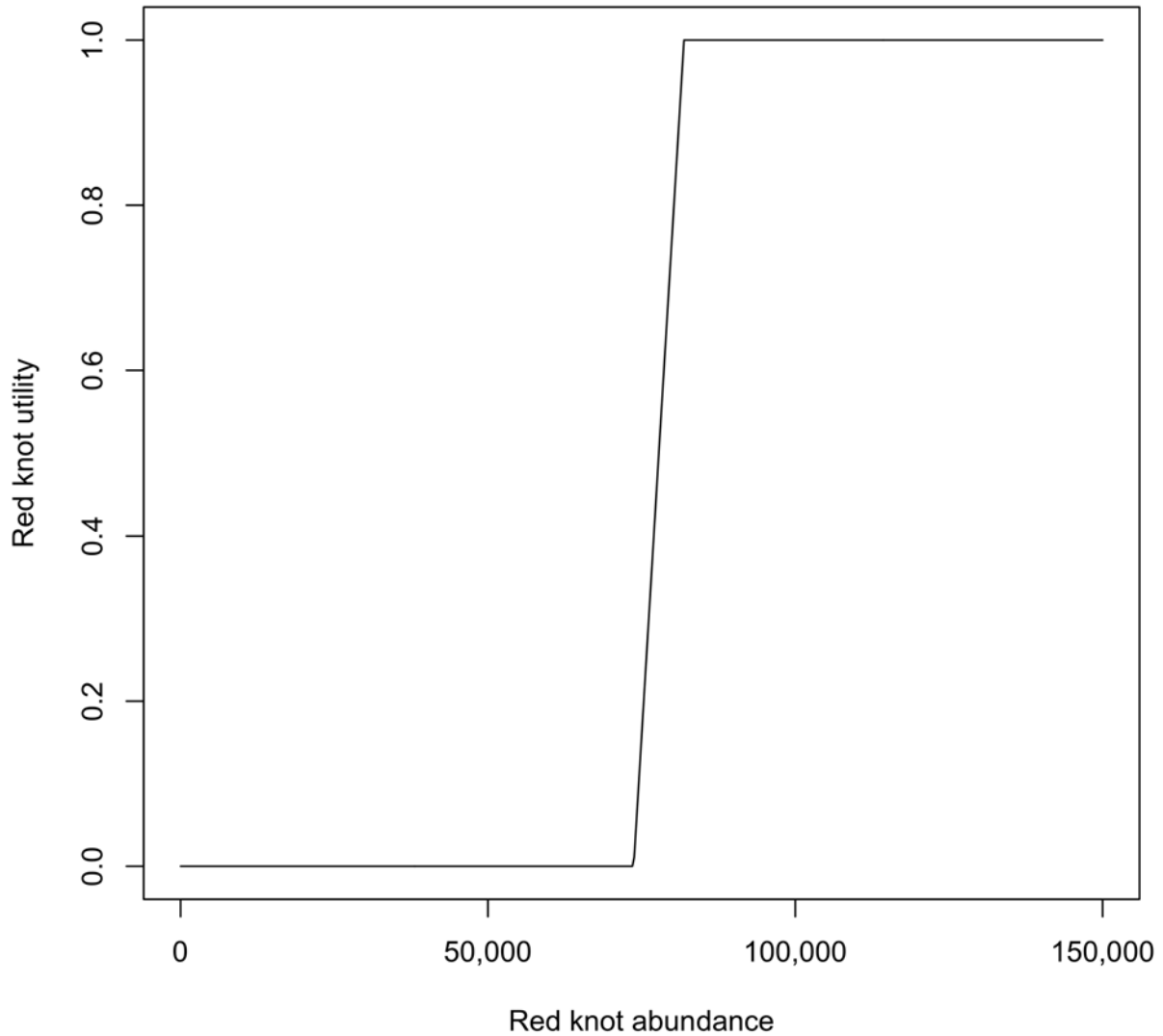


Figure 3.1: Red knot utility function used in the 2021 ARM Revision.

The utility curve recommended by participants of the January, 2026 workshop (black line in Figure 3.2), in contrast, has a smoother *S*-shape that rises more gradually across the range of red knot abundances. Both the new and original red knot utilities are piece-wise functions, but the new version has six connected segments, whereas the original has only three.

3.1.3 Female HSC harvest policy function

The female horseshoe crab harvest policy function in the 2021 ARM Revision is itself a function of two component functions, called *harvest factors*, one for female crabs and one for red knots. Each harvest factor has a logistic form (i.e., is *S*-shaped), and is a function of the abundance N_t of its focal species in year t , along with two parameters that dictate the curve's inflection point (β) and the slope at that location (α):

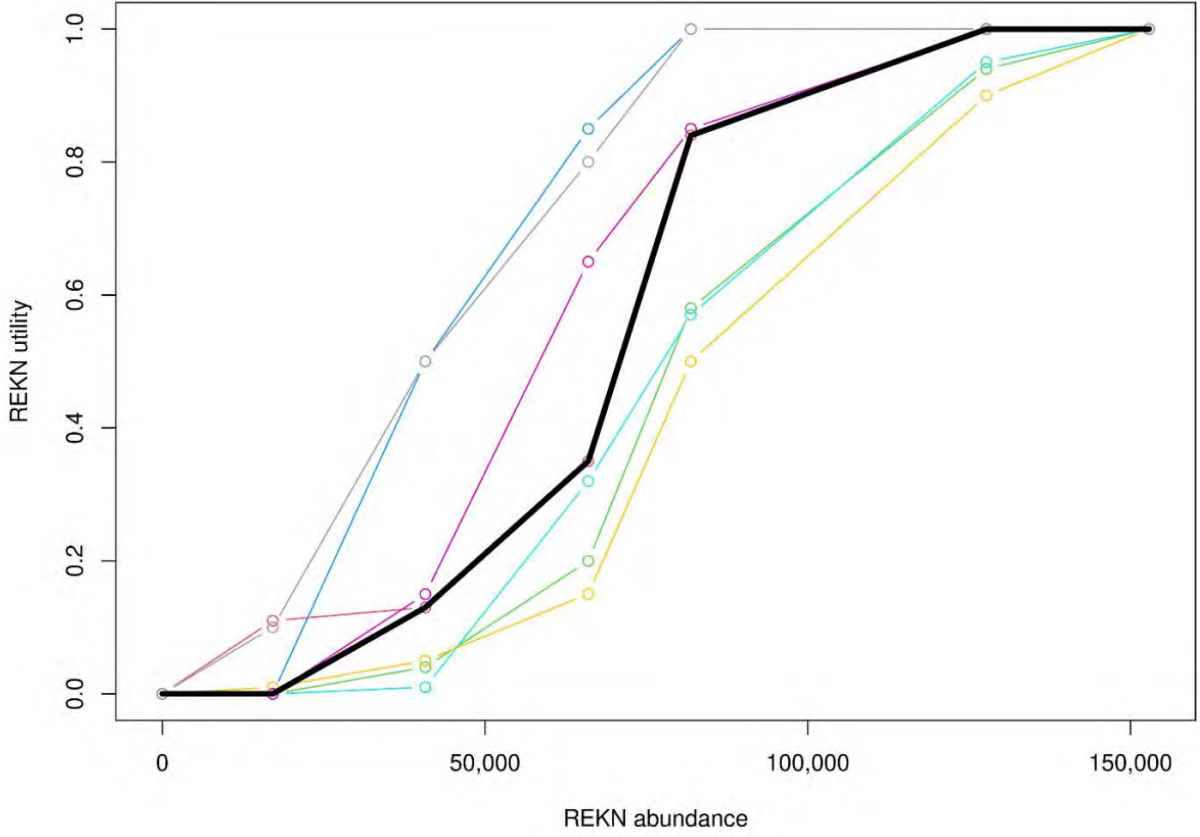


Figure 3.2: Red knot (REKN) utility function recommended by stakeholders in the January, 2026 workshop. Thin, colored lines represent individual stakeholders' suggested curves. The resulting average function (thick black line) was obtained by connecting median values across stakeholders, at each of a set of notable red knot abundances (marked with circles along each stakeholder curve).

$$f(N_t, \alpha, \beta) = \frac{1}{1 + e^{\alpha(\beta - N_t)}} \quad (3.3)$$

The two harvest factors are then used in the female harvest policy h^f in the following arrangement:

$$\begin{aligned} h^f(N_t^f, N_t^k, \alpha^f, \beta^f, \alpha^k, \beta^k) = & f(N_t^f, \alpha^f, \beta^f) \\ & + f(N_t^k, \alpha^k, \beta^k) \\ & - f(N_t^f, \alpha^f, \beta^f) \times f(N_t^k, \alpha^k, \beta^k) \end{aligned} \quad (3.4)$$

where superscript k denotes red knot parameters and f those for female horseshoe crabs. During the iterative procedure used to find the solution to the ARM decision model (i.e., the optimal harvest policy), α^f , β^f , α^k , and β^k are the values to be optimized (in addition to α^m , β^m , which determine the shape of the male horseshoe crab harvest policy curve).

Stakeholders in the January, 2026 workshop recommended that a threshold be placed on female crab harvest, below which no harvest would occur. The actual value of the threshold was later defined by the Delaware Bay Ecosystem Technical Committee; it was set to be 7,000,000 (abbreviated here 7e6). This threshold was incorporated into the policy function by first defining a step function that

takes a value of 0 or 1:

$$s(N_t^f) = \begin{cases} 0, & \text{if } N_t^f < 7\text{e}6 \\ 1, & \text{if } N_t^f \geq 7\text{e}6. \end{cases} \quad (3.5)$$

Then the entire righthand side of h^f was multiplied by this step function, essentially setting harvest to 0 when $N_t^f < 7\text{e}6$:

$$\begin{aligned} h^f(N_t^f, N_t^k, \alpha^f, \beta^f, \alpha^k, \beta^k) = & [f(N_t^f, \alpha^f, \beta^f) \\ & + f(N_t^k, \alpha^k, \beta^k) \\ & - f(N_t^f, \alpha^f, \beta^f) \times f(N_t^k, \alpha^k, \beta^k)] \\ & \times s(N_t^f). \end{aligned} \quad (3.6)$$

3.2 Methods

To best understand the effect—on model behavior and the resulting solution—of each change recommended in the January, 2026 workshop, a sequence of model runs was performed, with a single change made before each run. The starting place for this sequence was the corrected version of the 2021 ARM Revision (*errFix*; Section 2)

The order of these model runs and associated information appear in Table 3.1. A single change was made with each run, but the changes were cumulative, such that each run incorporates all changes added in previous runs. Except for the changes noted there, model runs relied on exactly the same codebase, parameter values and input data.

Table 3.1: Model runs to exhibit the effect of changes made to the ARM decision model; these changes are specified in the *Adjustment* column. Note that the changes are cumulative, with each run incorporating all changes from previous runs, as well as the one specified in its own row in the table.

Order	Label	Adjustment	Description	Results section
1	<i>errFix</i>	Error in reward function fixed	2.1	2.2
2	<i>hscUtil</i>	HSC utility	3.1.1	3.3.1
3	<i>reknUtil</i>	REKN utility	3.1.2	3.3.2
4	<i>femHarv</i>	Female HSC harvest policy	3.1.3	3.3.3

3.3 Results

3.3.1 New horseshoe crab utility function

Figures 3.3–3.8 show outcomes after the horseshoe crab utility function was updated.

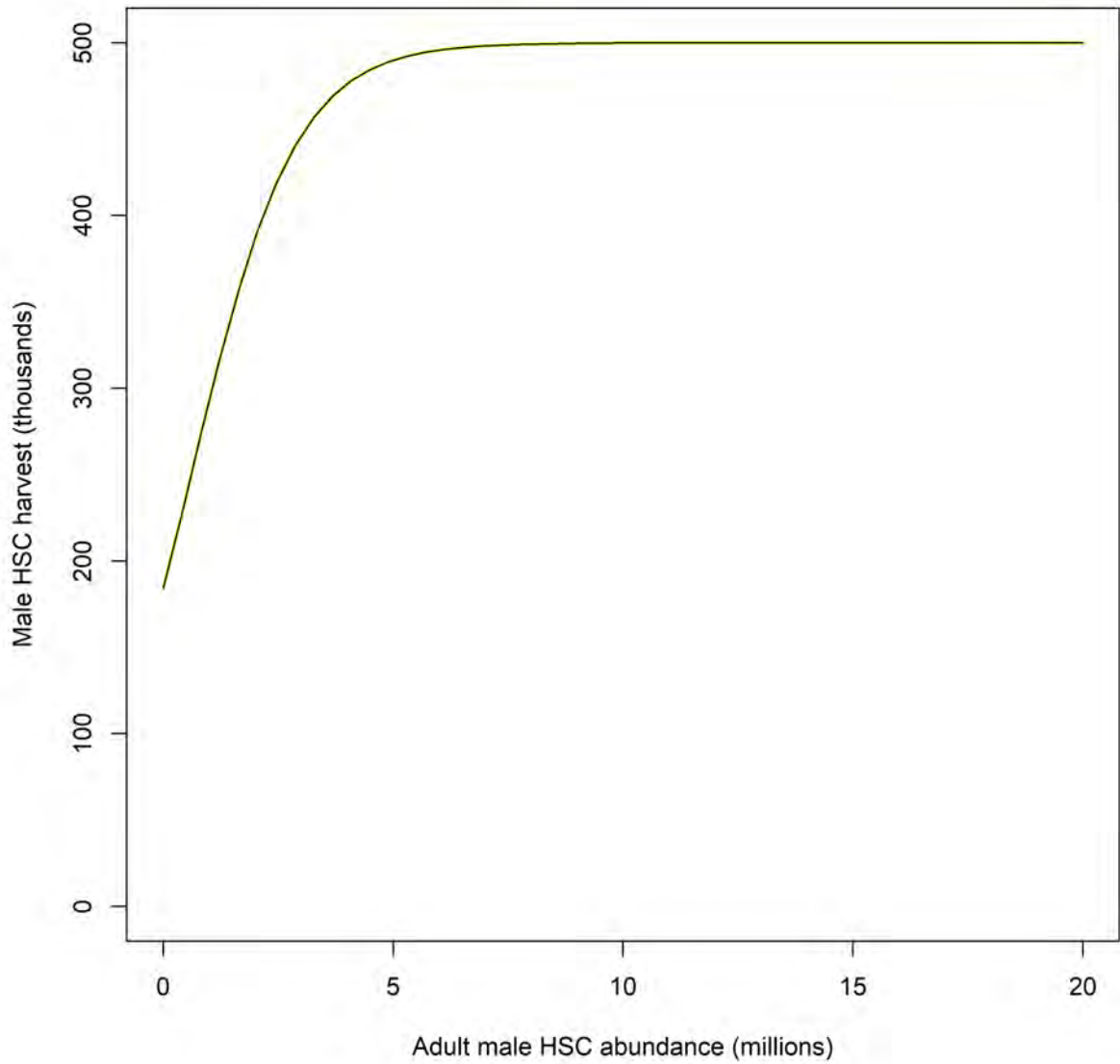


Figure 3.3: Male harvest policy function from the **hscUtil** model.

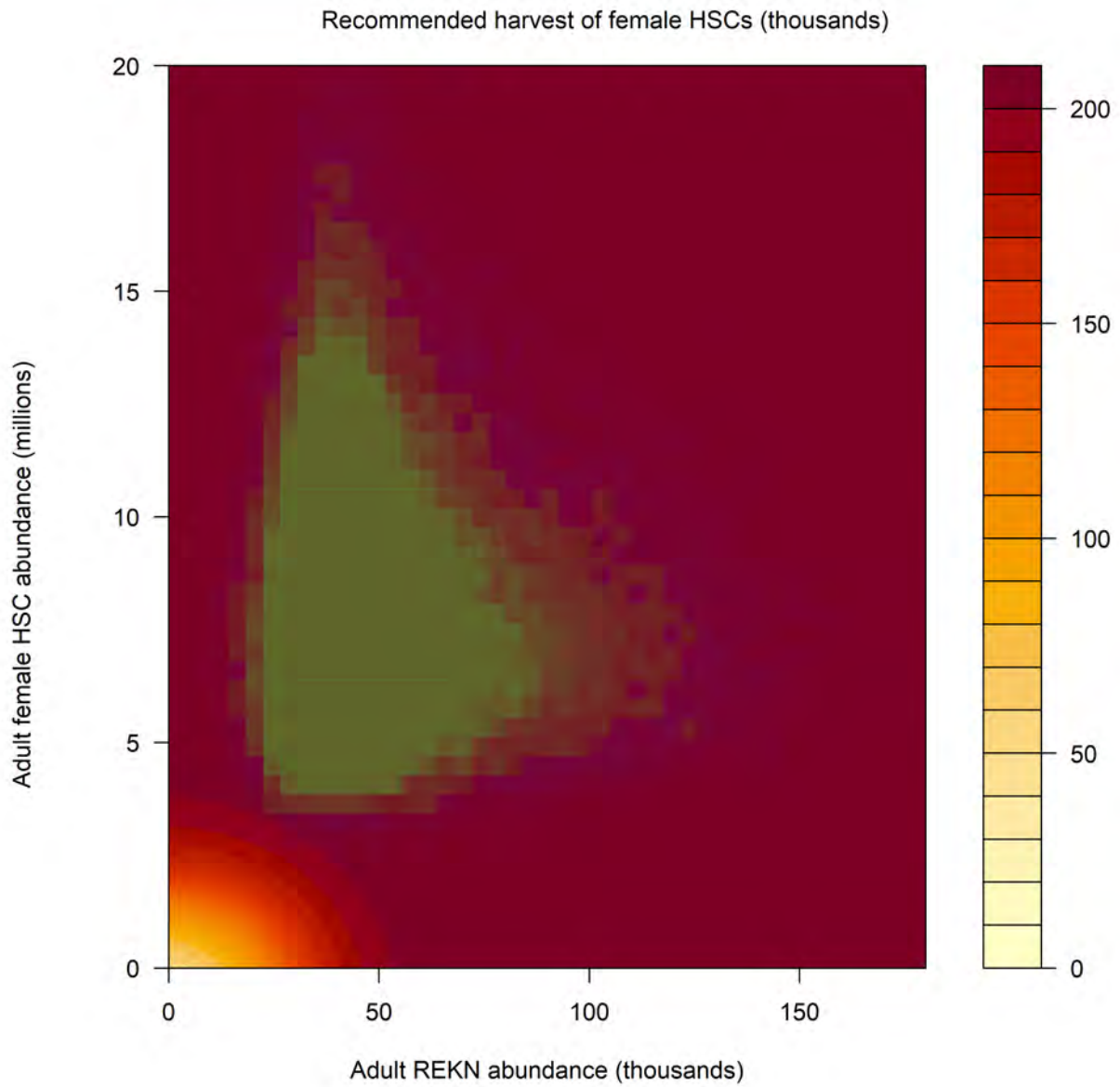


Figure 3.4: Female harvest policy function from the **hscUtil** model. The green and blue ‘blob’ region shows where the system is projected to be (i.e., in terms of female HSC and REKN abundance) in years 1–10 of the 100-year time horizon. The green cells collectively contain 75% of the observations, the blue an additional 20%.

