Atlantic States Marine Fisheries Commission
Horseshoe Crab Adaptive Resource Management Framework Stakeholder Meeting
Apr 14, 2026, 12-3 pm

Meeting Details

- Meeting link: https://v.ringcentral.com/join/720349047
- Meeting ID: 720349047

Objectives & Meeting Outcomes

1. Review proposed changes (from the stakeholder workshop and Technical Committee meeting) to the Utility, Reward, and Harvest (U/R/H) functions in the Adaptive Resource Management (ARM) Framework that represent stakeholder values
2. Discuss and confirm broadly-supported recommendations for revising the U/R/H functions, document different perspectives
3. Discuss next steps and opportunities for improving the ARM Framework and process

Pre-Workshop Reading

- Stakeholder workshop summary report (*required*)
- ARM/DBETC Memo and Meeting Summary (*required*)

Draft agenda

TIME	AGENDA ITEM	SUMMARY
12:00 PM	Welcome	• Welcome, agenda review • Process update: *What's happened since the workshop and what comes next?*

12:15 PM	Utility / Harvest updates & discussion	• Review and confirm updates on U/H functions *that had support from stakeholder group and Technical Committees*
		  ○ Male-to-female HSC harvest values in the HSC utility function
		  ○ Maximum HSC harvest levels
		• Review, discuss, and confirm updates to U/H functions *that were modified by Technical Committees since the workshop*
		  ○ HSC abundance to trigger 0 harvest
		  ○ Red knot utility curve

1:20 PM	Break	
1:35 PM	Reward function	• Review and discuss different paths and perspectives for updating the Reward function, including review of Technical Committee perspectives

2:10 PM	Additional ideas for the ARM	• Revisiting when female HSC harvest is acceptable, and ideas for ways forward. Discuss and document ideas for next steps for improving the ARM in the future: *What would we like to see happen next?*
		  ○ *Process for updating science*
		  ○ *Process for ARM revision*
		  ○ *Process for communicating broadly*

2:50 PM	Wrap-up & next steps	• Wrap-up and next steps
3:00 PM	Adjourn	

Note: This agenda is subject to change during the meeting, depending on the direction of the group.

Delaware Bay Horseshoe Crab Adaptive Resource Management (ARM) Framework Stakeholder Workshop

January 29 & 30, 2026 – Ocean City, MD

DRAFT (26 Feb 20226) Workshop Summary

The Horseshoe Crab Adaptive Resource Management (ARM) Framework is a model used by the Atlantic States Marine Fisheries Commission (ASMFC) to set annual harvest levels for horseshoe crabs in the Delaware Bay region. The framework is designed to balance the needs of the horseshoe crab (sometimes abbreviated as HSC in this document) fishery with the ecological needs of migratory shorebirds, particularly the rufa red knot (sometimes abbreviated REKN), which depends on horseshoe crab eggs as a food source.

Building on previous stakeholder feedback and technical recommendations about the ARM Framework, we conducted a stakeholder engagement process to develop potential modifications to several core mathematical functions of the ARM model – specifically the Utility, Reward, and Harvest (U/R/H) functions. The U/R/H functions represent stakeholder values placed on horseshoe crabs and red knots, and associate harvest levels with population abundances of both species.

The current stakeholder engagement process has followed a phased approach where we **(1)** held two virtual **educational sessions** in December 2025 and January 2026 to build a shared understanding of the ARM models and the role of the U/R/H functions, **(2)** held a two-day in-person **stakeholder values workshop** in January 2026 to have structured dialogue among participating groups, elicit quantitative values that represent groups' interests that can be integrated into the model, and strive for consensus recommendations for model updates, and **(3)** will advance **model updates and communication** following the workshop to integrate participant values and input into the next iteration of the ARM Framework.

Fourteen stakeholder participants from six broad interest groups participated in the workshop, along with technical experts from the ARM Subcommittee and agency staff involved with the DBETC (**Table 1**). This document summarizes key discussions, emerging recommendations, and possible next steps from the stakeholder workshop. A final report summarizing the entire stakeholder engagement process will be developed after additional Delaware Bay Ecosystem Technical Committee (DBETC) and ARM subcommittee meetings.

Table 1. Stakeholders and additional technical/agency staff who attended the January ASMFC workshop.