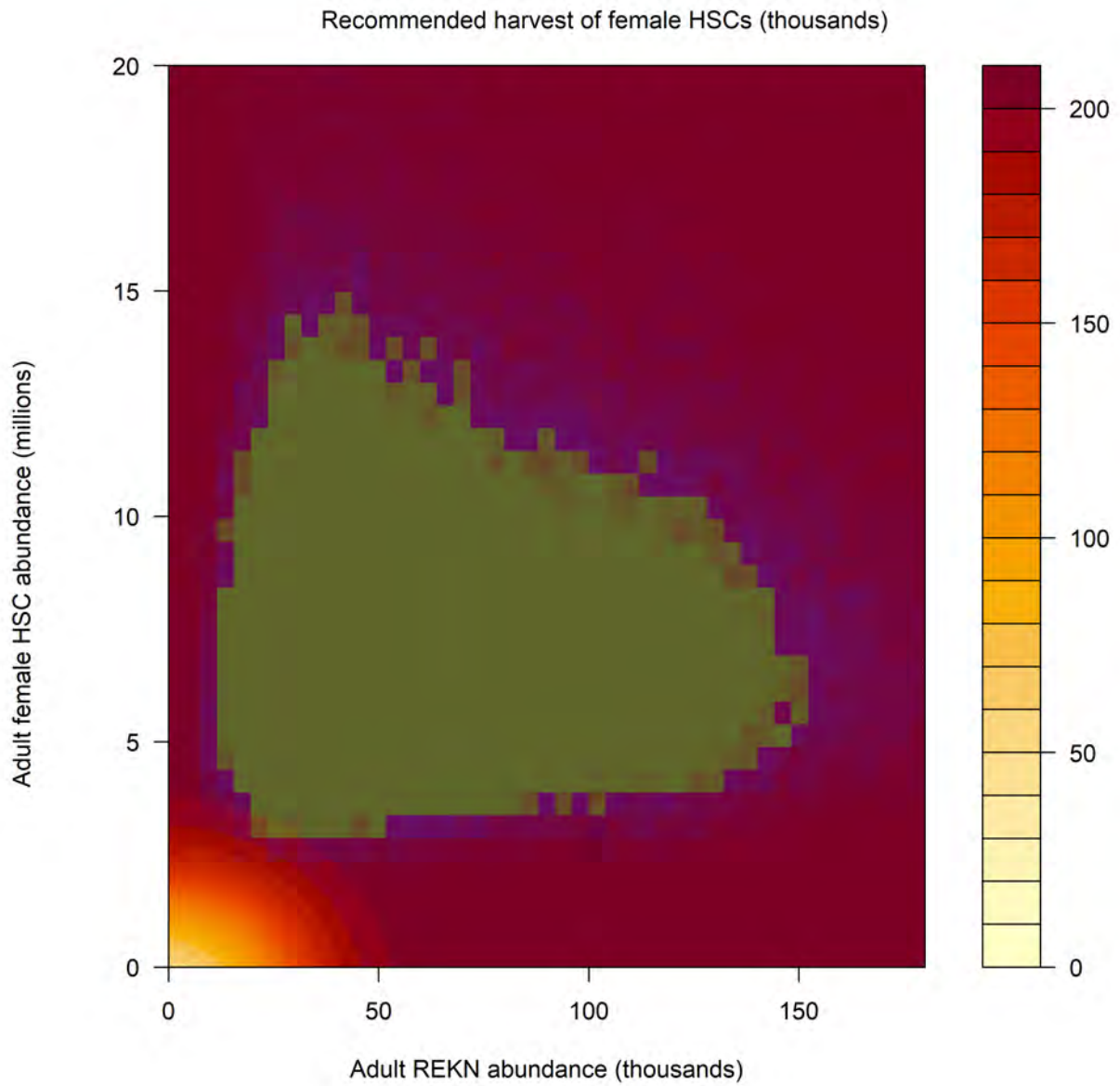


Figure 3.5: Female harvest policy function from the **hscUtil** model. The green and blue ‘blob’ region shows where the system is projected to be (i.e., in terms of female HSC and REKN abundance) in years 11–20 of the 100-year time horizon. The green cells collectively contain 75% of the observations, the blue an additional 20%.

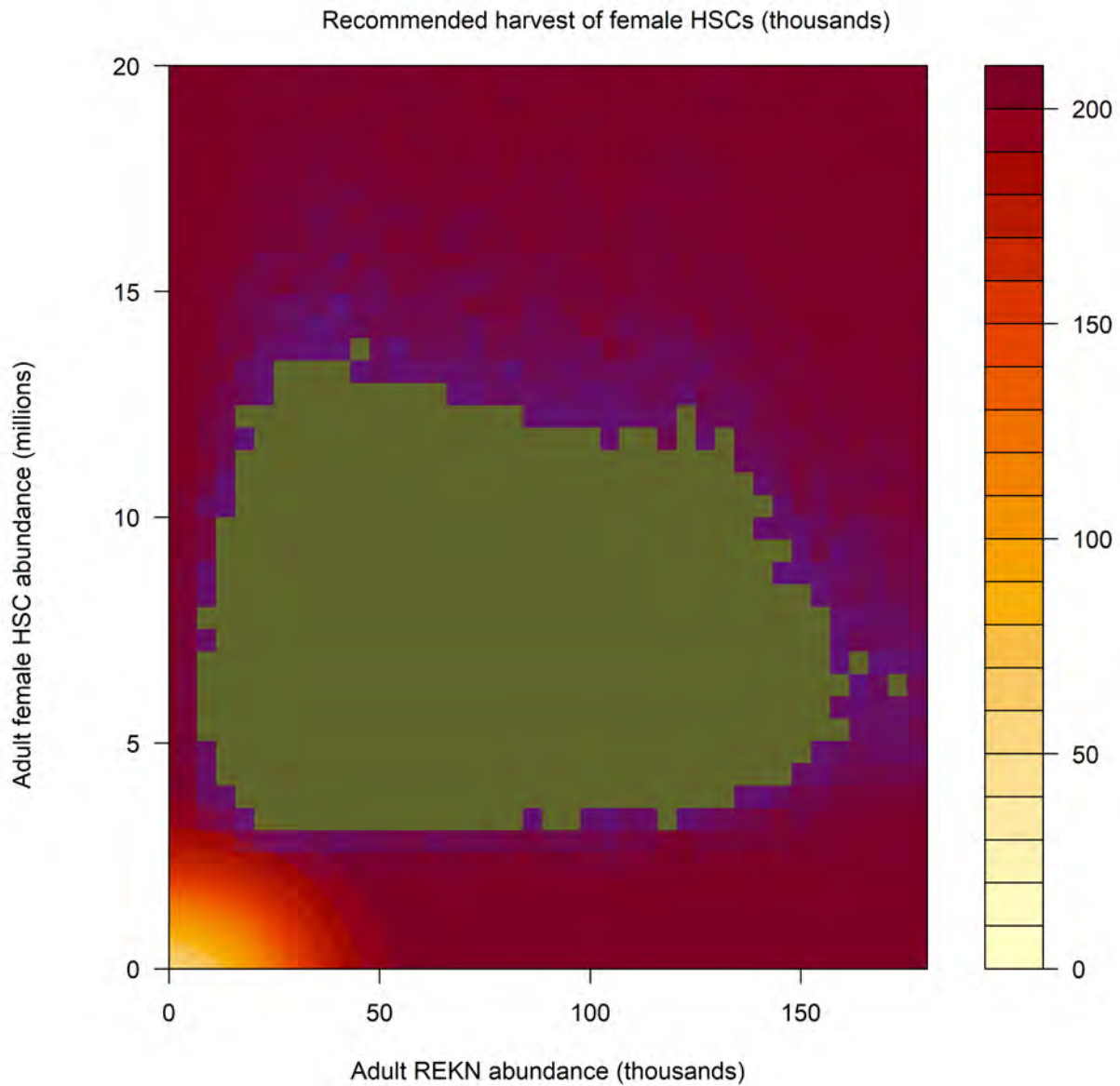


Figure 3.6: Female harvest policy function from the **hscUtil** model. The green and blue ‘blob’ region shows where the system is projected to be (i.e., in terms of female HSC and REKN abundance) in years 21–30 of the 100-year time horizon. The green cells collectively contain 75% of the simulated values, the blue an additional 20%.

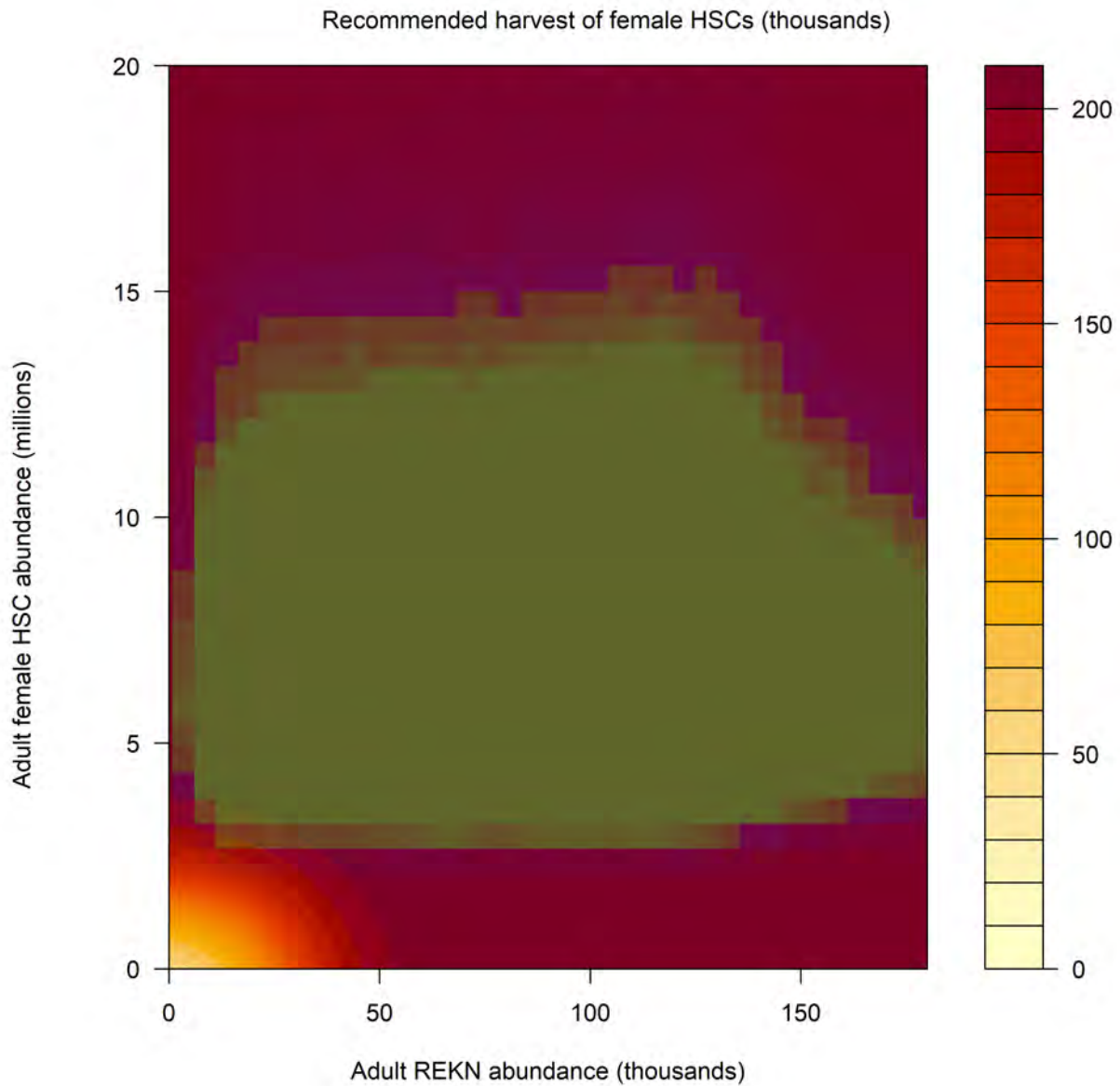


Figure 3.7: Female harvest policy function from the **hscUtil** model. The green and blue ‘blob’ region shows where the system is projected to be (i.e., in terms of female HSC and REKN abundance) in years 31–100 of the 100-year time horizon. The green cells collectively contain 75% of the simulated values, the blue an additional 20%.

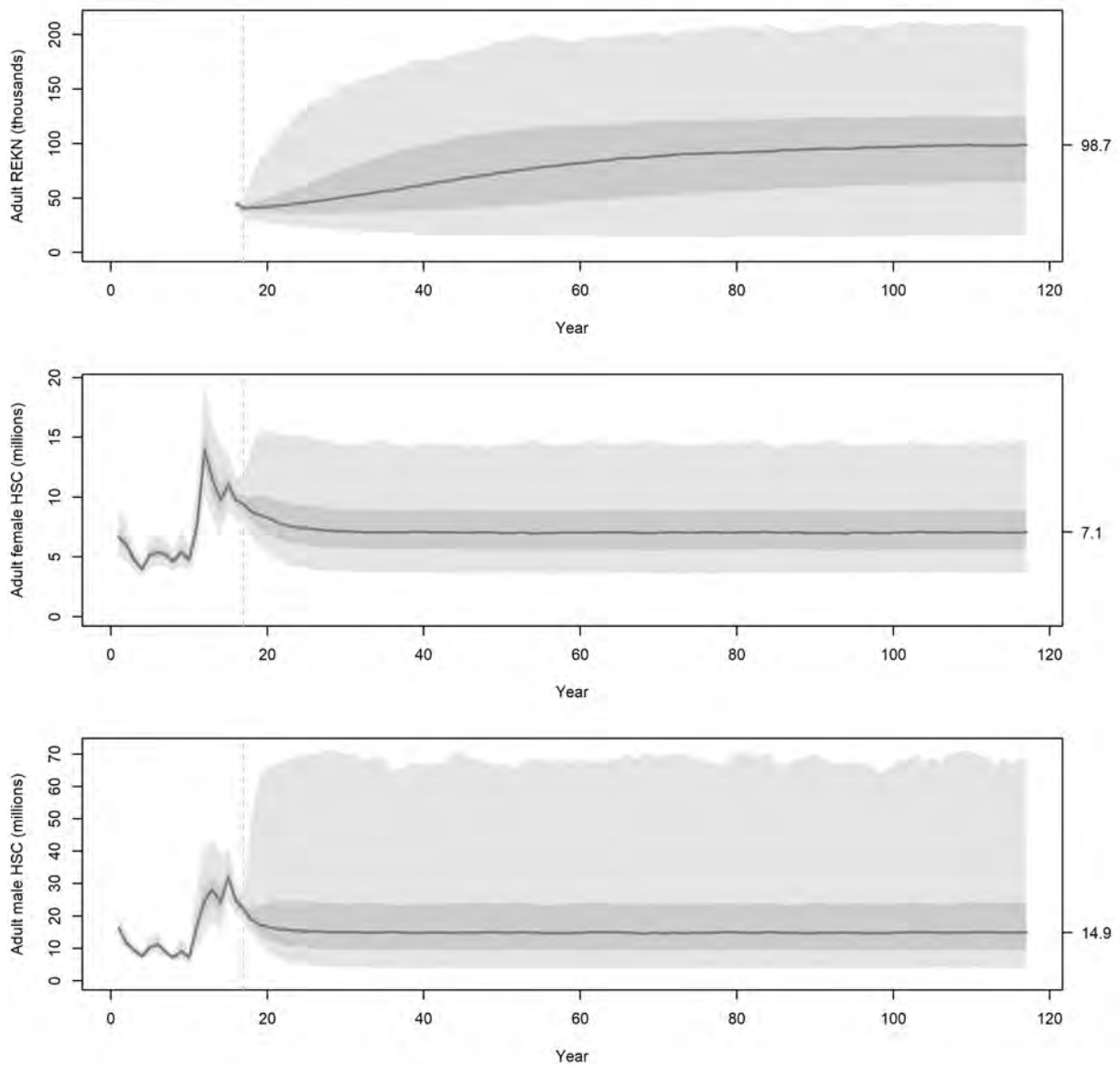


Figure 3.8: Projected population abundances under the **hscUtil** model. Top panel, red knot; center, female horseshoe crab; bottom, male horseshoe crab. Dashed vertical line in each plot shows where observed data series ends and simulated values begin. Trajectory line is the median of all simulated values; light gray envelopes bound the 2.5% and 97.5% percentiles; dark gray are 50% to 75%. Values shown in the right margin are the median values at year 100.

3.3.2 New red knot utility function

Figures 3.9–3.14 show outcomes after the red knot utility function was updated.

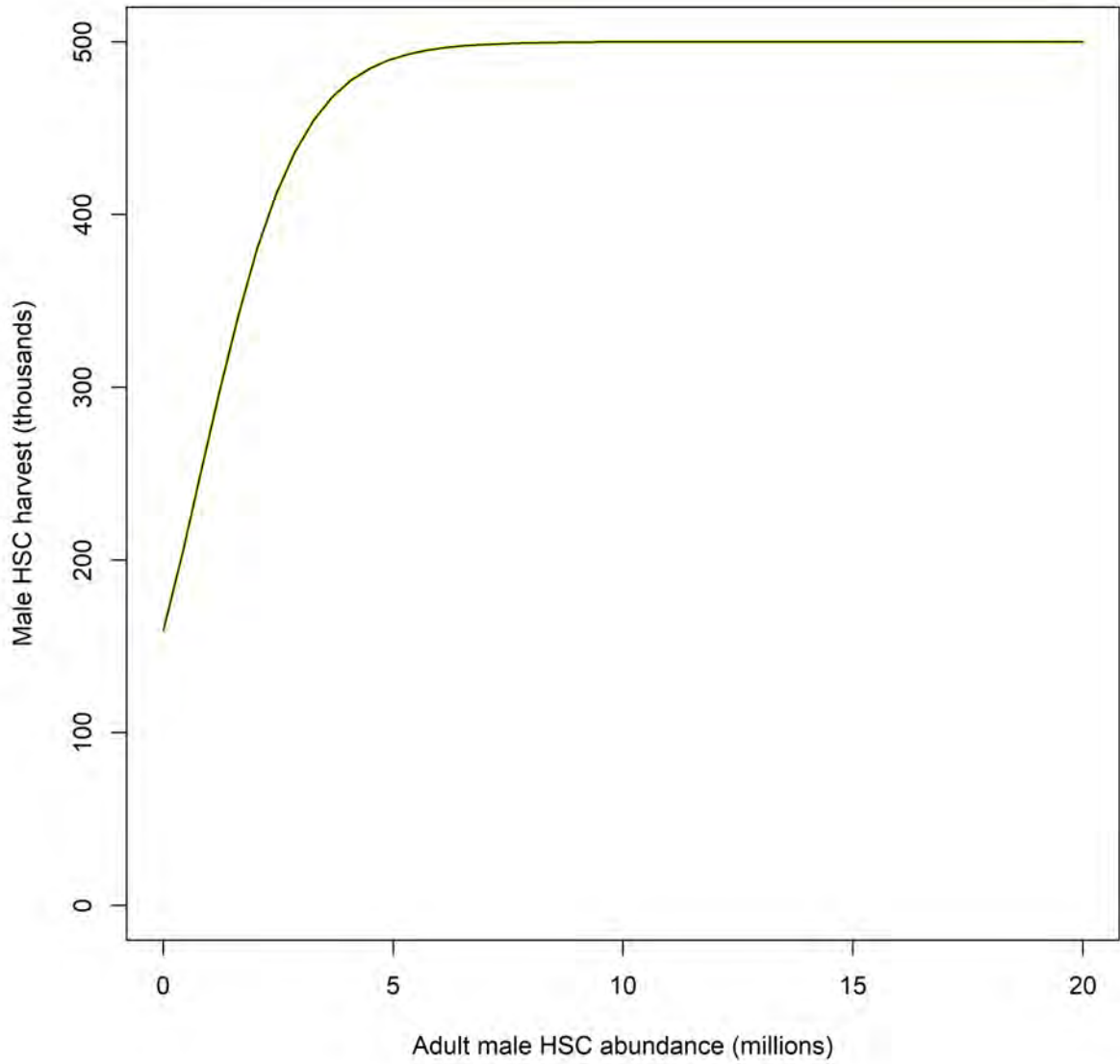


Figure 3.9: Male harvest policy function from the **reknUtil** model.