Broad group	Name	Organization
Stakeholders		
Bait Fishers	Stuart Potter	Independent
	Jeff Eutsler	Independent
	David Trader	Independent
Dealers	Peter Hughes	Martin Fish Company
	Danielle To	Sea King
Biomedical	Allen Burgenson	Lonza
	Nora Blair	Charles River Laboratories
	Lisa Ferguson	The Wetlands Institute

Ecosystem Conservation	Danielle McCulloch	American Littoral Society
	Carly Toulan	Maryland Coastal Bays Program
Horseshoe Crab (HSC) Conservation	Glenn Gauvry	ERDG
	Susan Linder	Wildlife Restoration Partnerships
Shorebird Conservation	Joanna Burger	Rutgers University
	David Mizrahi	NJ Audubon
Additional technical participants & ASMFC staff		
DBETC members	Wendy Walsh	USFWS
	Jordan Zimmerman	DNREC
ARM Subcommittee members	John Sweka	USFWS
	Jim Lyons	USGS
	Bryan Nuse	Bird Conservancy of the Rockies
	Conor McGowan	USGS
ASMFC staff members	Caitlin Starks	ASMFC
	Toni Kerns	ASMFC
	Samara Nehemiah	ASMFC
	Madeline Musante	ASMFC

Summary of workshop discussions & possible next steps

Table 2. Summary of key workshop discussions and possible next steps, organized by discussion topic.

Topic	Discussion outcomes and possible next steps
General	○ Broad agreement that we should continue using and improving the ARM framework. ○ Some participants trust the current science in the ARM and its recommended harvest policies; other participants distrust or are uncertain about the current science and data inputs in the ARM, even expressing that they will not accept the ARM recommendations until scientific disagreements are settled.
Female horseshoe crab harvest	The group participated in a "debate" exercise where all participants (regardless of their actual perspectives) were asked to brainstorm arguments for *both* sides of a two-sided debate: "Female HSC harvest should never be allowed" and "Female HSC harvest is OK under certain conditions." Arguments for allowing female HSC harvest in Delaware Bay included: ○ If no harvest is allowed, female harvest could increase in other regions and shift economic gains to other states ○ Females are still caught and handled by fishers, which can stress females and increases the effort (e.g., number of tows) fishers need to meet their quotas because they have to throw females back ○ Harvest levels being considered in the ARM are a small proportion of the HSC population size ○ Best-available science is being used in the ARM, which recommends female harvest

Topic	Discussion outcomes and possible next steps
	○ Fishers and dealers also described how not allowing female HSC harvest impacts their businesses, including the secondary/indirect effects on their families, infrastructure, and other related businesses Arguments for *not* allowing female HSC harvest included: ○ Desire for a cautionary approach to ensure the horseshoe crab population thrives and supports the broader Delaware Bay ecosystem, recognizing other effects like habitat loss and climate change may be harder to mitigate in the future. ○ Importance of eggs from uncaught female horseshoe crabs for supporting broader fish communities in the Delaware Bay and, therefore, also broader economic viability of other fisheries. ○ Desire to have more certainty about the harvest policy so fishers/dealers can make more informed business decisions Members of the group suggested a variety of conditions to determine when female harvest would be acceptable, including: when we see less year-to-year variability in HSC numbers, see consistent increased and sustained populations of HSC and REKN (including meeting recovery criteria of REKN), and see a thriving ecosystem. The group also suggested potential "safeguards" that could be incorporated into the ARM; several of these ideas were addressed through other workshop discussions and elicitations summarized below.
Red knot utility	Participants from the HSC, shorebird, and ecosystem conservation groups completed two elicitation exercises rating their level of satisfaction, given red knot stopover abundances from 0 (total extirpation) to 152,900 birds (highest published value for stopover population size from Harrington 2001, reporting on 1989 data). The second exercise asked, "What is your level of satisfaction at different levels of red knot stopover abundance in 2050?" Relative to the first exercise, participants felt this wording better captured their values toward preserving and growing the red knot population over time. The group reviewed their responses and was comfortable using the average responses from that exercise to update the red knot utility curve in the ARM (see Figure 1). See "Additional discussion & elicitation details" section below for more information. **Next step**: update the ARM red knot utility function using the elicited values.
Horseshoe crab utility	Participants from the bait fishers, dealers, and biomedical groups completed an elicitation exercise related to updating the male-to-female HSC harvest values in the HSC utility function. The question asked, "Considering the horseshoe crab bait market over the next 5 years, catching one female is worth catching how many males?" The group reviewed their responses and saw a clear difference across groups (see **Figure 2**). Biomedical participants estimated that one female was worth one male, because there is no difference in the volume or value of blood they take from a female or male (and that both are needed for LAL production). Fishers/dealers estimated that one

Topic	Discussion outcomes and possible next steps
	female was worth between 2 and 3 males (median of 2.65), because females are larger, one female can be used to bait more traps, and the conch and eel fisheries are more successful using female crabs. The group discussed that in the specific context of the ARM, the HSC utility function was focused on the value toward bait harvest (and not the biomedical industry). Therefore, the group (including the biomedical participants) was comfortable with using the median response from the fishers/dealers (1 female to 2.65 males) to update the HSC utility function. See "Additional discussion & elicitation details" section below for more information. **Next step**: update the ARM HSC utility function using the elicited value.
Harvest policy functions	The group discussed a concern that the current harvest functions do not intercept zero, which means that the resulting harvest policy does not technically allow for a recommendation of zero HSC harvest. The group considered several options for ensuring zero harvest at low HSC or REKN abundances, and some participants expressed a preference for options that would change the functions to capture low abundance thresholds based on historical data, model predictions, and stakeholder input. See "Additional discussion & elicitation details" section below for more information. **Next step**: The ARM modelers can explore the feasibility of these options and come back to the group with proposals at the virtual follow-up session.
Maximum harvest levels	The group explored if there was interest in updating the sex-specific maximum harvest levels in the ARM (currently set at 500,000 males and 210,000 females). Participants from fishers/dealers shared reasons why these limits should be maintained (i.e., not reduced), including: fishers are harvesting less than current quotas due to bait market downswing since ~2020; maintaining current limits would allow for sufficient harvest if/when the market recovers; the maximum limits still represent a small portion of the total population size; and the fishers' experience is that when quotas are reduced or taken away, they never come back. After further discussion, fishers/dealers recommended that limits could be increased to a scientifically defensible number (i.e., one that would still ensure a sustainable HSC population). Their rationale included that the current limits are much smaller than what was historically harvested (especially since the maximum limits are divided up across four states), the market would respond to higher limits and resuming female harvest, and this would grow the industry and benefit their livelihoods. Participants from other groups did not support increasing the harvest limits, noting the lack of public acceptance of harvesting females even within the current limits, and suggested we should ensure public support for current levels before considering an increase. **Next step**: The group did not agree on a clear direction. Based on the rationales shared, we recommend keeping the current maximum harvest limits, which still allows space for

Topic	Discussion outcomes and possible next steps
	the horseshoe crab bait market to recover as well as the opportunity to strive for acceptance of female harvest at these lower levels recommended by the ARM.
Reward function	The group discussed ways to restructure the reward function in the ARM to better capture a broader set of values related to the Delaware Bay system. Currently, the ARM reward function includes utilities of (1) horseshoe crab harvest, (2) red knot abundance, and (3) a term that multiplies HSC harvest and red knot abundance utilities to give more value to management actions that balance both goals. Participants proposed adding terms to the reward function that reflect broader ecosystem values, such as habitat quality, horseshoe crab abundance, other shorebirds, and other metrics of ecosystem integrity to be defined further. It was also suggested to add a term for uncaught female horseshoe crabs as an indicator of egg abundance that supports fish communities and other fisheries in the Delaware Bay that were not involved in this process. ASMFC and technical staff reminded participants that any new terms to the reward function would need to (a) be measurable (i.e., have available data) and predictable (i.e., a model could forecast how the value would respond to management actions), and (b) be in scope of the ARM Framework. Some participants were satisfied with the current structure of the reward function, while others were interested in exploring ways to add another term related to the broader integrity of the ecosystem (e.g., horseshoe crab abundance). Some participants recognized the challenges in restructuring the ARM to include additional terms related to HSC abundance or other indicators of ecosystem integrity; as an alternative, some participants suggested changing the weights (currently set at 1:1 for HSC harvest and red knot utility), giving more weight to the red knot utility term to represent additional ecosystem values not directly captured in the model. **Next step**: The ARM Subcommittee could develop possible options for updating (or not updating) the reward function with additional terms to reflect ecosystem values. They can provide rationale based on the degree each option is within the ARM's current scope and feasible to implement with available data. These can be discussed with the group at the virtual follow-up session.
Science	Although the workshop focused on values-based ARM components, participants also discussed the underlying science in the ARM framework. Some participants expressed doubts that the ARM captures best available science, as well as its predictions of how horseshoe crab and red knot populations would behave in the future under different harvest management. **Next steps beyond the current values-focused process**: With the intention to build understanding of the Delaware Bay ecosystem, build understanding and trust in the ARM model, and collaboratively improve the ARM, the following possible next steps could be explored: o Working Session (short workshop) with ARM modelers and few interested parties to discuss HSC egg density data and mechanisms in model that could