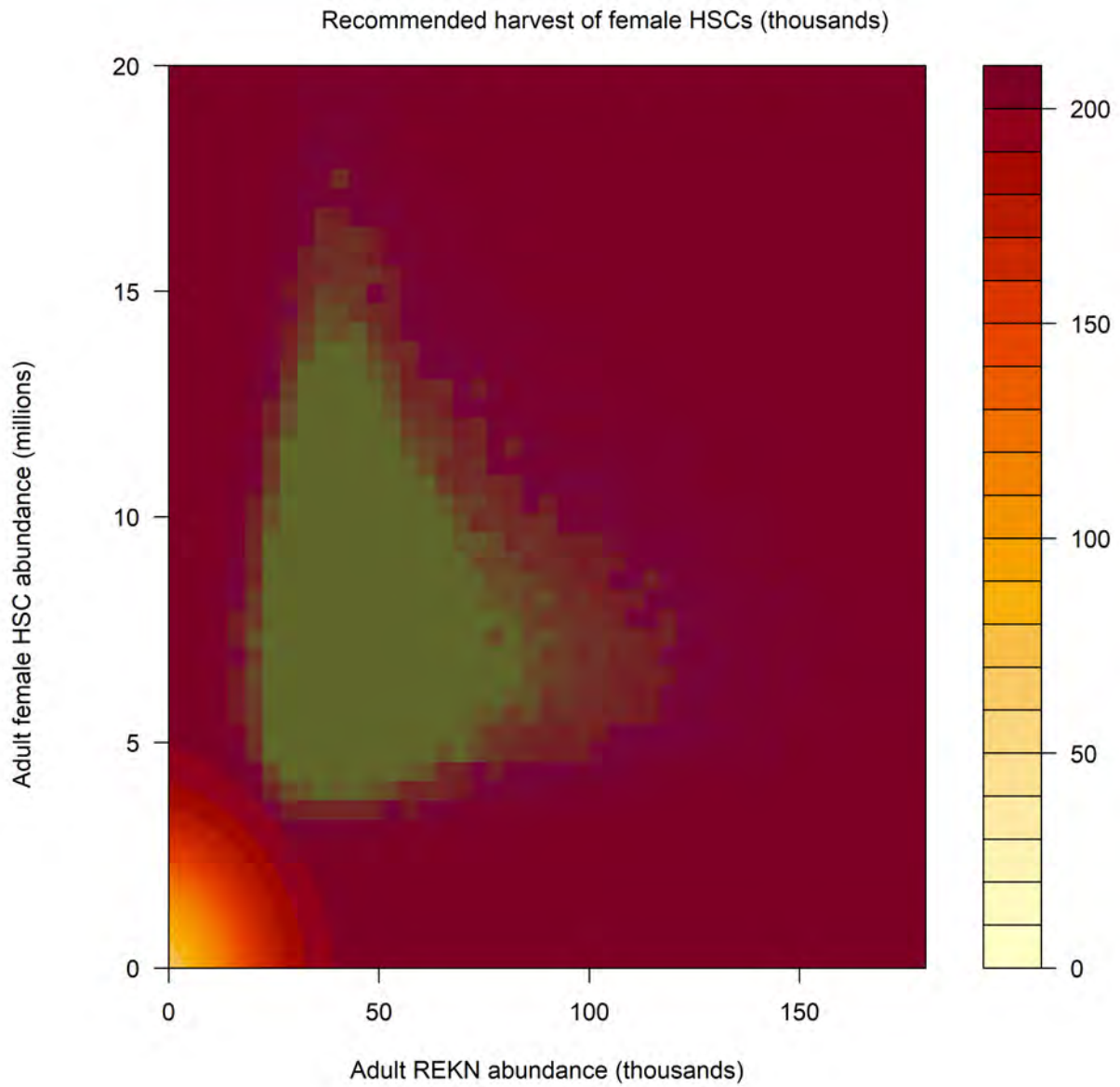


Figure 3.10: Female harvest policy function from the **reknUtil** model. The green and blue ‘blob’ region shows where the system is projected to be (i.e., in terms of female HSC and REKN abundance) in years 1–10 of the 100-year time horizon. The green cells collectively contain 75% of the observations, the blue an additional 20%.

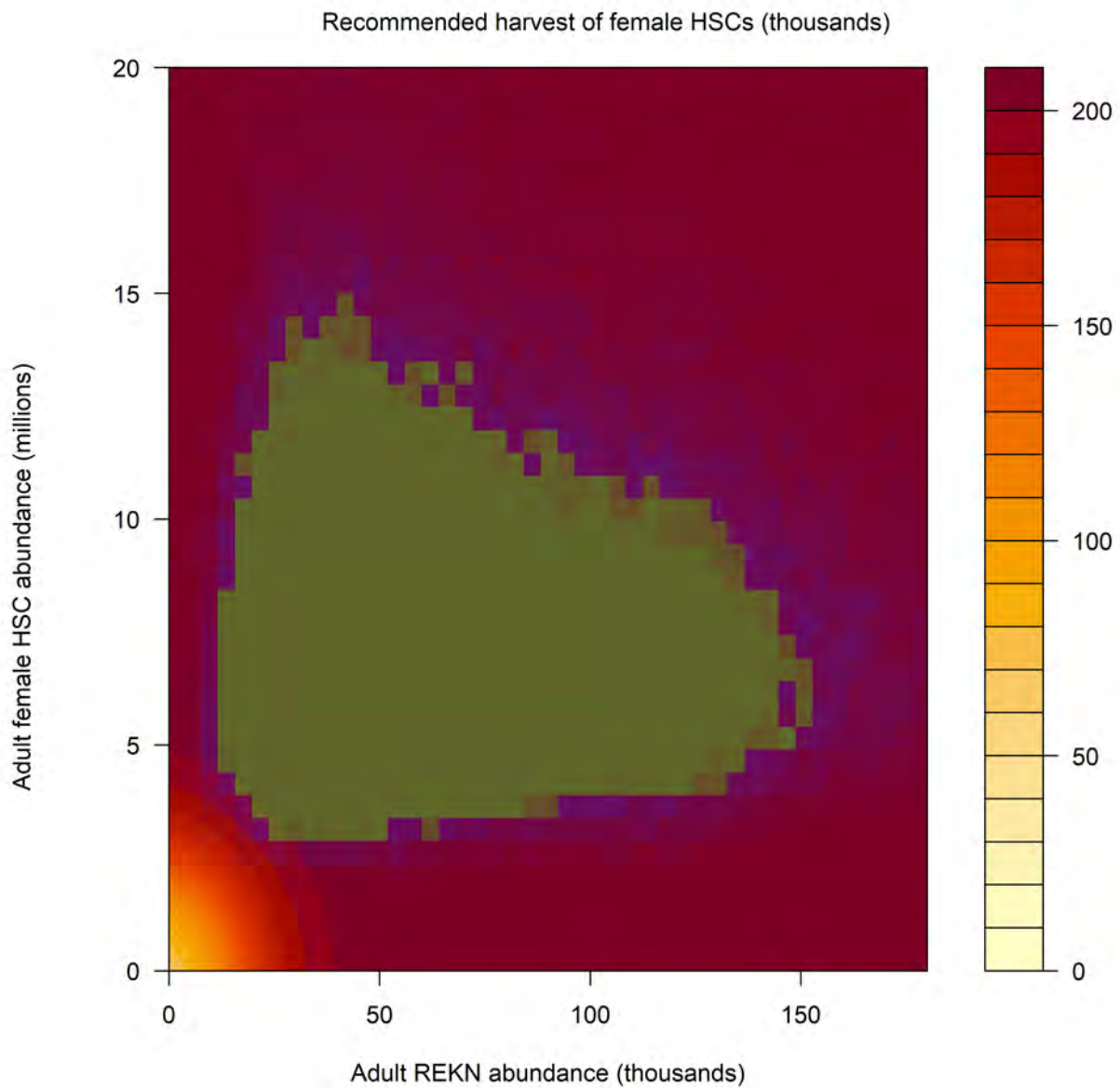


Figure 3.11: Female harvest policy function from the **reknUtil** model. The green and blue ‘blob’ region shows where the system is projected to be (i.e., in terms of female HSC and REKN abundance) in years 11–20 of the 100-year time horizon. The green cells collectively contain 75% of the observations, the blue an additional 20%.

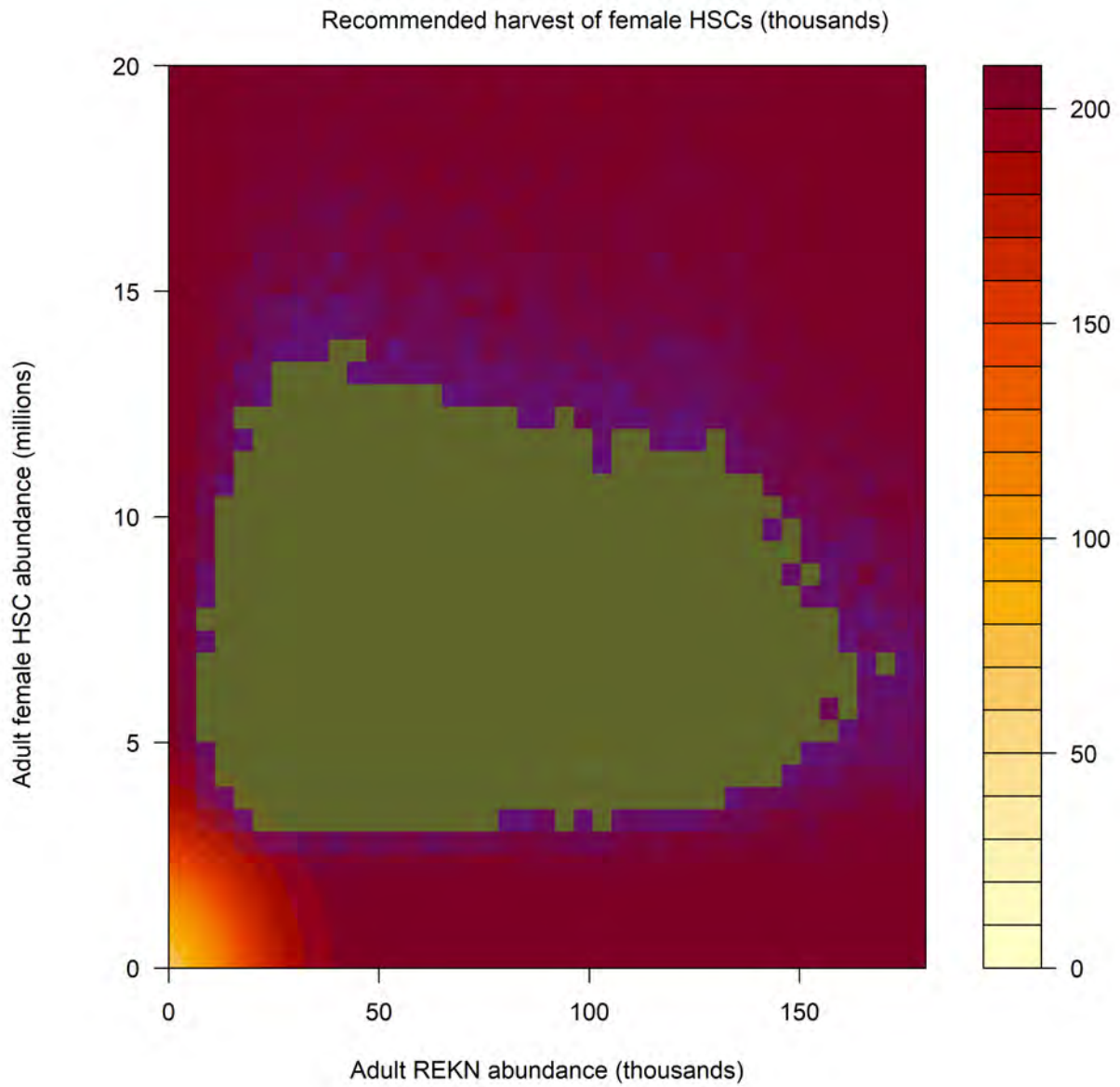


Figure 3.12: Female harvest policy function from the **reknUtil** model. The green and blue ‘blob’ region shows where the system is projected to be (i.e., in terms of female HSC and REKN abundance) in years 21–30 of the 100-year time horizon. The green cells collectively contain 75% of the simulated values, the blue an additional 20%.

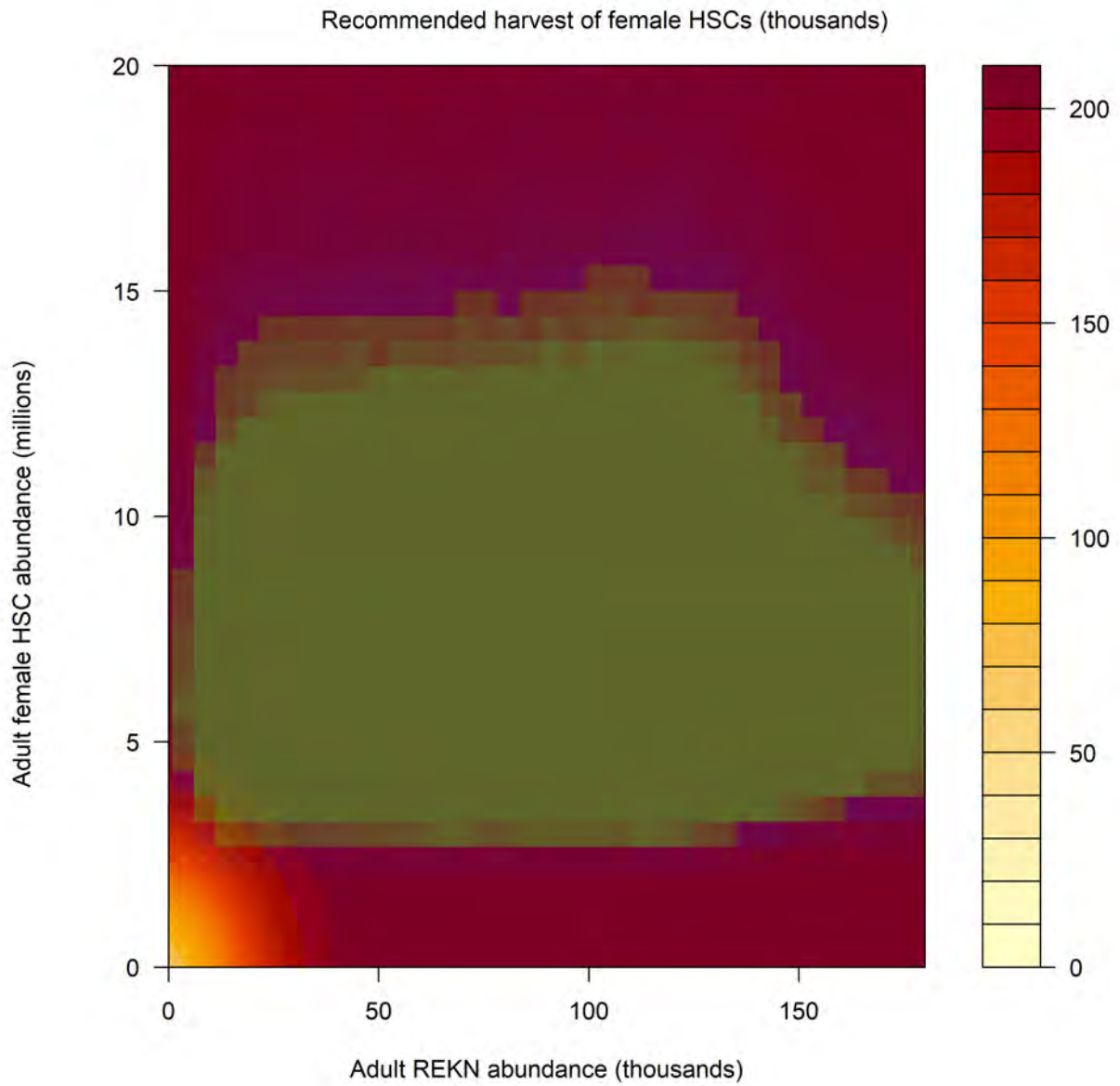


Figure 3.13: Female harvest policy function from the **reknUtil** model. The green and blue ‘blob’ region shows where the system is projected to be (i.e., in terms of female HSC and REKN abundance) in years 31–100 of the 100-year time horizon. The green cells collectively contain 75% of the simulated values, the blue an additional 20%.

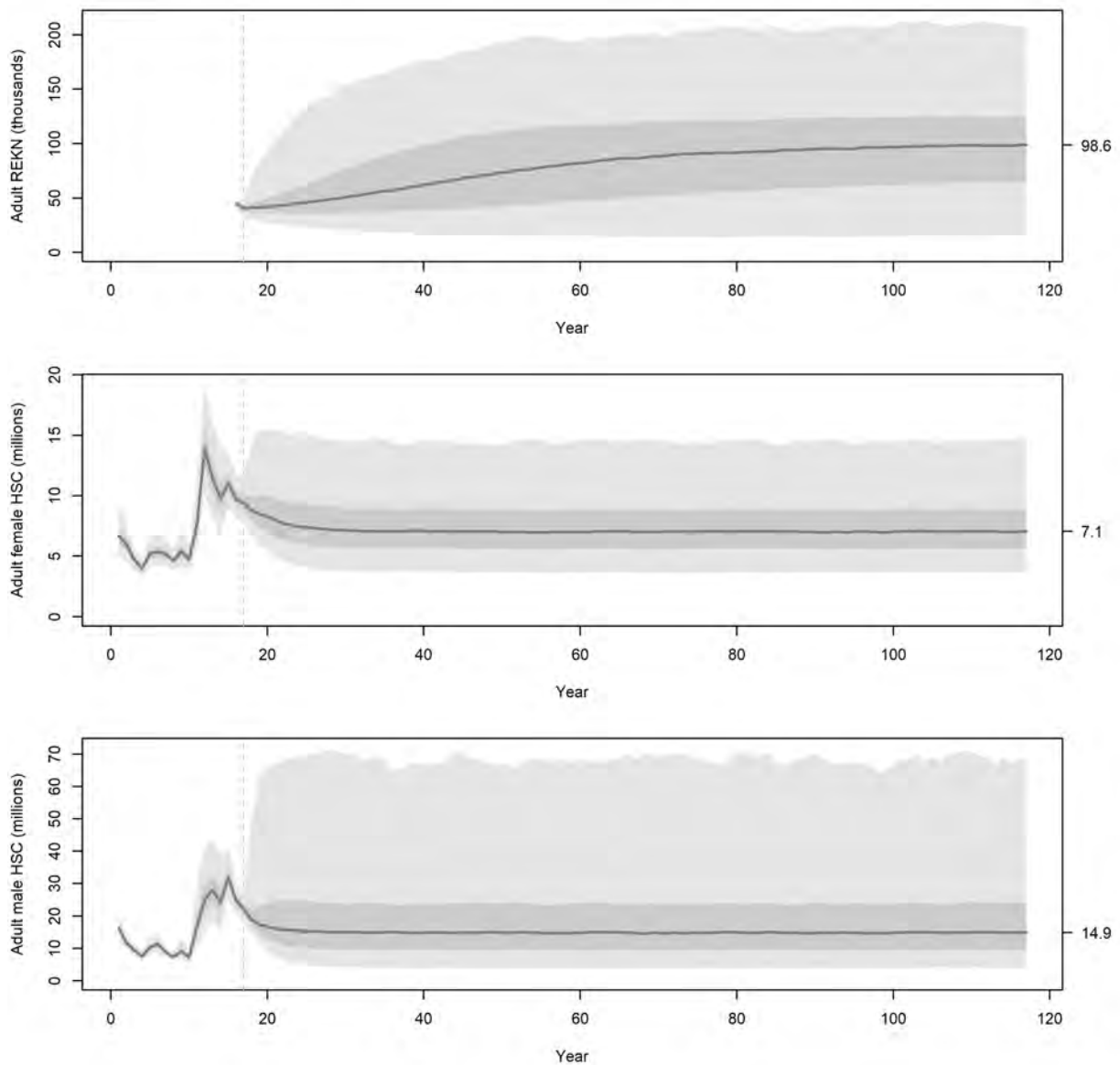


Figure 3.14: Projected population abundances under the **reknUtil** model. Top panel, red knot; center, female horseshoe crab; bottom, male horseshoe crab. Dashed vertical line in each plot shows where observed data series ends and simulated values begin. Trajectory line is the median of all simulated values; light gray envelopes bound the 2.5% and 97.5% percentiles; dark gray are 50% to 75%. Values shown in the right margin are the median values at year 100.

3.3.3 New female horseshoe crab harvest policy function

Figures 3.15–3.20 show outcomes after the female horseshoe crab harvest policy function was updated.

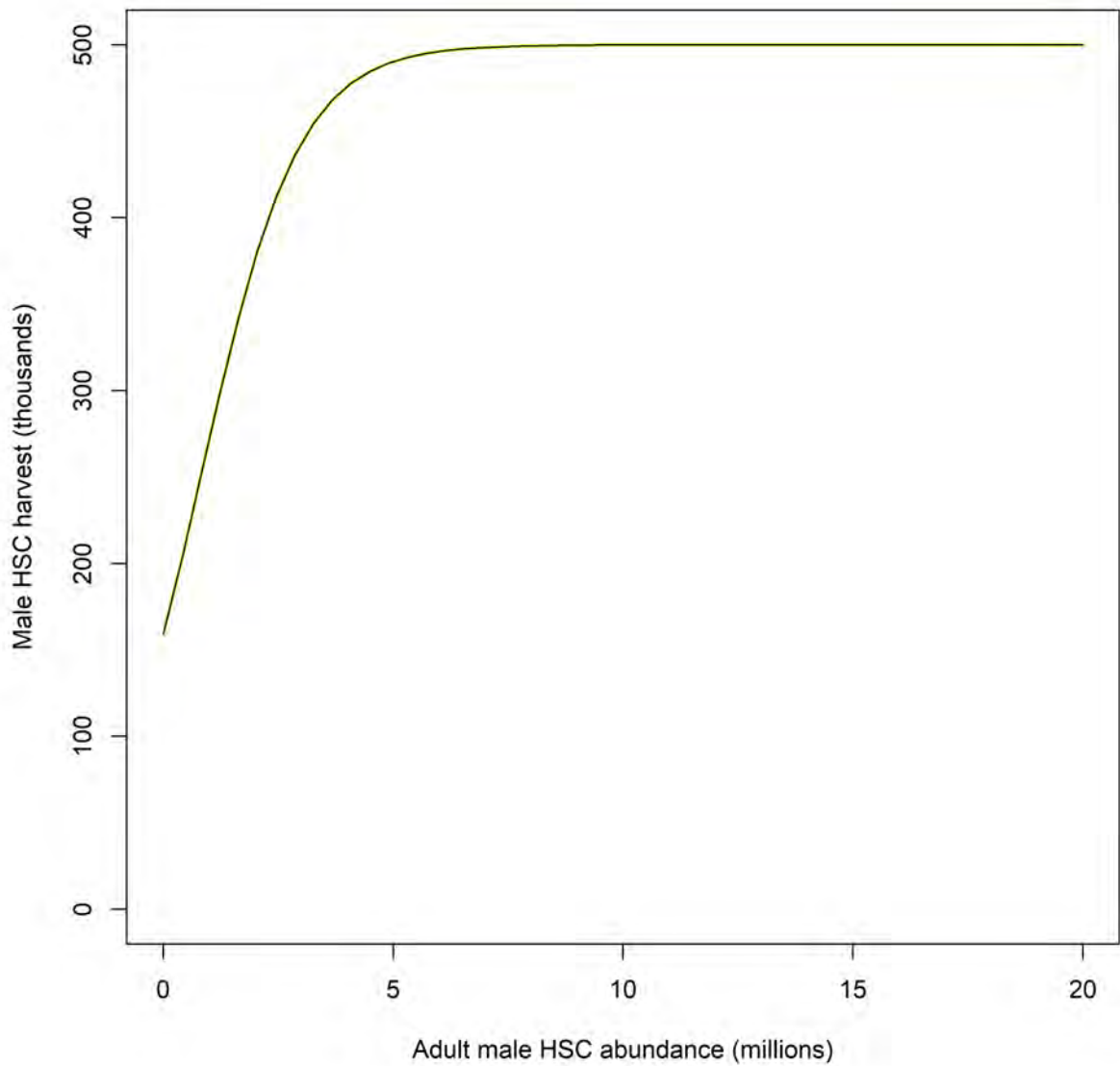


Figure 3.15: Male harvest policy function from the **femHarv** model.

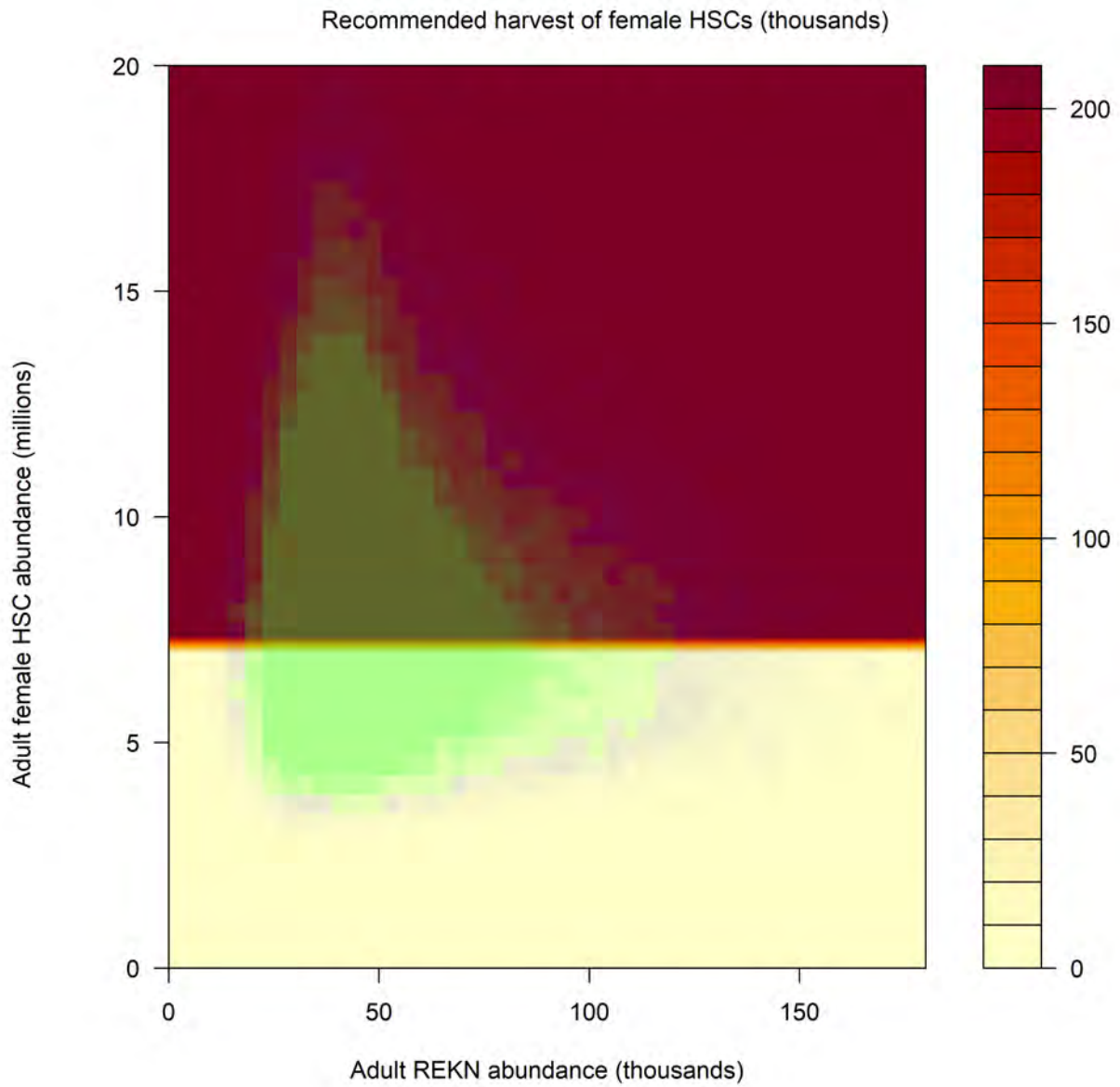


Figure 3.16: Female harvest policy function from the **femHarv** model. The green and blue ‘blob’ region shows where the system is projected to be (i.e., in terms of female HSC and REKN abundance) in years 1–10 of the 100-year time horizon. The green cells collectively contain 75% of the observations, the blue an additional 20%.

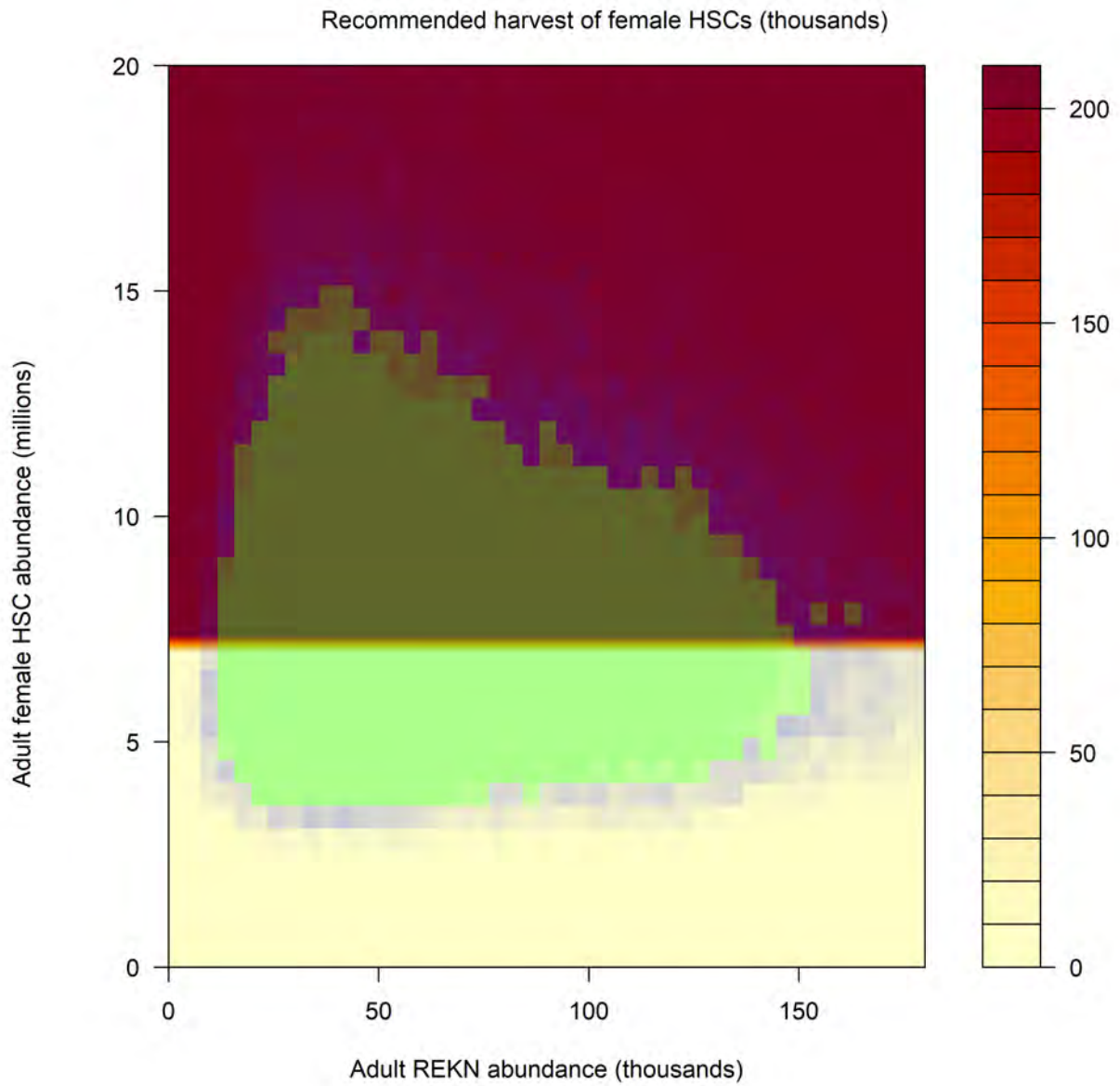


Figure 3.17: Female harvest policy function from the **femHarv** model. The green and blue ‘blob’ region shows where the system is projected to be (i.e., in terms of female HSC and REKN abundance) in years 11–20 of the 100-year horizon. The green cells collectively contain 75% of the observations, the blue an additional 20%.

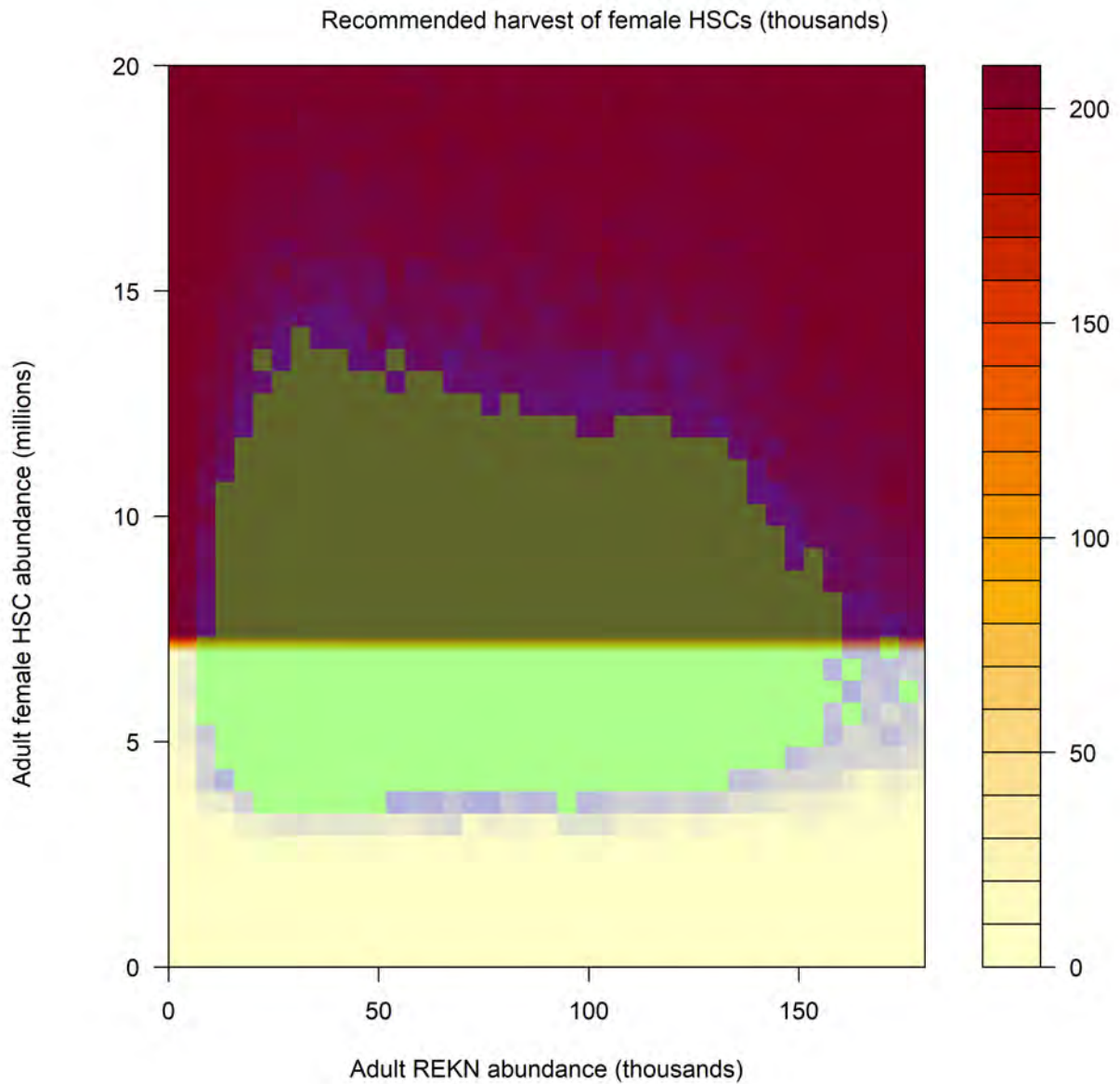


Figure 3.18: Female harvest policy function from the **femHarv** model. The green and blue ‘blob’ region shows where the system is projected to be (i.e., in terms of female HSC and REKN abundance) in years 21–30 of the 100-year time horizon. The green cells collectively contain 75% of the simulated values, the blue an additional 20%.

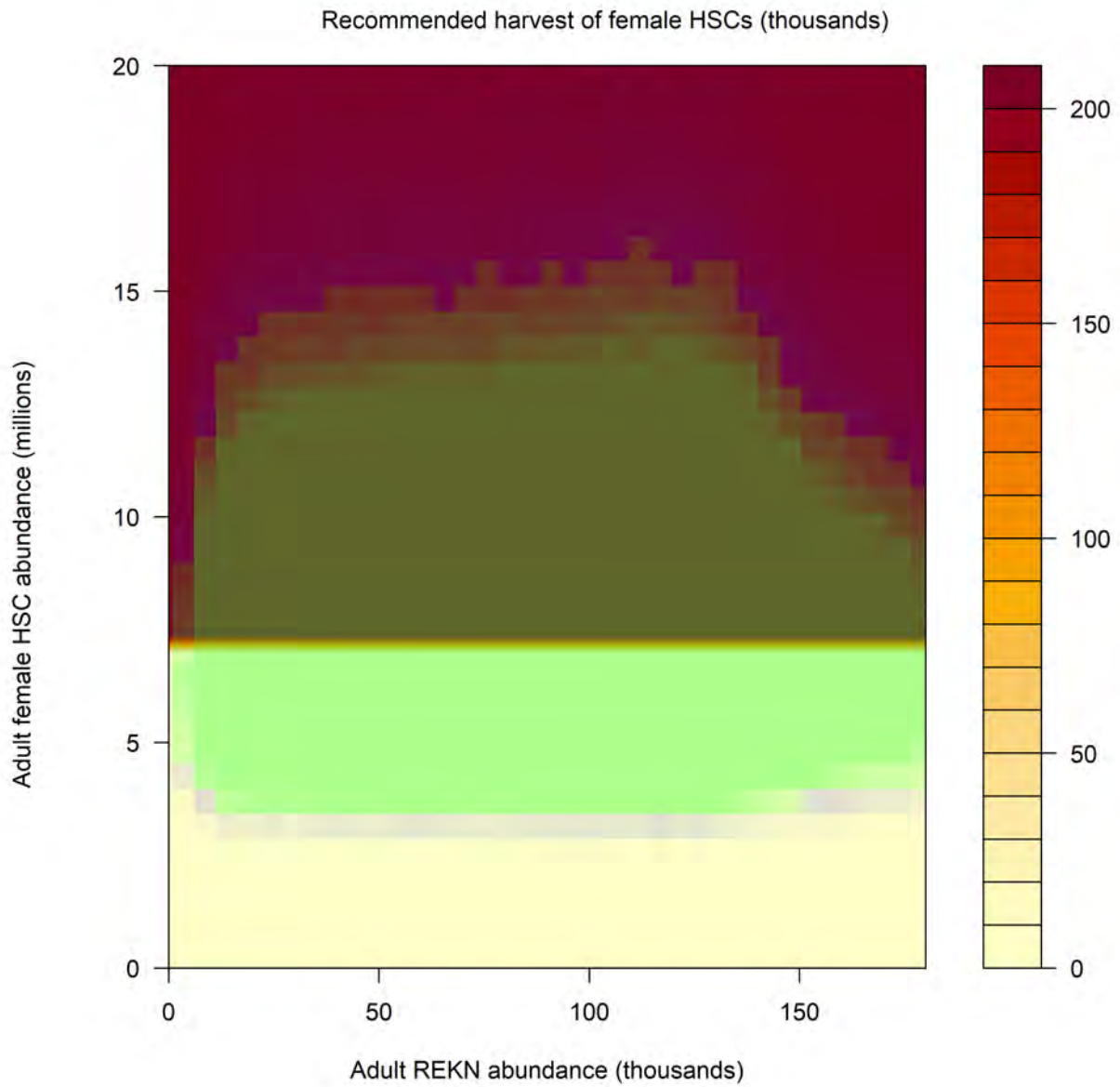


Figure 3.19: Female harvest policy function from the **femHarv** model. The green and blue ‘blob’ region shows where the system is projected to be (i.e., in terms of female HSC and REKN abundance) in years 31–100 of the 100-year time horizon. The green cells collectively contain 75% of the simulated values, the blue an additional 20%.