Topic	Discussion outcomes and possible next steps
	better link HSC abundance, egg density, and red knot (and other ecosystem) outcomes. ○ A participant also suggested the need for better understanding the relationship between HSC abundance and egg density on the beach. There could be increased research and monitoring toward this, and that would not necessarily need to be in the model itself. ○ Educational Session on how uncertainty is incorporated in the model, with a focus on "how do we know if HSC and REKN is stable or increasing over time, even with some harvest?"
Process	Throughout the workshop, participants also highlighted opportunities to improve the process of communicating and updating the ARM. Additionally, a participant suggested that to increase public understanding and trust in the ARM, ASMFC could develop simpler, digestible outreach material describing the key aspects of the ARM process, science, and recommendations. **Next steps could include:** ○ Follow-up meeting with ARM Subcommittee and DBETC to identify options for incorporating stakeholder values into ARM. ○ ASMFC should better communicate to interested parties the process and policies surrounding data inclusion in any update or revision of the science underpinning the ARM. ○ ASMFC does provide a "Stock Assessment Overview" for the ARM on its website that is intended as digestible material for the public. However, ASMFC could improve communication about this document to ensure stakeholders are aware and understanding of the information.
Other	Some participants raised the question: if/when female horseshoe crab harvest is implemented, how do we improve public trust in this decision? The group discussed that it seems trust is building for at least some members of the stakeholder group with each other and the ARM process. However, participants raised that all group members need to play a role in communicating to their constituents to build trust in the process.

Additional discussion & elicitation details

Red knot utility

Wendy Walsh presented on red knot stopover abundance estimates from historical data and minimum criteria for recovery (**Table 3**). These were used as benchmarks in an elicitation exercise, which ranged from 0 (total extirpation) to 152,900 birds (highest published value for stopover population size from Harrington 2001, reporting on 1989 data).

Table 3. Benchmark abundances of the total rufa red knot stopover population in Delaware Bay presented at the stakeholder workshop. Abundances in green were used in the red knot utility elicitation exercise.

Stopover abundance	Description
0	Extirpated from Delaware Bay; inconsistent with the objective of the ARM and incompatible with rufa red knot recovery.
12,800	Lower bound (95% CI) of any published value for stopover population size (Gillings *et al*. 2009 reporting on 2004 data).
17,108	Lowest published value for stopover population size (Cohen *et al*. 2009 reporting on 2004 data).
40,750	Low estimate of minimum stopover population size that would be compatible with USFWS (2023) recovery criteria.
46,028	Average of 2011-2024 stopover population sizes estimates (Lyons 2025).
66,000	High estimate of minimum stopover population size that would be compatible with USFWS (2023) recovery criteria.
81,900	Threshold set by stakeholders for valuing female crab harvest in the previous ARM Framework (adjusted for turnover using 2013 conversion factor).
127,685	Earliest population estimate (1981-1983 average, adjusted for turnover using 2024 conversion factor).
152,900	Highest published value for stopover population size (Harrington 2001 reporting on 1989 data).
203,200	Upper bound (SD) of any published value for stopover population size (Harrington 2001 reporting on 1989 data).

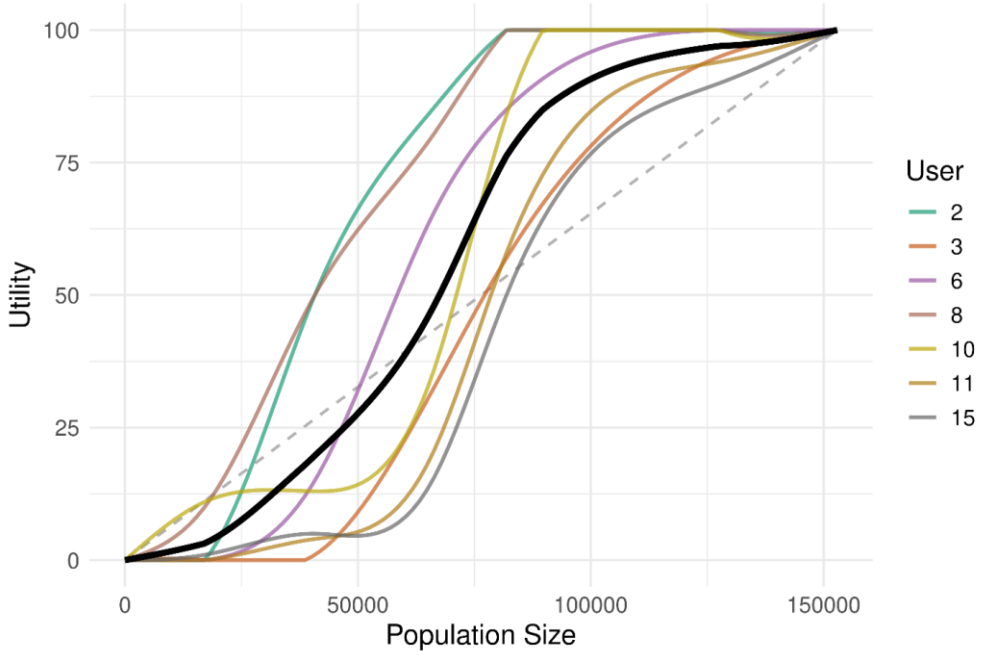
We elicited values from stakeholders through two exercises with slightly different questions. The first exercise asked participants, “What is your level of satisfaction at different levels of red knot stopover abundance?” They were instructed to think of these abundances in a vacuum without considering what management actions or other conditions resulted in achieving those abundances. A second exercise was conducted to better capture participants’ attitudes toward risking losing red knots or achieving an increased population over time. It asked, “What is your level of satisfaction at different levels of red knot stopover abundance in 2050?” and instructed participants to consider that the best current estimates of red knot abundance have been relatively stable around 40,000 – 50,000 birds for the last ~10 years. For both exercises, we followed best practices for expert elicitation using the following steps:

1. Completed one round where participants responded to the questions individually using an online tool.
2. Showed the group the individual responses and group averages.
3. Discussed rationale for distinctly different responses.

4. Allowed participants to adjust their responses, based on the discussion.
5. Reviewed the final responses and confirmed the group was comfortable using the group average.

Discussion outcome: Because the second exercise better captured participants' values toward preserving and growing the red knot population over time, the group was comfortable using the average responses from that exercise to update the red knot utility curve in the ARM (see **Figure 1**). We can revisit this curve with the stakeholder group in a follow-up meeting to confirm it represents their values or if any modifications are needed.

Figure 1. Group mean (black line) and individual participants' responses (other lines) for a red knot utility function showing level of satisfaction (utility) to red knot stopover abundances from 0 to 152,900 birds. Responses were from the HSC, shorebird, and ecosystem conservation group participants (n = 7).



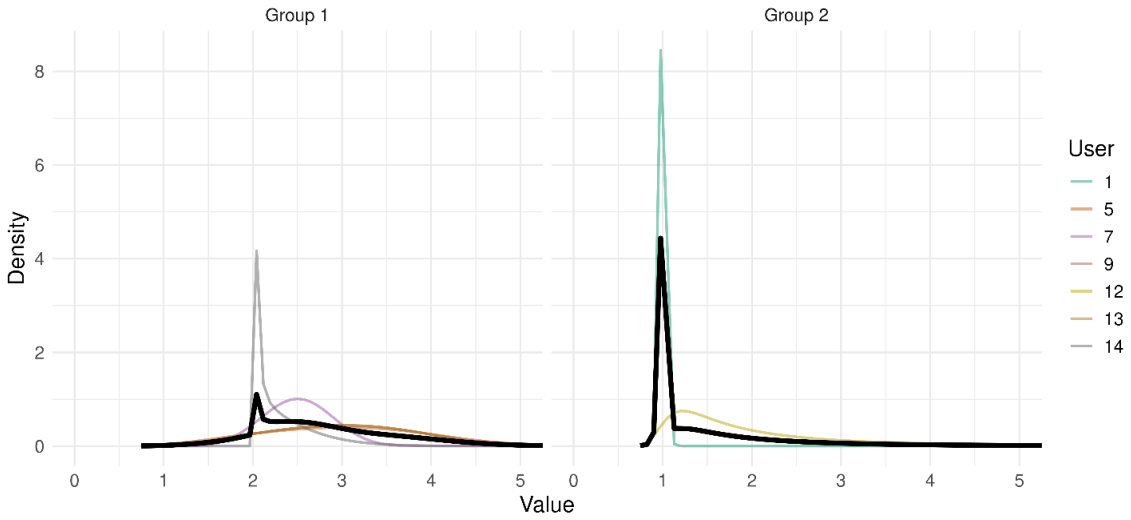
Horseshoe crab utility: male-to-female harvest value

Participants from the bait fishers, dealers, and biomedical groups completed an elicitation exercise that asked, "Considering the horseshoe crab bait market over the next 5 years, catching one female is worth catching how many males?" The elicitation followed the same basic steps as the red knot utility exercise (see above). A key difference was that participants were asked to consider the question and provide four responses to capture their uncertainty around this value:

1. The lowest plausible value
2. The highest plausible value
3. Realistically, the best estimate
4. The level of confidence that the true value is between the lowest and highest values provided.

Figure 2. Group mean (black lines) and individual participants' responses (other lines) representing the number of males expected to be of equivalent value to catching one female horseshoe crab. Each line shows the

distribution of each person's responses (fit to their low, best, and high estimates). Group 1 is fisher and dealer participants (n = 5); Group 2 is biomedical participants (n = 2).