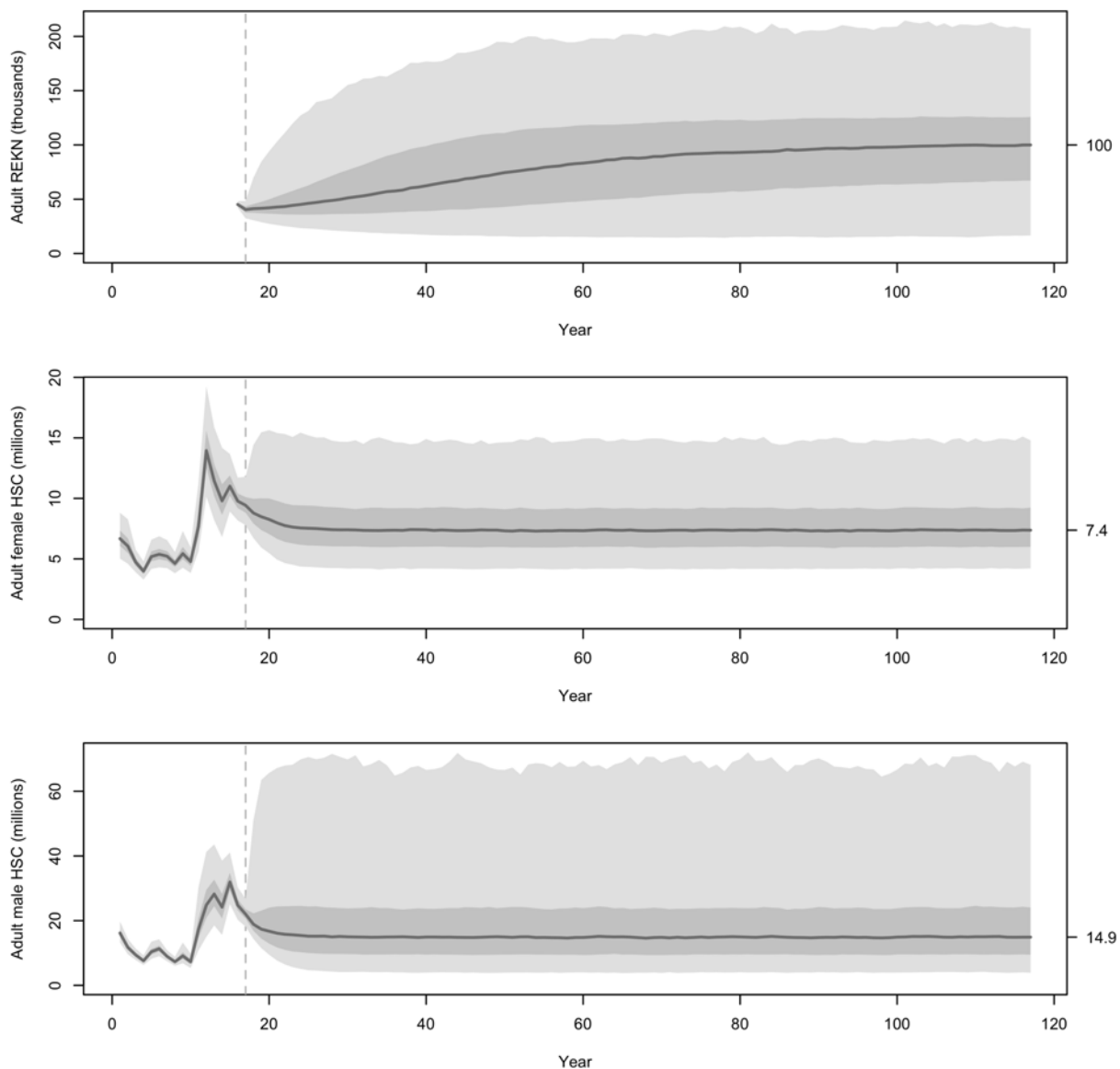


Figure 3.20: Projected population abundances under the **femHarv** model. Top panel, red knot; center, female horseshoe crab; bottom, male horseshoe crab. Dashed vertical line in each plot shows where observed data series ends and simulated values begin. Trajectory line is the median of all simulated values; light gray envelopes bound the 2.5% and 97.5% percentiles; dark gray are 50% to 75%. Values shown in the right margin are the median values at year 100.

3.3.4 Comparison of model runs

Although the ARM model uses a 100-year time horizon for population projections, these population trajectories and their associated uncertainty envelopes are seen to stabilize within about 10 years for horseshoe crabs and within about 70 years for red knots. One simple means to summarize expected population outcomes for a given model run, then, is to note the median value for a number of population metrics at the end of the time horizon (simulation year 100). These year-100 values are shown and compared in Table 3.2. An important caveat in interpreting these values is that the uncertainty around them is very large, and none of the comparative changes shown in the table are ‘statistically significant’. However, a comparison of annual median values is nevertheless informative because it is these expected values, irrespective of the variation around them, that the ARM decision model itself uses to compare time paths during the optimization procedure.

Table 3.2: Expected values in simulation year 100 of several population and management metrics, for the sequence of model runs, along with percent change in each metric (at year 100) between consecutive runs. Symbols: N^k , red knot abundance; N^f , female horseshoe crab abundance; N^m , male horseshoe crab abundance; H^f , female horseshoe crab harvest; H^m , male horseshoe crab harvest; ϕ^k , red knot survival; ρ^k , red knot recruitment. For descriptions of model runs, see Table 3.1.

Model run	Expected value, year 100							Percent change, from previous run						
	N^k	N^f	N^m	H^f	H^m	ϕ^k	ρ^k	N^k	N^f	N^m	H^f	H^m	ϕ^k	ρ^k
<i>errFix</i>	9.87e4	7.1e6	1.49e7	2.1e5	5e5	0.93	0.05							
<i>hscUtil:</i>	9.87e4	7.1e6	1.49e7	2.1e5	5e5	0.93	0.05	0	0	0	0	0	0	0
<i>reknUtil:</i>	9.86e4	7.1e6	1.49e7	2.1e5	5e5	0.93	0.05	-0.1	0	0	0	0	0	0
<i>femHarv:</i>	1.0e5	7.4e6	1.49e7	1.17e5	5e5	0.93	0.05	+1.4	+4.2	0	-44.3	0	0	0

3.4 Discussion

Comparing the four model runs considered in this update effort (Table 3.2) reveals three main conclusions. First, for most of the population and management metrics, there is little to no change across the model runs.

Second, in the one instance where harvest policy was substantially altered (*femHarv*), proportionally large changes in female harvest resulted in relatively small changes in female horseshoe crab and red knot population size. This is probably due to the relatively small value of the female harvest cap (210,000) relative to the expected long-run female population size (above 7 million).

And third, the imposition of a stakeholder-defined threshold on female harvest led to a proportionally large reduction in year-100 harvest (-44.3%). The total harvest under that threshold scenario (*femHarv*), across all simulation years, would be 43.5% lower than under the *errFix* model ({2.5, 97.5} percentiles: {27.5, 44.7}). Additionally, the presence of the threshold would cause the recommended female horseshoe crab harvest to jump from 0 to 210,000, or vice versa, fairly frequently. Figure 3.21 shows the number of times the female harvest recommendation changed during the 100-year time horizon, across all 10,000 simulated time paths. The median value is 22 switches over 100 years, or once every 4.5 years. However, many time paths experienced more frequent switching: there is a 1 in 10 chance that the switching interval is less than 3.6 years (i.e., the 10th percentile across simulations was 3.57).

Finally, it is important to recall that during these updates to the ARM decision model, all input parameters and data were held constant. This means that the updated solutions do not reflect any new ecological data (e.g., horseshoe crab or red knot abundances), beyond what was used in the 2021 ARM Revision. In other words, no information about the system after 2019 has yet been incorporated into the model. An update that would fully update the model inputs and use the most recent available data and population estimates is planned for 2027.

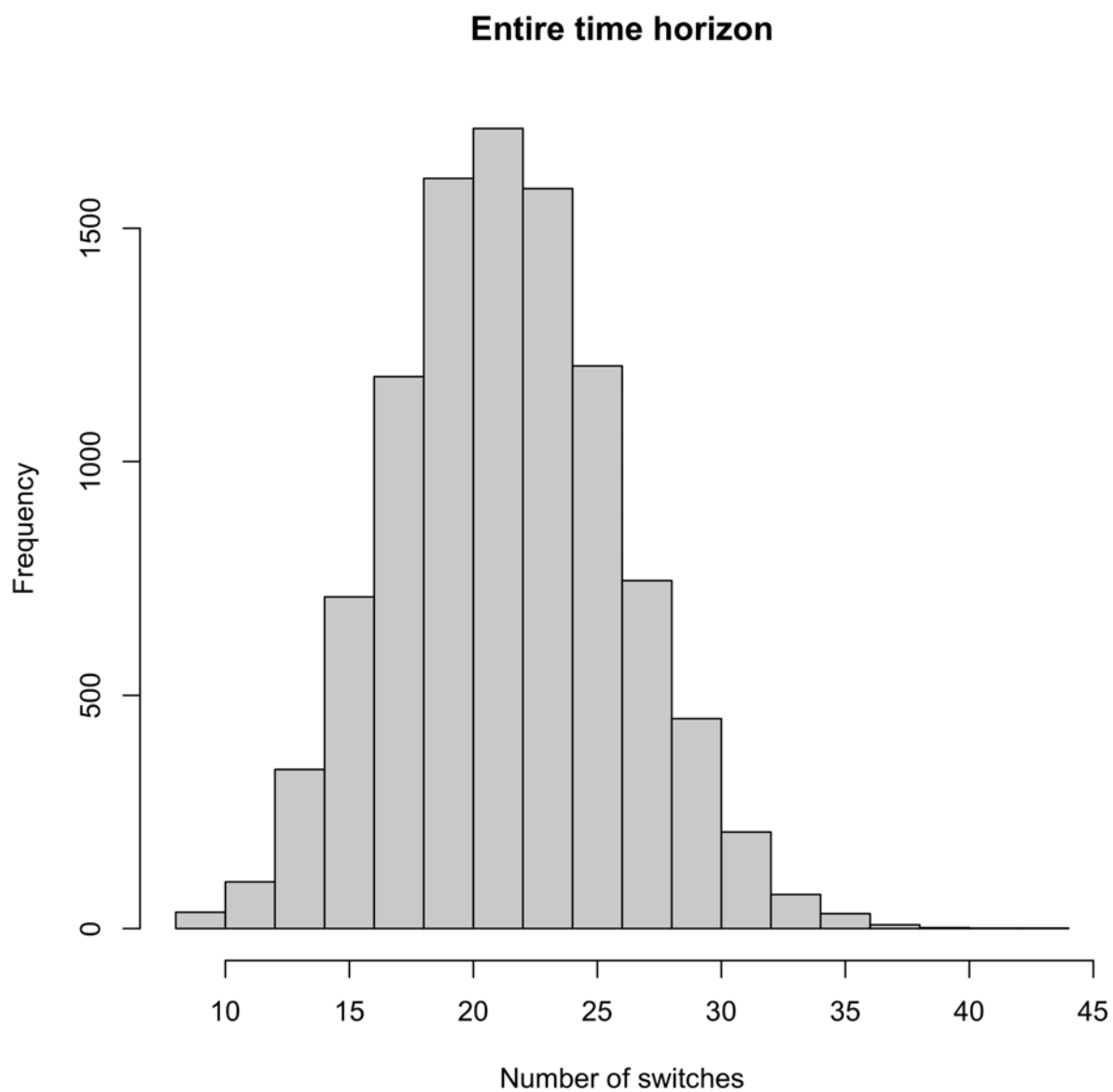


Figure 3.21: Histogram of the number of times the female harvest recommendation switched from 0 to 210,000 or vice versa, across all 10,000 simulated time paths, under the full post-workshop model (*femHarv*).

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Draft for Board Review

ATLANTIC STATES MARINE FISHERIES COMMISSION

REVIEW OF THE INTERSTATE FISHERY MANAGEMENT PLAN

HORSESHOE CRAB
(*Limulus polyphemus*)

2025 Fishing Year



Prepared by the Plan Review Team

October 2026



Sustainable and Cooperative Management of Atlantic Coastal Fisheries

Draft for Board Review

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I. Status of the Fishery Management Plan

Date of FMP Approval: December 1998

Addenda: Addendum I (April 2000)
Addendum II (May 2001)
Addendum III (May 2004)
Addendum IV (June 2006)
Addendum V (September 2008)
Addendum VI (August 2010)
Addendum VII (February 2012)
Addendum VIII (November 2022)
Addendum IX (May 2025)

Management Unit: Entire coastwide distribution of the resource from the estuaries eastward to the inshore boundary of the EEZ

States with Declared Interest: Massachusetts – Florida, Potomac River Fisheries Commission

Active Boards/Committees: Horseshoe Crab Management Board, Advisory Panel, Technical Committee, and Plan Review Team; Delaware Bay Ecosystem Technical Committee; Adaptive Resource Management Subcommittee

Goals and Objectives

The Interstate Fishery Management Plan for Horseshoe Crabs (FMP) established the following goals and objectives.

2.0. Goals and Objectives

The goal of this Plan is to conserve and protect the horseshoe crab resource to maintain sustainable levels of spawning stock biomass to ensure its continued role in the ecology of the coastal ecosystem, while providing for continued use over time. Specifically, the goal includes management of horseshoe crab populations for continued use by:

- 1) current and future generations of the fishing and non-fishing public (including the biomedical industry, scientific and educational research);*
- 2) migrating shorebirds; and,*
- 3) other dependent fish and wildlife, including federally listed (threatened) sea turtles.*

To achieve this goal, the following objectives must be met:

- (a) prevent overfishing and establish a sustainable population;*
- (b) achieve compatible and equitable management measures among jurisdictions throughout the fishery management unit;*

- (c) establish the appropriate target mortality rates that prevent overfishing and maintain adequate spawning stocks to supply the needs of migratory shorebirds;*
- (d) coordinate and promote cooperative interstate research, monitoring, and law enforcement;*
- (e) identify and protect, to the extent practicable, critical habitats and environmental factors that limit long-term productivity of horseshoe crabs;*
- (f) adopt and promote standards of environmental quality necessary for the long-term maintenance and productivity of horseshoe crabs throughout their range; and,*
- (g) establish standards and procedures for implementing the Plan and criteria for determining compliance with Plan provisions.*

Fishery Management Plan Summary

The framework for managing horseshoe crabs along the Atlantic coast was approved in October 1998 with the adoption of the Interstate Fishery Management Plan (FMP) for Horseshoe Crabs. The goal of this plan is to conserve and protect the horseshoe crab resource to maintain sustainable levels of spawning stock biomass to ensure its continued role in the ecology of coastal ecosystems while providing for continued use over time.

In 2000, the Horseshoe Crab Management Board approved Addendum I to the FMP. Addendum I established a state-by-state cap on horseshoe crab bait landings at 25 percent below the reference period landings (RPL's), and *de minimis* criteria for those states with a limited horseshoe crab fishery. Those states with more restrictive harvest levels (Maryland and New Jersey) were encouraged to maintain those restrictions to provide further protection to the Delaware Bay horseshoe crab population, recognizing its importance to migratory shorebirds. Addendum I also recommended that the National Marine Fisheries Service (NMFS) prohibit the harvest of horseshoe crabs in federal waters (3-200 miles offshore) within a 30 nautical mile radius of the mouth of Delaware Bay, as well as prohibit the transfer of horseshoe crabs in federal waters. A horseshoe crab reserve was established on March 7, 2001, by NMFS in the area recommended by ASMFC. This area is now known as the Carl N. Shuster Jr. Horseshoe Crab Reserve (Figure 1).

In 2001, the Horseshoe Crab Management Board approved Addendum II to the FMP. The purpose of Addendum II was to allow the voluntary transfer of harvest quotas between states to alleviate concerns over potential bait shortages on a biologically responsible basis. Voluntary quota transfers require Technical Committee review and Management Board approval.

In 2004, the Board approved Addendum III to the FMP. The addendum sought to further the conservation of horseshoe crab and migratory shorebird populations in and around the Delaware Bay. It reduced harvest quotas and implemented seasonal bait harvest closures in New Jersey, Delaware, and Maryland, and revised monitoring components for all jurisdictions.

Addendum IV was approved in 2006. It further limited bait harvest in New Jersey and Delaware to 100,000 crabs (male only) and required a delayed harvest in Maryland and Virginia.

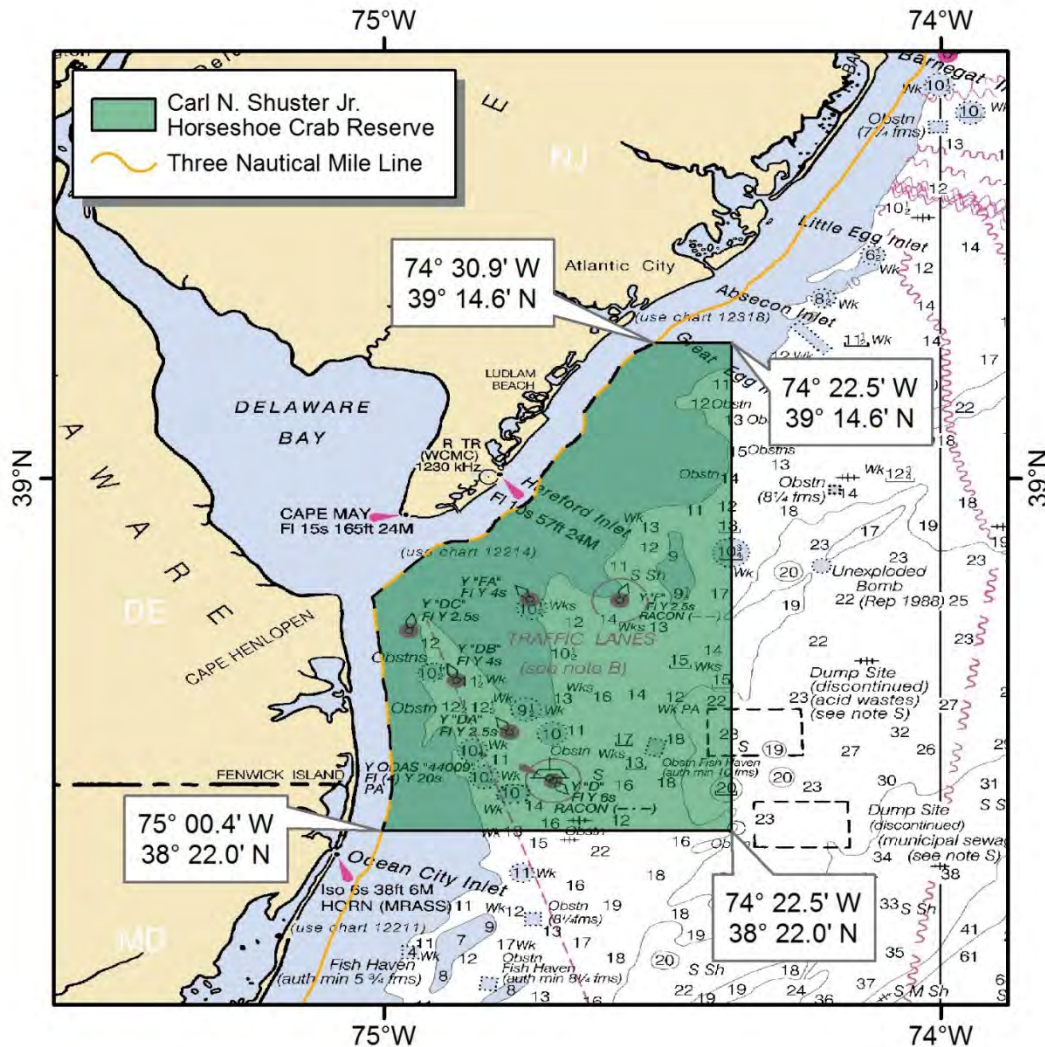


Figure 1. Carl N. Shuster Jr Horseshoe Crab Reserve.

Addendum V, adopted in 2008, extended the provisions of Addendum IV through October 31, 2010.

In early 2010, the Board initiated Draft Addendum VI to consider management options that would follow expiration of Addendum V. The Board voted in August 2010 to extend the Addendum V provisions, via Addendum VI, through April 30, 2013. The Board also chose to include language allowing them to replace Addendum VI with another Addendum during that time, in anticipation of implementing an Adaptive Resource Management (ARM) Framework.

The Board approved Addendum VII in February 2012. This addendum implemented an ARM framework for use during the 2013 fishing season and beyond. The framework considers the abundance levels of horseshoe crabs and shorebirds in determining the optimized bait harvest level for the Delaware Bay states of New Jersey, Delaware, Maryland, and Virginia (east of the COLREGS).

The ARM Framework underwent a revision process in 2021 to incorporate more available data and update the software platform. Several improvements were made to the ARM Framework during this revision. The ARM Revision improves the population models for horseshoe crabs and red knots by incorporating Delaware Bay region-specific data collected over the past few decades. Horseshoe crab population estimates from the Catch Multiple Survey Analysis (CMSA) model used in the 2019 Benchmark Stock Assessment were incorporated into the ARM Revision. Additionally, the ARM Revision includes more sources of horseshoe crab removals than the previous version, adding mortality in the biomedical industry and commercial discards from other fisheries. The maximum number of male and female horseshoe crabs the ARM Revision can recommend remains the same at 210,000 females and 500,000 males. However, harvest recommendations under the ARM Revision are now based on a continuous scale rather than the fixed harvest packages in the previous Framework. Also, the harvest of females is decoupled from the harvest of males so that each are determined separately. While additional data and model improvements are used in the ARM Revision, the conceptual model of horseshoe crab abundance influencing red knot survival and reproduction remains intact with the intent of ensuring the abundance of horseshoe crabs does not become a limiting factor in the population growth of red knots. The Board accepted the ARM Revision and Peer Review for management use in January 2022.

Addendum VIII was approved in November 2022. Addendum VIII adopts the changes to the ARM Framework as recommended in the peer-reviewed 2021 ARM Framework for use in setting annual specifications for horseshoe crabs of Delaware Bay-origin.

Addendum IX was approved in May 2025 and allows the Board to set multi-year specifications for up to three years until 2031 based on the ARM Framework. In interim years when the ARM is not used, the Board will manage maximum male harvest limits based on Delaware Bay region spawning survey data. Addendum IX also reestablishes a harvest closure for the Delaware Bay region states from January 1 through June 7, and clarifies the policy included in Addenda VII and VIII for applying Maryland and Virginia harvest caps.