Horseshoe crab harvest policy functions

The group discussed the concern that the current harvest functions do not go through zero, which means that the resulting harvest policy does not technically allow for a recommendation of zero HSC harvest, even at very low HSC or REKN population levels. Several options for defining conditions where zero HSC harvest would be implemented were discussed:

1. User-defined threshold: a minimum threshold for HSC abundance could be chosen based on historical data and other stakeholder inputs, and the harvest policy functions could be updated so that zero harvest would be recommended if the HSC population fell below this threshold. This approach would still allow the ARM to fit the shape of these functions to data.
2. Model policy-based: the ARM simulates HSC abundance in the future (given annual harvest decisions) using 1000s of simulations to capture uncertainty of what the population is expected to be. It was suggested that this range of predicted abundances could be used to define a lower abundance threshold, where if we actually observed a HSC abundance dropping below the range of the ARM's predictions, zero harvest would be recommended. Likewise, if the observed HSC abundance was within the ARM's predictions, we could use the ARM's harvest recommendations.
3. Board-based harvest control rule: In the HSC management program outside of the ARM model (e.g., in an Addendum) a harvest control rule would require that "if the HSC abundance estimate is below a certain threshold, there will be zero harvest for the upcoming year."

Discussion outcome: The group expressed some preference toward the first two options that would still allow learning to occur within the model, as that is one of the key advantages of adaptive management relative to a simple harvest control rule. Those options were also seen as more data-driven and defensible. These approaches would still allow for assurances that the ARM would recommend 0 harvest under extreme low abundances of HSC. The group suggested that the ARM modelers explore the feasibility of these options and come back to the group with proposals at the virtual follow-up session.

Atlantic States Marine Fisheries Commission

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Horseshoe Crab Delaware Bay Ecosystem Technical Committee and ARM Subcommittee Meeting

DBETC Attendance: W. Walsh* (USFWS), K. Christie* (DE), E. Simpson* (VA), F. Ferretti (VT), S. Doctor* (MD), J. Zimmerman (DE), S. Karpanty* (VT), Y. Jiao (VT)
*Serves on both ARM Subcommittee and DBETC
ARM Subcommittee Attendance: J. Sweka (USFWS), J. Lyons (USGS), M. Conroy (DE), B. Nuse
Staff: C. Starks, S. Nehemiah, K. Drew, T. Kerns
Non-ARM or TC Members: B. Crawford (Compass), K. O'Donnel (Compass), A. Lai (VT)

The Horseshoe Crab Delaware Bay Ecosystem Technical Committee (DBETC) and Adaptive Resource Management Framework Subcommittee (ARMSC) met via webinar on February 23, 2026, to discuss the results of the Stakeholder Workshop in January. The purpose of this call was to summarize the workshop outcomes and get consensus from TC members about next steps for updating the ARM.

Results of stakeholder workshop and proposed updates

B. Crawford and K. O'Donnell with Compass Resource Management reviewed the outcomes of the stakeholder engagement workshop. Following the results of the stakeholder engagement workshop, the DBETC and ARMSC discussed potential changes to the ARM utility, reward, and harvest (U/R/H) functions considering stakeholder input.

Horseshoe crab harvest utility function

At the stakeholder workshop, harvesters and dealers agreed that the current economic value of one female crab is worth 2.65 male crabs. This is an increase from a value of 2, which has been used in the horseshoe crab utility function of the ARM since 2009. The DBETC and ARMSC agreed that changing the horseshoe crab utility function (replacing the current multiplier of 2 for male horseshoe crabs with 2.65) to reflect this updated value was reasonable. However, DBETC members noted that this elicitation was done under the current management conditions where females have not been harvested for many years. Therefore, if females are allowed to be harvested in the future this value may change. J. Sweka noted that the horseshoe crab utility function could be updated in the future as stakeholder values change.

Red knot abundance utility function

At the workshop, ecosystem stakeholders provided individual utility curves regarding their satisfaction of red knot stopover abundance in 2050. When averaged, the elicited utility function reflects a logistic-type curve. However, the shape of the curve at low population sizes may change depending on how the individual responses are averaged.

The DBETC and ARMSC discussed how to change the utility function and the impacts of these changes. Some DBETC members expressed concern with the logarithmic shape of the averaged curve. The modeling team suggested that the final curve will be smoothed out to address these concerns. Other DBETC members asked how the population values in the elicitation corresponded to the endangered

species act (ESA) recovery targets. W. Walsh noted that stakeholders were given reference values that corresponded to values in the ESA recovery plan, so they were considered in the final utility curve.

The ARMSC and DBETC had no opposition to changing utility function to be more representative of stakeholder values that were provided in the elicitation. It was mentioned that if/when new U/R/H functions are finalized, FWS may consider re-running the ESA assessment for red knots.