II. Status of the Stock and Assessment Advice

A benchmark stock assessment was completed and approved for management use in 2019¹. This assessment was the first to successfully apply a stock assessment model to a component of the horseshoe crab stock. A Catch Multiple Survey Analysis (CMSA) model, a stage-based model that tracks progression of crab abundances from pre-recruits to full recruits to the fishery, was applied to female crabs in the Delaware (DE) Bay region (New Jersey-Virginia). This model

¹ The 2019 benchmark stock assessment report is available at:
http://www.asafc.org/uploads/file/5cd5d6f1HSCAssessment_PeerReviewReport_May2019.pdf

estimated regional female crab abundance using relative abundance information from the Virginia Tech Benthic Trawl Survey, New Jersey Ocean Trawl Survey, and Delaware Adult Trawl Survey, and estimates of mortality including natural mortality, commercial bait harvest, commercial discard mortality, and mortality associated with biomedical use. While reference points were not approved to determine stock status, the CMSA population estimates were recommended as the best estimates for female horseshoe crab abundance in the DE Bay region.

Autoregressive Integrated Moving Average (ARIMA) models, similar to those used in previous assessments, were applied to all regions. ARIMA models were fit to fishery-independent survey indices trends of abundance in each of the regional horseshoe crab populations: Northeast (Massachusetts-Rhode Island), New York (Connecticut-New York), DE Bay, and Southeast (North Carolina-Florida). No definitions for overfishing or overfished status have been adopted by the Management Board. However, the assessment characterized the status of each regional and the coastwide population based on the percentage of surveys within a region (or coastwide) having a >50% probability of the terminal year being below the ARIMA reference point. The ARIMA reference point was the 1998 index for each survey. “Poor” status was defined as >66% of surveys meeting this criterion, “Good” status was defined as <33% of surveys, and “Neutral” status was defined as 34–65% of surveys.

An assessment update was completed in May 2024². The updated CMSA model estimates were approximately 40 million mature male and 16 million mature female horseshoe crabs in the Delaware Bay region in 2022. The CMSA model results indicate that mature female horseshoe crabs have been steadily increasing in the region since the implementation of the initial ARM Framework in 2012. The ARIMA models used to determine stock status for the four regions and the coastwide horseshoe crab populations were also updated. The current stock status indicates that the Northeast region is in a neutral state, and the New York region continues to be in a poor state, with three out of four surveys being below 1998 reference points. Based on the ARIMA results, the Delaware Bay, Southeast, and coastwide populations are in good condition, an improvement since the 2019 benchmark.

III. Status of the Fishery

Bait Fishery

Historically, horseshoe crab bait fisheries have operated coastwide from Massachusetts to Florida, with most of the landings coming from the Mid-Atlantic states. The timing of harvest has varied from state to state, depending on seasonal horseshoe crab spawning migrations (to beaches in the spring, and to deeper waters in the winter). Many states regulate horseshoe crab fisheries with various season/area closures, including spring and lunar closures to protect

²The 2024 stock assessment update can be found here: <https://asmfc.org/resources/stock-assessment/horseshoe-crab-stock-assessment-update-2024/>

spawning horseshoe crabs. Some states, including New Jersey and South Carolina, have completely closed their commercial bait fisheries. New Jersey has prohibited commercial harvest of horseshoe crabs for bait in state waters since 2006. Connecticut prohibited the hand-harvest of horseshoe crabs in 2023, closing the commercial hand-harvest bait fishery in state waters. This greatly reduced harvest overall since much of the bait fishery was from hand-harvest; no harvest from trawls has been reported in the last two years.

Coastwide reported bait landings in 2025 totaled 488,887 crabs excluding confidential landings. This is 30% of the ASMFC coastwide quota of 1,609,030 crabs (Table 1, Figure 2) and represents an 11% decrease from 2024 landings of 550,909 crabs. Landings increased in Delaware and North Carolina but decreased in all other states with commercial harvest. Connecticut harvest decreased to zero in 2024 and 2025 following the ban on hand-harvest of horseshoe crabs in state waters implemented in October 2023.

Table 1. Annual commercial horseshoe crab bait landings by jurisdiction. "C" indicates confidential landings.

Jurisdiction	MA	RI	CT	NY	NJ*	DE*	MD*	PRFC	VA**	NC	SC	GA	FL	TOTAL
ASMFC Quota 2024	330,377	26,053	48,689	366,272	173,014	173,014	255,980	0	172,828	24,036	0	29,312	9,455	1,609,030
State Quota 2025	140,000	14,655	48,689	150,000	0	169,170	255,980	-	172,828	24,036	0	29,312	9,455	1,014,125
Landings by Year														
2014	130,316	13,841	20,634	134,370	0	168,044	148,269	0	145,266	24,557	0	0	2,046	787,342
2010	56,514	18,729	30,036	125,368	0	62,519	161,545	0	146,857	9,938	0	0	993	612,499
2011	89,382	12,502	20,538	147,035	0	107,583	167,053	0	121,650	27,127	0	0	0	692,870
2012	124,648	20,570	18,958	184,721	0	102,322	169,087	0	151,887	22,885	0	1,789	0	796,867
2013	148,717	18,058	21,503	169,739	0	163,582	240,688	0	156,761	26,569	0	5,745	0	951,362
2014	130,316	13,841	20,634	134,370	0	168,044	148,269	0	145,266	24,557	0	0	2,046	787,342
2015	117,611	7,867	19,632	145,324	0	151,262	27,494	0	102,235	24,839	0	0	264	596,528
2016	110,399	20,676	21,945	176,632	0	109,836	157,013	0	128,848	25,197	0	0	689	751,235
2017	134,707	3,415	19,944	195,717	0	201,132	237,146	0	160,643	25,161	0	0	1,394	979,259
2018	159,002	1,889	21,870	138,223	0	126,065	66,647	0	144,047	10,998	0	0	C	668,741
2019	172,664	C	17,588	167,181	0	170,713	118,471	0	146,687	13,463	0	0	0	806,767
2020	163,695	C	15,942	63,367	0	124,803	61,165	0	24,031	3,672	0	0	0	456,675
2021	156,013	1,706	17,492	97,860	0	172,927	181,044	0	112,497	2,145	0	0	C	741,684
2022	135,731	C	1,343	111,481	0	147,558	84,627	0	89,748	500	0	0	C	570,988
2023	139,746	2,314	3,297	130,658	0	168,208	186,466	0	107,166	934	0	0	C	738,789
2024	139,970	C	0	141,451	0	85,530	74,353	0	109,136	468	0	0	C	550,908
2025	137,261	C	0	76,077	0	122,526	56,517	0	96,506	C	0	C	C	488,887

*Male-only harvest

**Virginia harvest east of the COLREGS line is limited to 81,331 male-only crabs. Virginia harvest east of the COLREGS in 2025 was confidential.

Reported coastwide landings since 1998 consistently show more male than female horseshoe crabs harvested annually. Several states presently have sex-specific restrictions in place which limit or ban the harvest of females. The American eel pot fishery prefers female horseshoe crabs as bait, while the whelk (conch) pot fishery is less dependent on females. States with greater than 5% of coastal landings are required to report sex for at least a portion of their bait harvest; for 2025 these states include Massachusetts, New York, Delaware, Maryland, and Virginia. Excluding Massachusetts data³, these states reported that 81% of bait landings were male, 15% were female, and 4% were unclassified in 2025.

The majority of reported commercial horseshoe crab bait landings in 2025 were taken using trawl, hand, and dredge gear types. Other gears that account for the remainder of the harvest include rakes, hoes, and tongs, fixed nets, and gill nets.

Biomedical Use

The horseshoe crab is an important resource for research and manufacture of materials used for human health. Several companies along the Atlantic Coast process horseshoe crab blood for use in manufacturing Limulus Amebocyte Lysate (LAL), and biomedical collections occurred in five states (MA, RI, NJ, MD, VA, SC). Addendum III requires states where horseshoe crabs are collected for biomedical purposes to collect and report total collection numbers, crabs rejected, crabs bled (by sex) and to characterize mortality.

The Plan Review Team (PRT) annually calculates total coastwide collections and estimates mortality associated with biomedical use. In 2025, 1,031,504 horseshoe crabs were collected coastwide solely for biomedical purposes⁴ (Table 2). This represents a 3.8% decrease from 2024. Of the total biomedical collections in 2025, males accounted for 59%, and females comprised 41%. Some crabs were rejected prior to bleeding due to mortality, injuries, slow movement, and size (mortality observed while crabs were going through the biomedical process is included under 'Observed Mortality' in Table 2). Approximately 3.4% of crabs collected solely for biomedical purposes were observed and reported as dead from the time of collection up to the point of release.

³ Massachusetts harvester data were not provided. The report will be updated with data provided at a later date.

⁴ This does not include bait crabs borrowed for bleeding and then returned to the bait market; these are counted against state bait quotas. The dual use of horseshoe crabs harvested for bait is encouraged as a conservation tool. Facilities that bleed horseshoe crabs to manufacture LAL can utilize crabs from the bait market in what is often referred to as the "rent a crab" program. Permitted bait harvesters and/or dealers can "rent" crabs caught for the bait industry to the bleeding facility; these crabs are returned to the bait vendor after bleeding. These crabs are caught under bait permits, are counted against the bait quota of the state of origin, and must comply with that state's regulations for bait harvest. The dual use of crabs in this program can reduce overall harvest, may decrease overall mortality, can provide the LAL manufacturers with an additional source of raw material, and may offer harvesters and dealers opportunity within this secondary market.

During the 2019 benchmark stock assessment, a meta-analysis of literature estimates was performed to estimate post-bleeding mortality of horseshoe crabs. Although many of these studies did not implement biomedical best practices, these values are the only available estimates of mortality experienced after bleeding. Based on the literature review, post-bleeding mortality is estimated at 15%. Tagging data were used in the assessment to compare survivorship between crabs that were and were not bled. These results indicated some decrease in short-term survivorship, but greater long-term survivorship for bled crabs. These results are likely attributable to the culling process used by biomedical facilities to select healthy crabs for bleeding.

Post-bleeding mortality, calculated as 15% of the number of bled biomedical-only crabs (not from the bait market), for 2025 was estimated to be 141,971 horseshoe crabs. Total biomedical mortality (observed mortality plus post-bleeding mortality) for 2025 was estimated at 177,777 horseshoe crabs. The total estimated mortality from biomedical collections represents approximately 26.6% of the 2025 total directed use mortality (666,664 crabs), which includes both total biomedical mortality and removals for bait. While the biomedical proportion of the total directed use mortality increased slightly, the overall directed-use mortality decreased by 9% from 2024 to 2025 (Figure 3).

Table 2. Numbers of horseshoe crabs collected, bled, and estimated mortality for the biomedical industry. Numbers shown are for crabs collected solely for biomedical use. Mortality of bled crabs that later enter the bait industry is included in bait harvest.

Year	Crabs Collected	Crabs Bled	Post-Bleeding Mortality	Observed Mortality	Total Mortality
2010	480,914	412,781	61,917	6,829	68,746
2011	545,164	486,850	73,028	24,139	97,166
2012	541,956	497,956	74,693	7,370	82,063
2013	464,657	440,402	66,060	5,447	71,507
2014	467,897	432,340	64,851	5,658	70,509
2015	494,123	464,506	69,676	5,362	75,038
2016	344,495	318,523	47,778	1,004	48,782
2017	483,245	444,115	66,617	6,056	72,674
2018	510,407	479,142	71,871	5,588	77,459
2019	637,029	589,361	88,404	12,789	101,193
2020	697,025	649,546	97,432	8,907	106,339
2021	718,809	667,951	100,193	11,911	112,104
2022	911,826	828,181	124,227	21,693	145,920
2023	1,113,644	1,038,673	155,801	22,431	178,232
2024	1,073,329	1,008,943	151,341	33,352	184,693
2025	1,031,504	946,473	141,971	35,806	177,777

**Some biomedical collections were reduced in 2016 due to temporary changes in production.*

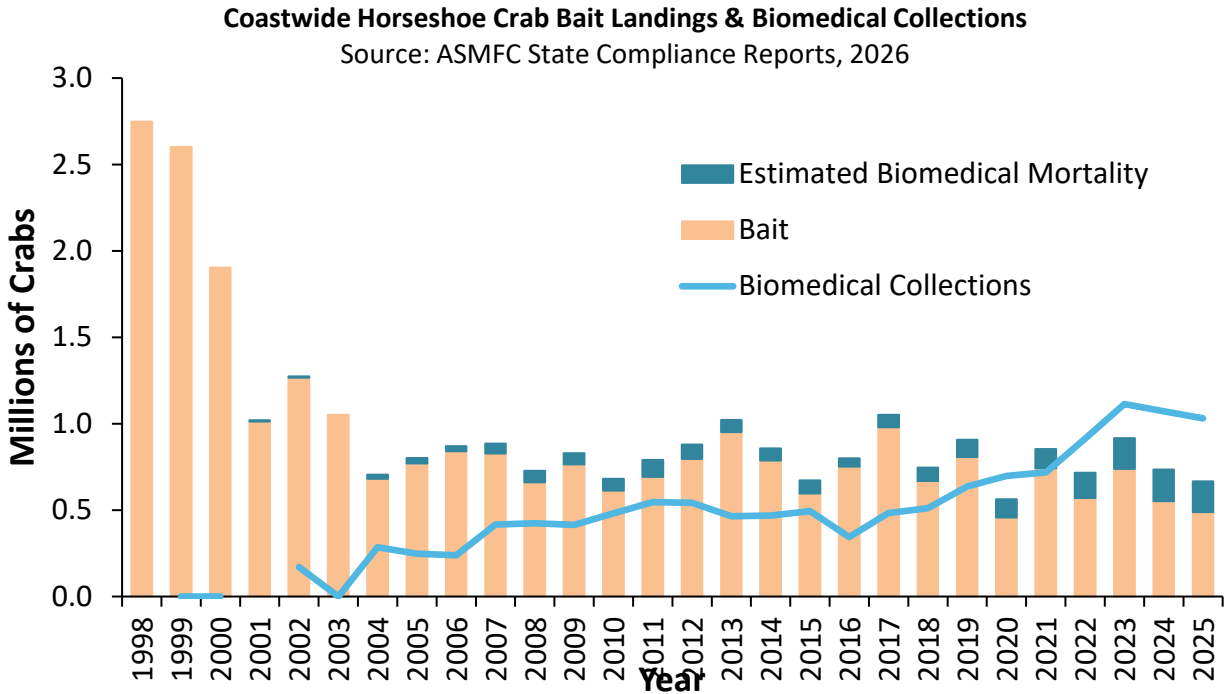


Figure 2. Annual horseshoe crab bait harvest, biomedical collections, and biomedical mortality.

*Biomedical collections are annually reported to the Commission and include all horseshoe crabs brought to bleeding facilities except those that were harvested as bait, “rented” by biomedical facilities and counted against state bait quotas.

*Crabs collected solely for biomedical crabs are returned to the water after bleeding; a 15% mortality rate is assumed for all bled crabs that are released. This number plus observed mortality reported annually by bleeding facilities via state compliance reports equals the 'Estimated Biomedical Mortality.'

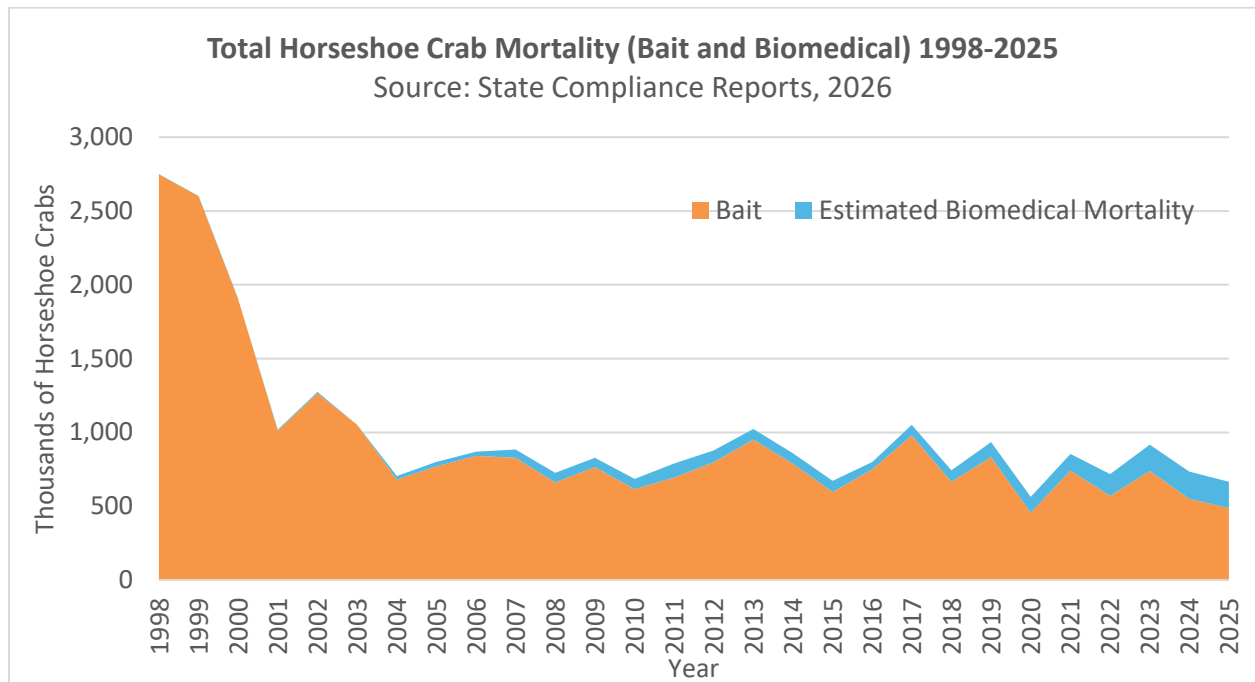


Figure 3. Total Annual Horseshoe Crab Mortality from Bait and Estimated Biomedical Mortality.

In 2023, a work group appointed by the Board reviewed and updated the *Best Management Practices for Handling Horseshoe Crabs for Biomedical Purposes*⁵. The work group included technical committee and advisory panel members with expertise in horseshoe crab biology, ecology, and biomedical processing. The purpose of the BMPs is to recommend broadly applicable industry standards that are expected to minimize mortality and injury of horseshoe crabs associated with the biomedical process.

IV. Status of Research and Monitoring

The Horseshoe Crab FMP set forth an ambitious research and monitoring strategy in 1999 and again in 2004 to inform future management decisions. Despite limited time and funding there are many accomplishments since 1999. These accomplishments were largely made possible by forming partnerships between state, federal and private organizations, and the support of hundreds of public volunteers.

Addendum III Monitoring Program

Addendum III requires affected states to carry out three monitoring components:

1. All states who do not qualify for *de minimis* status report monthly harvest numbers and subsample a portion of the catch for sex and harvest method. In addition, those states with annual landings above 5% of the coastwide harvest report all landings by sex and harvest method. Although states with annual landings less than 5% of annual coastwide harvest are not required to report landings by sex, the PRT recommends all states require sex-specific reporting for horseshoe crab harvest.
2. States with biomedical collections are required to monitor and report collection numbers and mortality associated with the transportation and bleeding of the crabs.
3. States must identify spawning and nursery habitat along their coasts. All states have completed this requirement, and a few continue active monitoring programs.

Virginia Tech Research Projects

The Virginia Tech Horseshoe Crab Trawl Survey (VT Survey) has been sampling horseshoe crab to estimate relative abundance since 2002, except for the years 2013-2015, due to a lack of funding. The survey was conducted in 2025 and is in progress for 2026. Funding sources beyond 2026 continue to be explored. The lower Delaware Bay area of the survey was not sampled in 2022-2024 as increased operational costs resulted in limitations to time on the water, but sampling resumed in 2025.

For the Delaware Bay Area (DBA), the 2025 survey results indicate that mean stratified catch-per-tow values for immature females and males increased significantly in 2025 from 2024 but

⁵ Best Management Practices for Handling Horseshoe Crabs for Biomedical Purposes can be found here: <https://asmfc.org/resources/management-special-report/best-management-practices-for-handling-horseshoe-crabs-for-biomedical-purposes/>

remained consistent with patterns observed since 2016. Catch-per-tow of newly mature females continued to show a substantial rebound from pre-2024 levels following a revision in the sampling protocol to probe for eggs in ambiguous females, as recommended by the ARM Subcommittee and DBETC in early August 2024. Newly mature males showed a decrease in catch-per-tow. Catch-per-tow of mature females and males declined from their 2024 values, becoming more similar to abundance levels seen in earlier years. There continues to be a significant correlation between stratified mean catches of mature males and mature females, and immature males and females, but not for newly mature individuals.

2025 is the first year the Lower Delaware Bay was sampled since 2021, and the data suggests an increase in catch-per-tow across all demographic groups between these two years. Mean stratified catch-per-tow values for immature females and immature males more than doubled from 2021. Mature females more than doubled in mean catch-per-tow between 2021 and 2025, while mature males saw a substantial increase. Catch-per-tow of newly mature males and females also increased compared to 2021.

The indices from this survey, along with the New Jersey Ocean Trawl and Delaware Fish and Wildlife Adult Trawl Survey indices, are used to estimate horseshoe crab abundance in the ARM Framework to produce optimal harvest limits for the upcoming year.

Spawning Surveys

The Delaware Bay spawning survey was completed for the 26th consecutive year in 2025. Twelve beaches in Delaware and ten beaches in New Jersey were sampled. Peak spawning occurred during the first lunar period (May 10-14) in Delaware and during the third lunar period (June 9-13) in New Jersey. Bay-wide male and female spawning activity has exhibited an increasing trend across the 26 year time-series, and the increasing trend is statistically significant since 2010 for males.

Tagging Studies

The USFWS continues to maintain a toll-free telephone number and a website for reporting horseshoe crab tag returns and assists interested parties in obtaining tags. Tagging work continues to be conducted by biomedical companies, research organizations, and other parties involved in outreach and spawning surveys. Beginning with the 2013 tagging season, additional efforts were implemented to ensure that current tagging programs are providing data that benefits the management of the coastwide horseshoe crab population. All existing and new tagging efforts are required to submit an annual application to be considered for the USFWS tagging program and all participants must submit an annual report along with their tagging and resighting data to indicate how their tagging program addresses at least one of the following objectives: determine horseshoe crab sub-population structure, estimate horseshoe crab movement and migration rates, and/or estimate survival and mortality of horseshoe crabs. The PRT recommends all tagging programs approved by the states coordinate with the USFWS tagging program, in order to ensure a consistent coastwide program to support management.

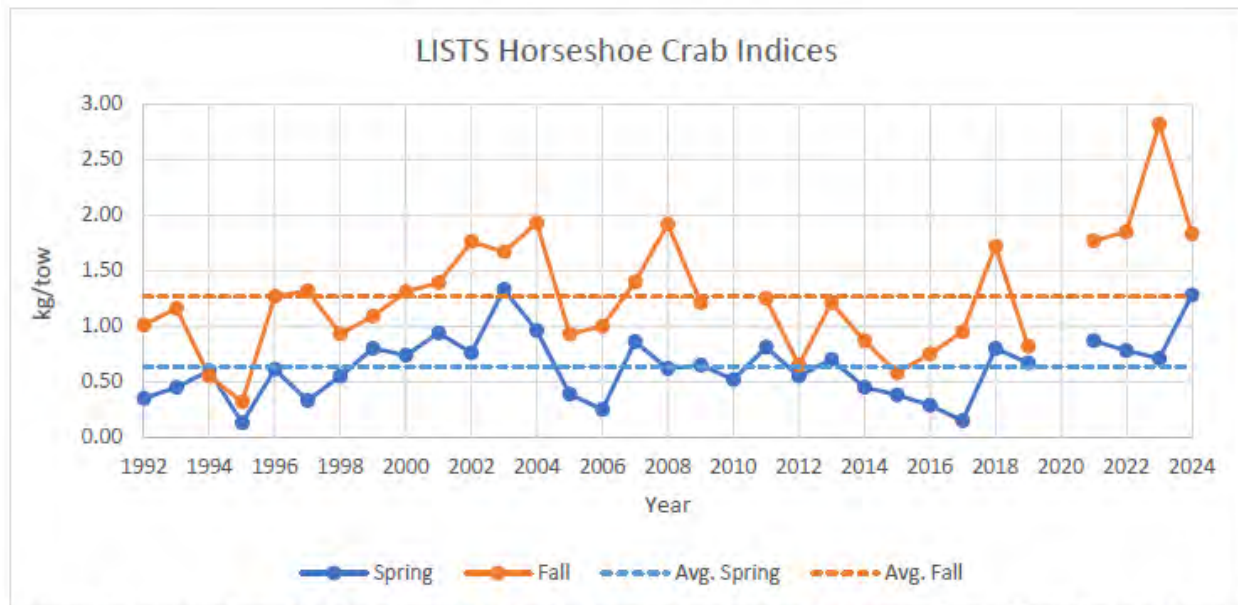
From 1999 through 2025, 472,560 horseshoe crabs have been tagged and released through the USFWS tagging program along the Atlantic coast, and 76,838 unique crabs have been recaptured. Horseshoe crabs have been tagged and released from every state on the Atlantic Coast from Florida to New Hampshire. In the early years of the program, tagging was centered around Delaware Bay; however, tagging has expanded and increased in Long Island Sound and the Southeast. Tagging information from this database is used in the Stock Assessment to define stock structure, estimate total mortality, and characterize impacts of biomedical use on horseshoe crab mortality.

New York Region Monitoring

Following the 2019 Benchmark Stock Assessment, which characterized the status of the horseshoe crab population in the New York region as “Poor”, the Board directed the PRT to monitor fishery-independent surveys in this area to track progress of state management actions toward improving this regional population. During the assessment, five surveys were included in the ARIMA model to characterize this population. One of these, the Northeast Area Monitoring and Assessment Program (NEAMAP), includes sample areas outside of the New York region, making it too data-intensive to specify the regional index on an annual basis. The most recent information from the state-conducted surveys used in the assessment is summarized below, but can be viewed in greater detail in the Connecticut and New York state compliance reports. The Western Long Island (WLI), Little Neck Bay and Manhasset Bay seine surveys were combined in the assessment to form a single index, but are shown below separately. None of these beach seine surveys were completed in 2020 due to the COVID-19 pandemic but resumed in 2021. Figures 5-8 show the annual index for each survey over the time series until 2025.

Connecticut

- Long Island Sound Trawl (LISTS) (Fall) – 2024 index – The 2022 and 2023 surveys were limited in April and June due to staff limitations and in June because of mechanical issues with the research vessel. In 2025, LISTS did not operate due to boat operation issues that persisted throughout the year. Both the spring and fall 2024 indices were above the timeseries average of 0.63 kg/tow and 1.28 kg/tow, respectively. Following several years of decline, the spring index showed a small increase in 2024 (1.28 kg/tow). In contrast, the fall index declined from its time-series peak of 2.82 kg/tow to 1.83 kg/tow; although it remained above the fall time-series average.



No sampling was conducted in 2020 due to COVID-19. For more detail on the LISTS procedures and sampling visit [Long Island Sound Trawl Survey \(ct.gov\)](https://www.ct.gov/deep/odwr/long-island-sound-trawl-survey) for the most recent report.

Figure 4. LISTS Horseshoe Crab Indices, 1992-2024. LISTS did not operate in 2025 due to boat operation issues.

New York

- Peconic Trawl – 2025 index = 0.31 (delta distribution average catch per unit effort [CPUE]), increase from 2024.
- WLI Jamaica Bay Seine (all horseshoe crabs) – 2025 index = 0.64 (geometric mean), increase from 2024.
- WLI Little Neck Bay Seine (all) – 2025 index = 0.66 (geometric mean), decrease from 2024.
- WLI Manhasset Bay Seine (all) – 2025 index = 1.93 (geometric mean), increase from 2024.

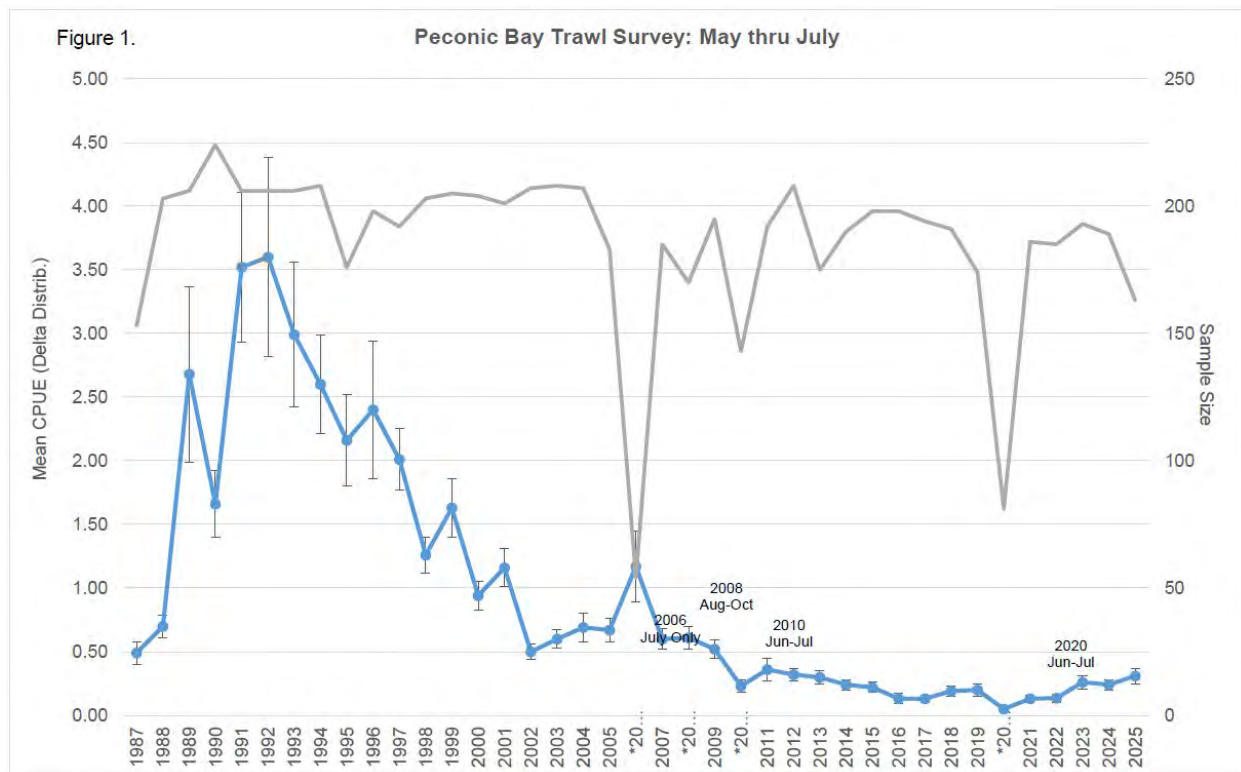


Figure 5. Peconic Bay Trawl Survey: May through July, 1987-2025. (Gray line=sample size, blue line=mean CPUE).

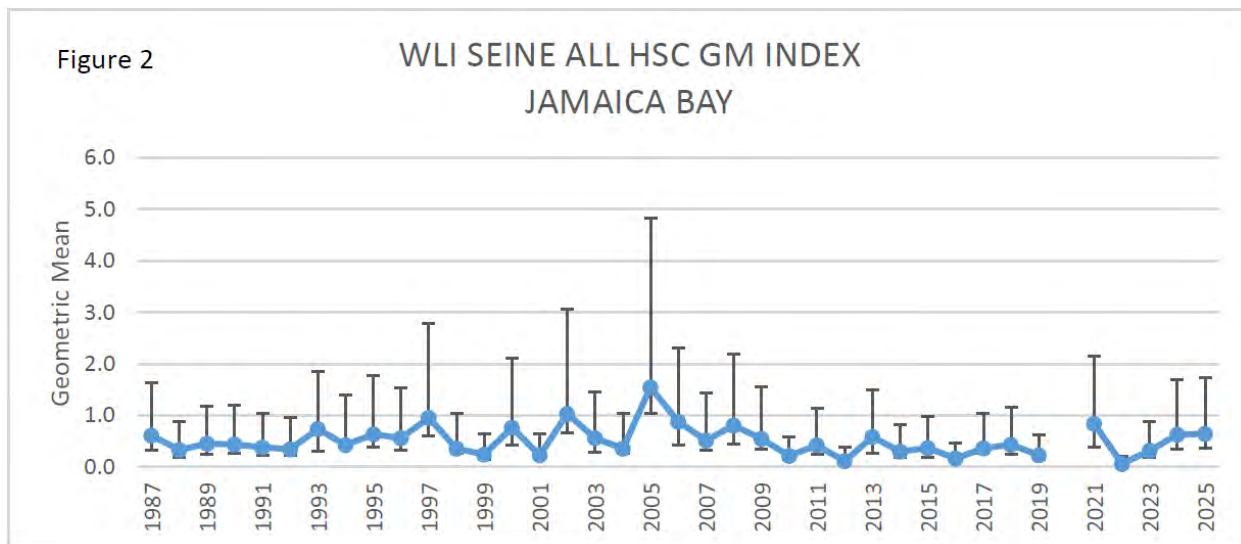


Figure 6. NYSDEC WLI Jamaica Bay Beach Seine Survey All Horseshoe Crab GM Index, 1987-2025. *Due to the COVID-19 pandemic, in 2020 sampling did not begin until July.

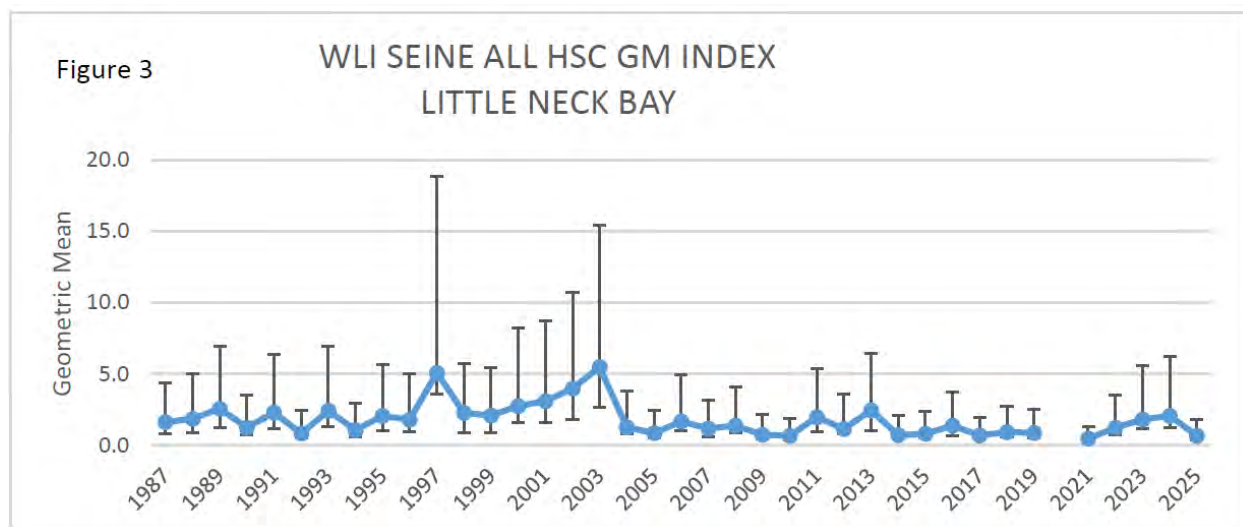


Figure 7. Little Neck Bay Seine Survey All Horseshoe Crab GM Index, 1987-2025. *Due to the COVID-19 pandemic, in 2020 sampling did not begin until July.

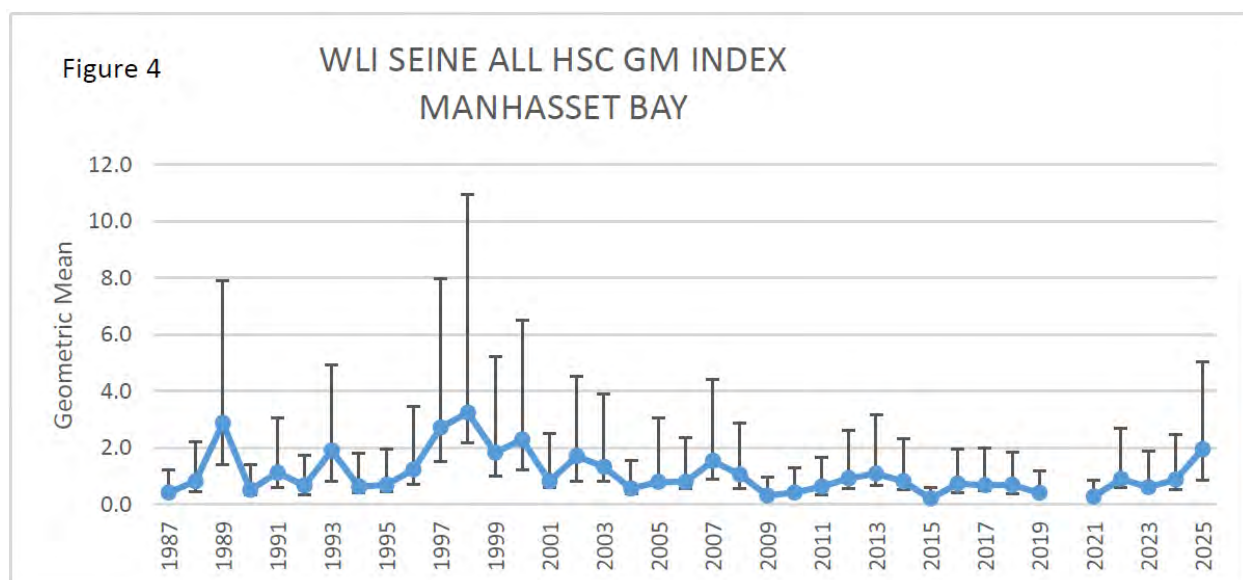


Figure 8. Manhasset Bay Seine Survey All Horseshoe Crab GM Index, 1987-2024. *Due to the COVID-19 pandemic, in 2020 sampling did not begin until July.

V. Status of Management Measures and Issues

ASMFC

Initial state harvest quotas were established through Addendum I. Addendum III outlined the monitoring requirements and recommendations for the states. Addendum IV set harvest closures and quotas, and other restrictions for New Jersey, Delaware, Maryland, and Virginia, which were continued in Addenda V and VI.

In February 2012 the Board approved Addendum VII to implement the ARM Framework; it was implemented in 2013. The ARM Framework was updated in 2021, and the Board adopted use of the revised ARM Framework through Addendum VIII in 2022. Addendum VIII maintains the Addendum VII allocation mechanism to divide the Delaware Bay optimized harvest output from the ARM Framework among the four Delaware Bay states (New Jersey, Delaware, Maryland, and Virginia east of the COLREGS line).

State-specific charts outlining compliance and monitoring measures are included in Section VII. Massachusetts did not report all required data to ASMFC by the required deadline. The PRT finds that all other jurisdictions are in compliance with the FMP and subsequent Addenda in 2025.

Changes to State Regulations

- In New York, a bill was signed by the State Governor on February 13, 2026, to enact changes providing for a phase-out of the take of horseshoe crabs, allowing time for industry to transition. This phase-out will begin in 2026, with the quota reduced to 75% of the current voluntary quota level in 2026, 50% in 2027, and 25% in 2028, followed by a full moratorium which goes into effect on January 1, 2029.

Alternative Baits

Trials testing effectiveness of alternative baits to horseshoe crab for the American eel and whelk fisheries have previously been conducted. Additionally, a survey of bait usage in the eel and whelk fisheries was conducted in 2017. This survey is available at:

<https://asmfc.org/resources/management-technical-committee/horseshoe-crab-technical-committee-report-on-bait-use-surveys-of-the-american-eel-and-channeled-whelk-fisheries-october-2017/>.

Shorebirds

The USFWS received petitions in 2004 and 2005 to emergency list the red knot under the Endangered Species Act. In fall 2005, it was determined that emergency listing was not warranted at the time. As part of a court settlement, the USFWS agreed to initiate proposed listings of over 200 species, including the red knot. In fall 2013, the USFWS released a proposal for listing the red knot as threatened. In January 2015 the USFWS designated the red knot as threatened under the Endangered Species Act.

In 2022 the USFWS conducted an analysis of the changes to horseshoe crab management that would occur under the 2021 ARM Revision to determine the likelihood of impacts to the red knot. The finding from analysis is that there is a < 1% chance of a red knot population decline due to the implementation of potential female harvest under the revised ARM. Therefore, the Service concluded that take, defined under the Endangered Species Act as killing or injuring, of red knots is not likely.

The red knot has been listed as an endangered species in the State of New Jersey since 2012.