Changes to harvest policy function

Stakeholders expressed interest in updating the harvest policy functions in the ARM such that there would be 0 horseshoe crab harvest at low horseshoe crab abundance levels, in particular for females. This would provide a safeguard but still allow the model to learn by incorporating this rule into the model. The stakeholders did not provide a threshold number for horseshoe crab abundance at the workshop but requested the ARM modelers provide potential options for this threshold value (Table 1).

Table 1. Female horseshoe crab abundance reference points

CMSA Female Abundance (millions)	Description
0	Extirpation
3.75	Recruitment Declines
3.77	Lowest CMSA estimate (2006)
4.04	Lowest extrapolation from Sweka et al. 2025
6.25	2003 mark-recap estimate (Smith et al. 2006)
6.90	Max harvest within M error
7.80	Current predicted equilibrium size (no bait)
11.20	Original ARM threshold
12.66	Recent CMSA average (2017 – 2024)
17.48	Highest extrapolation from Sweka et al. 2025
19.38	Most recent (2024) CMSA estimate
20.65	Highest (2023) CMSA estimate

The DBETC and ARMSC discussed potential values to use as the female threshold below which there is 0 harvest. J. Sweka and B. Nuse discussed some options for setting a threshold where the TC and ARMSC could determine a value or the model could pick a threshold value during its optimization process. Some ARMSC members were concerned about letting the model 'choose' a threshold because that threshold should be representative of stakeholder values. Other DBETC members noted that a higher threshold would help build trust with some stakeholders, but a higher threshold could potentially cause harvest recommendations to fluctuate significantly (e.g., between zero and near the maximum) from year to year, which could make management difficult and regulations confusing. Other members noted that even though harvest may jump from zero to relatively high levels, under the maximum harvest values, harvest will always be a small proportion of the total population.

B. Nuse noted that the modeling team could consider creating a harvest policy curve where at lower abundance levels harvest could ramp up slowly, and at higher abundance levels harvest would be more free to settle at higher values. However, this approach would require two 'threshold' values of female horseshoe crab abundance to define where 0 harvest would occur and one to define where harvest can be higher. The group had some reservations about this approach and agreed to 'vote' on a minimum population size to set harvest to 0.

The group agreed to do an informal elicitation using Google Forms to suggest a threshold size of female horseshoe crab abundance, below which female harvest should be zero. Preliminary results suggested a median value of 7 million female crabs, a mode of 8 million female crabs, and an average of approximately 7.05 million female crabs. However, responses from the Committee members ranged from 3.77-12.66 million female crabs.

The group provided some rationale for the values they suggested. One group member noted they chose 4 million female crabs because they saw this as a 'fire alarm' to which, if the population dropped to this level there should be cause for concern. One member selected 5 million because they thought it was a good, compromised value between the level at which recruitment starts being negatively affected and the maximum harvest value with uncertainty. Another member selected 7 million because this was the approximate value at which red knots started to decrease based on population estimates. One member selected 11.2 million because that felt reflective of stakeholder values and was the original threshold for female harvest in the ARM Framework but admitted that it may be too high of a value and may cause harvest recommendations to flip "on and off."

The group agreed to keep the form open until the end of the week (February 27, 2026) to give members who were absent from the meeting an opportunity to vote and to allow for members to change their votes based on rationale discussed during the meeting. C. Starks agreed to share the link again and share the anonymous responses and rationale so that members could understand how and why members voted, in case they wanted to change their scores. The group did not discuss a method for setting a threshold for male crabs and agreed to finalize this at a later date.

Changes to the reward function

At the workshop, stakeholders discussed potential ways to restructure the reward function. Some were satisfied with the current form while others suggested adding terms to reflect ecosystem values (e.g., horseshoe crab abundance, habitat quality).

The ARMSC and DBETC discussed potential changes to the reward function or the option of leaving it as is. One DBETC member was concerned that the current reward function did not represent stakeholder values. Some members expressed concern with changing the reward function. Several committee members noted that red knots were selected to represent ecosystem integrity in the ARM so adding other values could cause issues, particularly if those parameters are correlated. Other members noted that many ecosystem values are not measurable, predictable or within the ARM scope. Some members noted that horseshoe crab management should be seen as a 'success story' since the population has increased, which would suggest that the reward function is working as designed.

Compass conducted an elicitation for the group to understand how to move forward with the reward function. The elicitation covered three options: 1) Leave reward function as is; 2) explore adding in a term for HSC abundance and reweighting; and 3) explore changing weights for the current reward function terms. Each member was asked to give one of three responses to each option: 1 = endorse (i.e., favorite option), 2 = accept (i.e., can live with this option), or 3 = oppose (i.e., would not be happy with this option). Option 1 had nine endorsements, while no other option had any endorsement (Table 2). While some members "accepted" option 2 and 3, a majority of voters opted to oppose these options. Therefore, Compass noted that the group had near consensus for option 1.