VI. PRT Recommendations and Research Needs

State Reporting of Biomedical Data

States with biomedical collections are required to report data on the number of crabs collected, transported to facilities, bled, and observed mortalities. Some companies have operations and/or collect horseshoe crabs from multiple states. To improve the clarity of biomedical data, the PRT recommends that state compliance reports identify the biomedical companies collecting crabs in their state waters, as well as those operating LAL manufacturing facilities in their state, and report biomedical numbers by company.

De Minimis

States may apply for *de minimis* status if, for the last two years, their combined average horseshoe crab bait landings (by numbers) constitute less than one percent of coastwide horseshoe crab bait landings for the same two-year period. States may petition the Board at any time for *de minimis* status, if their fishery falls below the threshold level. Once *de minimis* status is granted, designated States must submit annual reports to the Board justifying the continuance of *de minimis* status.

States that qualify for *de minimis* status are not required to implement any horseshoe crab harvest restriction measures, but are required to implement components A, B, E, and F of the monitoring program (Section 3.5 of the FMP; further modified by Addendum III). Since *de minimis* states are exempt from a harvest cap, there is potential for horseshoe crab landings to shift to *de minimis* states and become substantial, before adequate action can be taken. To control shifts in horseshoe crab landings, *de minimis* states are encouraged to implement one of the following management measures:

1. Close their respective horseshoe crab bait fishery when landings exceed the *de minimis* threshold;
2. Establish a state horseshoe crab landing permit, making it only available to individuals with a history of landing horseshoe crabs in that state; or
3. Establish a maximum daily harvest limit of up to 25 horseshoe crabs per person per day. States which implement this measure can be relieved of mandatory monthly reporting, but must report all horseshoe crab harvests on an annual basis.

The following states have been removed from the Management Board since its formation: Pennsylvania (2007), Maine (2011), and New Hampshire (2014). South Carolina, Georgia, and Florida are requesting continued *de minimis* status for the 2025 fishing season based on the 2023-2024 season landings, and meet the FMP requirements for being granted this status (Table 1). The PRT recommends granting these jurisdictions *de minimis* status.

Biomedical Threshold

The 1998 FMP established a biomedical mortality threshold of 57,500 crabs that, if exceeded, requires the Board to consider management action. This threshold has been exceeded in all but

one year since 2008. Results of the 2019 Benchmark Stock Assessment indicate that levels of biomedical mortality prior to 2017 (the terminal year of data used in the assessment) did not have a significant effect on horseshoe crab population estimates or fishing mortality in the Delaware Bay region.

In 2020 the Board tasked the PDT to review the threshold for biomedical use to develop biologically-based options for the threshold and to develop options for action when the threshold is exceeded. It also tasked the PDT to review the best management practices (BMPs) for handling biomedical catch and suggest options for updating and implementing BMPs. The PDT concluded that given the lack of coastwide population estimates for horseshoe crabs, it is not possible to develop a biologically-based threshold for biomedical mortality. Thus, the PDT did not recommend a change to the threshold. Based on this information the Board determined no action is warranted. A Board-appointed work group was formed in 2023, which reviewed and updated the best management practices for biomedical handling to further reduce stress, injury, and mortality to horseshoe crabs collected for biomedical purposes.

Funding for Research and Monitoring Activities

The PRT strongly recommends the funding and continuation of the VT benthic trawl survey. Sampling in recent years has had to be reduced due to increased costs. This effort provides a statistically reliable estimate of horseshoe crab relative abundance that is essential to continued ARM implementation and use of the CMSA stock assessment model.

Discard Mortality Estimation

Results of the 2019 Benchmark Stock Assessment indicate that discard mortality may be significant, of similar or greater magnitude than bait harvest. The Review Panel's report indicated that these estimates could be further refined to reduce their uncertainty and more precisely characterize this mortality source. The PRT recommends the Board take steps to increase access to and use of data from the Northeast Fisheries Observer Program (NEFOP), allowing for improved monitoring and estimation of discard mortality.

Improvement of the New York Regional Population

Results of the 2019 Benchmark Stock Assessment and 2024 update indicate a "Poor" status for the New York regional population, due to negative trends in regional abundance indices. New York and Connecticut have indicated that they will take actions within their states to improve this population. The PRT and Board have recommended such actions so that this population's status may improve.

Effective October 1, 2023, Connecticut prohibited all hand-harvest of horseshoe crabs and their eggs within the state. New York implemented two additional lunar closures for May and June, resulting in a total of four 5-day lunar closures around the full and new moons in 2025. On February 10, 2025, a bill was introduced in New York State legislation, which stated that "no person shall take horseshoe crabs, including for commercial and biomedical purposes." This bill was signed with amendments by Governor Hochul on February 13, 2026. The Governor reached

an agreement with the Legislature to enact changes providing for a phase-out of the take of horseshoe crabs, allowing time for industry to transition. This phase-out will begin in 2026, with the quota reduced to 75% of the current voluntary quota level in 2026, 50% in 2027, and 25% in 2028, followed by a full moratorium which goes into effect on January 1, 2029.

The PRT will continue to annually report regional indices of abundance so that progress of management actions may be tracked through the annual FMP Reviews.

VII. State Compliance and Monitoring Measures

MASSACHUSETTS		
	2025 Compliance	2026 Management Proposal
<i>De minimis</i> status	Did not request <i>de minimis</i>	Did not request <i>de minimis</i>
Bait Harvest Restrictions and Landings		
ASMFC Quota (Voluntary State Quota)	330,377 (140,000)	330,377 (140,000)
Landings	139,746	--
Other Restrictions	Bait: 300 crab daily limit year round; limited entry; Biomedical: 1,000 crab daily limit and 200,000 annual quota; Conch pot and eel fishermen: no possession limit Mobile gear: 75 crab trip limit, exempted from "no-fishing days"; All: April 15-June 7 spawning closure; 7" PW minimum size; Pleasant Bay Closed Area	Bait: 300 crab daily limit year round; limited entry; Biomedical: 1,000 crab daily limit and 200,000 annual quota; Conch pot and eel fishermen: no possession limit Mobile gear: 75 crab trip limit, exempted from "no-fishing days"; All: April 15-June 7 spawning closure; 7" PW minimum size; Pleasant Bay Closed Area
Landings	137,261	-
Monitoring Component A₁		
Mandatory monthly reporting	Yes, plus weekly dealer reporting through SAFIS	Yes, plus weekly dealer reporting through SAFIS
Characterize commercial bait fishery	Yes	Yes
Monitoring Component A₂		
Biomedical reporting	Yes	Yes
Required information for biomedical use of crabs	Yes	Yes
Monitoring Component B₂ Continue existing benthic sampling programs	Yes	Yes
Monitoring Component B₃ Implement spawning survey	Yes	Yes
Monitoring Component B₄ Tagging program	Yes – w/NPS and USFWS; Pleasant Bay, Monomy NWR, Waquoit Bay	Yes – w/NPS and USFWS; Pleasant Bay, Monomy NWR, Waquoit Bay

RHODE ISLAND		
	2025 Compliance	2026 Management Proposal
<i>De minimis</i> status	Did not request <i>de minimis</i>	Did not request <i>de minimis</i>
Bait Harvest Restrictions and Landings		
ASMFC Quota (Voluntary State Quota)	26,053 (14,655)	26,053 (14,655)
Other Restrictions	- Daily possession limit: 60 crabs per permit - Bait Fishery Closure: May 1- May 31 - Biomedical Fishery Closure: 48 hours prior to and 48 hours following new and full moons during May. - Biomedical quota and best management practices	- Daily possession limit: 60 crabs per permit - Bait Fishery Closure: May 1- May 31 - Biomedical Fishery Closure: 48 hours prior to and 48 hours following new and full moons during May - Biomedical quota and best management practices
Landings	Confidential	--
Monitoring Component A₁		
Mandatory monthly reporting	Yes, weekly call in and monthly on paper	Yes, weekly call in and monthly on paper
Characterize commercial bait fishery	Yes	Yes
Monitoring Component A₂		
Biomedical reporting	Yes	Yes
Required information for biomedical use of crabs	Yes	Yes
Monitoring Component B₂ Continue existing benthic sampling programs	Yes	Yes
Monitoring Component B₃ Implement spawning survey	Yes, since 2000	Yes
Monitoring Component B₄ Tagging program	No	No

CONNECTICUT		
	2025 Compliance	2026 Management Proposal
<i>De minimis</i> status	Did not request <i>de minimis</i>	Did not request <i>de minimis</i>
Bait Harvest Restrictions and Landings		
ASMFC Quota	48,689	48,689
Other Restrictions	- Hand-harvest of horseshoe crabs or eggs in state waters prohibited, effective Oct. 1, 2023 - Daily possession limit of 150 crabs	- Hand-harvest of horseshoe crabs or eggs in state waters prohibited - Daily possession limit of 150 crabs
Landings	0	--
Monitoring Component A₁		
Mandatory monthly reporting	Yes	Yes
Characterize commercial bait fishery	No – exempt under Addendum III because landings are < 5% of coastwide total	No – exempt under Addendum III because landings are < 5% of coastwide total
Monitoring Component A₂		
Biomedical reporting	Not Applicable	Not Applicable
Required information for biomedical use of crabs	Not Applicable	Not Applicable
Monitoring Component B₂ Continue existing benthic sampling programs	Yes	Yes
Monitoring Component B₃ Implement spawning survey	Yes, since 1999 (methods differ from DE Bay survey)	Yes
Monitoring Component B₄ Tagging program	Yes, in collaboration with local universities (Sacred Heart University since 2015)	Yes

NEW YORK		
	2025 Compliance	2026 Management Proposal
<i>De minimis</i> status	Did not request <i>de minimis</i>	Did not request <i>de minimis</i>
Bait Harvest Restrictions and Landings		
ASMFC Quota (Voluntary State Quota)	366,272 (150,000)	366,272 (150,000)
Other Restrictions	Ability to close areas to harvest; seasonal quotas and daily harvest limits. Four 5-day lunar closures around the full and new moons in May and June. Daily trip limits.	Ability to close areas to harvest; seasonal quotas and daily harvest limits. Four 5-day lunar closures around the full and new moons in May and June. Daily trip limits. Phase-out of bait and biomedical harvest with quota reduced by 75% per year.
Landings	76,077	--
Monitoring Component A ₁		
Mandatory monthly reporting	Yes	Yes
Characterize commercial bait fishery	Yes	Yes
Monitoring Component A ₂		
Biomedical reporting	Yes	Yes
Required information for biomedical use of crabs	Not Applicable	Not Applicable
Monitoring Component B₂ Continue existing benthic sampling programs	Yes	Yes
Monitoring Component B₃ Implement spawning survey	Yes	Yes
Monitoring Component B₄ Tagging program	Yes	Yes

NEW JERSEY		
	2025 Compliance	2026 Management Proposal
<i>De minimis</i> status	Did not request <i>de minimis</i>	Does not request <i>de minimis</i>
Bait Harvest Restrictions and Landings		
ASMFC Quota (Voluntary State Quota)	164,364 (male only) (0)	173,014 (male only) (0)
Other Restrictions	Bait harvest moratorium	Bait harvest moratorium
Landings	0	--
Monitoring Component A ₁		
Mandatory monthly reporting	Not Applicable	Not Applicable
Characterize commercial bait fishery	Not Applicable	Not Applicable
Monitoring Component A ₂		
Biomedical reporting	Yes	Yes
Required information for biomedical use of crabs	Yes	Yes
Monitoring Component B₂ Continue existing benthic sampling programs	Yes	Yes
Monitoring Component B₃ Implement spawning survey	Yes	Yes
Monitoring Component B₄ Tagging program	No	No
Monitoring Component B₅ Egg abundance survey	Yes, no longer mandatory	Yes
Monitoring Component B₆ Shorebird monitoring program	Yes	Yes

DELAWARE		
	2025 Compliance	2026 Management Proposal
<i>De minimis</i> status	Did not request <i>de minimis</i>	Did not request <i>de minimis</i>
Bait Harvest Restrictions and Landings		
ASMFC Quota	173,014 (male only)	173,014 (male only)
Other Restrictions	Closed season (Jan 1 – June 7) Daily collection limit	Closed season (Jan 1 – June 7) Daily collection limit
Landings	122,526 (male only)	--
Monitoring Component A₁		
Mandatory monthly reporting	Yes (daily call-in reports & monthly logbooks)	Yes
Characterize commercial bait fishery	Yes	Yes
Monitoring Component A₂		
Biomedical reporting	Not Applicable	Not Applicable
Required information for biomedical use of crabs	Not Applicable	Not Applicable
Monitoring Component B₂ Continue existing benthic sampling programs	Yes	Yes
Monitoring Component B₃ Implement spawning survey	Yes	Yes
Monitoring Component B₄ Tagging program	No state program but has assisted in the past with various Delaware Bay horseshoe crab tagging initiatives	No
Monitoring Component B₆ Shorebird monitoring program	Yes	Yes

MARYLAND		
	2025 Compliance	2026 Management Proposal
<i>De minimis</i> status	Did not request <i>de minimis</i>	Did not request <i>de minimis</i>
Bait Harvest Restrictions and Landings		
ASMFC Quota	255,980 (male only)	255,980 (male only)
Other Restrictions	Season closure until May 1, catch limits, no harvest Saturday and Sunday	Season closure until May 1, catch limits, no harvest Saturday and Sunday
Landings	56,517 (male only)	--
Monitoring Component A ₁		
Mandatory monthly reporting	Yes (weekly reports for permit holders; monthly for non-permit holders)	Yes (weekly reports for permit holders; monthly for non-permit holders)
Characterize commercial bait fishery	Yes	Yes
Monitoring Component A ₂		
Biomedical reporting	Yes	Yes
Required information for biomedical use of crabs	Yes	Yes
Monitoring Component B₂ Continue existing benthic sampling programs	Yes	Yes
Monitoring Component B₃ Implement spawning survey	Yes	Yes
Monitoring Component B₄ Tagging program	Yes	Yes

POTOMAC RIVER FISHERIES COMMISSION		
	2025 Compliance	2026 Management Proposal
<i>De minimis</i> status	Did not request <i>de minimis</i>	Did not request <i>de minimis</i>
Ability to close fishery if <i>de minimis</i> threshold is reached	No horseshoe crab fishery	No horseshoe crab fishery
Daily possession limit <25 for <i>de minimis</i> state		
HSC landing permit		
Bait Harvest Restrictions and Landings		
ASMFC Quota	0	0
Other Restrictions	None	None
Landings	0	0
Monitoring Component A ₁		
Mandatory monthly reporting	Yes - weekly	Yes - weekly
Characterize commercial bait fishery	Not Applicable	Not Applicable
Monitoring Component A ₂		
Biomedical reporting	Not Applicable	Not Applicable
Required information for biomedical use of crabs	Not Applicable	Not Applicable
Monitoring Component B₂ Continue existing benthic sampling programs	Not Applicable	Not Applicable
Monitoring Component B₃ Implement spawning survey	Not Applicable	Not Applicable
Monitoring Component B₄ Tagging program	Not Applicable	Not Applicable

VIRGINIA		
	2025 Compliance	2026 Management Proposal
<i>De minimis</i> status	Did not request <i>de minimis</i>	Did not request <i>de minimis</i>
Bait Harvest Restrictions and Landings		
ASMFC Quota (Voluntary State Quota)	172,828 (81,331 male-only east of COLREGS line)	172,828 (81,331 male-only east of COLREGS line)
Other Restrictions	Closed season (January 1 – June 7) for federal waters. Harvest of horseshoe crabs east of the COLREGS line limited to trawl gear and dredge gear.	Closed season (January 1 – June 7) for federal waters. Harvest of horseshoe crabs east of the COLREGS line limited to trawl gear and dredge gear.
Landings	96,506	--
Monitoring Component A ₁		
Mandatory monthly reporting	Yes	Yes
Characterize commercial bait fishery	Yes	Yes
Monitoring Component A ₂		
Biomedical reporting	Yes	Yes
Required information for biomedical use of crabs	Yes	Yes
Monitoring Component B₂ Continue existing benthic sampling programs	Not Applicable	Not Applicable
Monitoring Component B₃ Implement spawning survey	No	No
Monitoring Component B₄ Tagging program	No	No

NORTH CAROLINA		
	2025 Compliance	2026 Management Proposal
<i>De minimis</i> status	Did not request <i>de minimis</i>	Did not request <i>de minimis</i>
Bait Harvest Restrictions and Landings		
ASMFC Quota	24,036	24,036
Other Restrictions	Fishery closure May 1-July 19. Trip limit of 50 crabs; Proclamation authority to adjust trip limits, seasons, etc.	Trip limit of 50 crabs; Proclamation authority to adjust trip limits, seasons, etc.
Landings	Confidential	--
Monitoring Component A ₁		
Mandatory monthly reporting	Yes	Yes
Characterize commercial bait fishery	Yes	Yes
Monitoring Component A ₂		
Biomedical reporting	Not Applicable	Not Applicable
Required information for biomedical use of crabs	Not Applicable	Not Applicable
Monitoring Component B₂ Continue existing benthic sampling programs	Yes	Yes
Monitoring Component B₃ Implement spawning survey	No	No
Monitoring Component B₄ Tagging program	No	No

SOUTH CAROLINA		
	2025 Compliance	2026 Management Proposal
<i>De minimis</i> status	<i>De minimis</i> status granted for 2025.	<i>De minimis</i> requested for 2026 and meets criteria.
Ability to close fishery if <i>de minimis</i> threshold is reached	No horseshoe crab bait fishery	No horseshoe crab bait fishery
Daily possession limit <25 for <i>de minimis</i> state		
HSC landing permit		
Bait Harvest Restrictions and Landings		
ASMFC Quota	0	0
Other Restrictions	None	None
Landings	0	--
Monitoring Component A ₁		
Mandatory monthly reporting	Yes (Biomedical)	Yes (Biomedical)
Characterize commercial bait fishery	Not Applicable	Not Applicable
Monitoring Component A ₂		
Biomedical reporting	Yes	Yes
Required information for biomedical use of crabs	Yes	Yes
Monitoring Component B₂ Continue existing benthic sampling programs	Yes	Yes
Monitoring Component B₃ Implement spawning survey	Yes	Yes
Monitoring Component B₄ Tagging program	Yes	Yes

GEORGIA		
	2025 Compliance	2026 Management Proposal
<i>De minimis</i> status	<i>De minimis</i> status granted for 2025.	<i>De minimis</i> requested for 2026 and meets criteria.
Ability to close fishery if <i>de minimis</i> threshold is reached	Yes	Yes
Daily possession limit <25 for <i>de minimis</i> state	25/person; 75/vessel with 3 licensees	25/person; 75/vessel with 3 licensees
HSC landing permit	Must have commercial shrimp, crab, or whelk license; LOA permit required	Must have commercial shrimp, crab, or whelk license; LOA permit required
Bait Harvest Restrictions and Landings		
ASMFC Quota	29,312	29,312
Other Restrictions	None	None
Landings	Confidential	--
Monitoring Component A ₁		
Mandatory monthly reporting	Yes	Yes
Characterize commercial bait fishery	Not Applicable	Yes
Monitoring Component A ₂		
Biomedical reporting	Not Applicable	Not Applicable
Required information for biomedical use of crabs	Not Applicable	Not Applicable
Monitoring Component B₂ Continue existing benthic sampling programs	Yes	Yes
Monitoring Component B₃ Implement spawning survey	No	No
Monitoring Component B₄ Tagging program	No	No

FLORIDA		
	2025 Compliance	2026 Management Proposal
<i>De minimis</i> status	<i>De minimis</i> status granted for 2025.	<i>De minimis</i> requested for 2026 and meets criteria.
Ability to close fishery if <i>de minimis</i> threshold is reached	Yes	Yes
Daily possession limit <25 for <i>de minimis</i> state	25/person w/ valid saltwater products license; 100/person with marine life endorsement	25/person w/ valid saltwater products license; 100/person with marine life endorsement
HSC landing permit	See above	See above
Bait Harvest Restrictions and Landings		
ASMFC Quota	9,455	9,455
Other Restrictions	Daily possession limit	Daily possession limit
Landings	Confidential	--
Monitoring Component A₁		
Mandatory monthly reporting	Yes	Yes
Characterize commercial bait fishery	Yes	Yes
Monitoring Component A₂		
Biomedical reporting	Not Applicable	Not Applicable
Required information for biomedical use of crabs	Not Applicable	Not Applicable
Monitoring Component B₂ Continue existing benthic sampling programs	Yes	Yes
Monitoring Component B₃ Implement spawning survey	Yes	Yes
Monitoring Component B₄ Tagging program	No	No