Table 2. Response to Compass elicitation on changes to the reward function. Note that not all participants voted during this elicitation or for all options.

	1 (leave as is)	2 (add HSC abundance)	3 (reweight current terms)
Endorse	9		
Accept		2	2
Oppose	1	6*	6

**this value was reported as 3 during the meeting but has been corrected based on the written responses in the chat*

Next Steps

The group will revisit the female horseshoe crab threshold value and resubmit their values, if desired. The ARMSC and DBETC will be notified of the final changes. The modeling team will propose changes to smooth the red knot utility function. Compass and the planning team will meet to present changes to the stakeholder group in March or April.

Any ARMSC or DBETC member that is interested in listening in to the modeling calls should contact C. Starks or S. Nehemiah to be included on the emails about upcoming meetings. An expected timeline of upcoming events is provided below (Table 3).

Table 3. Expected timeline for next steps.

Date	Completed	Task
December 10, 2025	✓	Educational Session #1
January 5-8, 2026	✓	Education Session #2
January 29 – 30, 2026	✓	In-person Stakeholder Workshop
February 23, 2026	✓	ARM/DBETC Meeting
March 9, 2026		Modeling team check-in call
March – April, 2026		Re-engage stakeholders; Draft report of proposed changes
May 2026		Presentation to Board on proposed changes
May – August 2026		Make changes and run the ARM model
September 2026		ARM/DBETC Meeting to discuss results
October 2026		Presentation to Board/Initiate Addendum X
October – December 2026		Draft new FMP Addendum X including ARM Revision 2.0
January 2027		Present draft Addendum X to Board for consideration
January 2027 – April 2027		Public comment on draft Addendum X
May/October 2027		Board final action on draft Addendum X

Atlantic States Marine Fisheries Commission

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MEMORANDUM

TO: **Horseshoe Crab Management Board**

FROM: **Delaware Bay Ecosystem Technical Committee and ARM Subcommittee**

DATE: **March 30, 2026**

SUBJECT: **Committee Recommendations on Utility, Reward, and Harvest Policy Functions**

The Delaware Bay Ecosystem Technical Committee (DBETC) and Adaptive Resource Management (ARM) Subcommittee met jointly via webinar on February 23, 2026, to review the results of the January 2026 Stakeholder Workshop and get consensus from TC members about next steps for updating the ARM. The full details of the Committees' discussions are included in the attached meeting summary. Below are the Committees' recommendations for changes to the utility, reward, and harvest policy functions of the ARM Framework.

Horseshoe crab harvest utility function

- Update the value ratio for male to female horseshoe crabs to 2.65 males to 1 female.

The DBETC and ARM Subcommittee support the recommendation from the stakeholder workshop, which reflects the fishing industry stakeholders' current value of females compared to males. The current utility function uses a 2:1 ratio.

Red knot abundance utility function

- Update the utility function based on stakeholder values elicited at the January workshop.

The ARMSC and DBETC had no opposition to changing utility function to be more representative of stakeholder values that were provided in the elicitation during the January workshop. The ARM modeling team will develop a new utility curve to present to stakeholders for review.

Changes to the reward function

- Maintain the current reward function (Annual reward: $r_y = u_y^h + u_y^k + u_y^h u_y^k$)

The DBETC and ARM Subcommittee reached near consensus for maintaining the current reward function in the ARM Framework, which is the sum of the horseshoe crab utility, red knot utility, and the product of the two utilities. While some members expressed a desire to restructure the function to account for other ecosystem values, it was noted that new factors (other than horseshoe crab and red knot abundance) could not be added to the reward function without incorporation of additional data sources and modeling, and an additional peer review process.

Such changes could be considered in the future through a peer-reviewed ARM Framework revision.

Changes to the harvest policy function

- Update the harvest policy function such that there would be no female harvest when the female horseshoe crab abundance is below 7 million crabs.

At the January 2026 workshop, stakeholders expressed an interest in adding a threshold to the harvest policy function such that there would be no female harvest at low horseshoe crab abundance levels. The stakeholders did not provide a specific value for this threshold.

Using an elicitation of the DBETC and ARM Subcommittee members, the Committees recommended a threshold value of 7 million females. This is the median value of the elicited abundance thresholds provided by Committee members. If this change is adopted, it would mean the harvest policy function is revised such that if the CMSA-estimated Delaware Bay population of female horseshoe crabs is below 7 million females, then the ARM Framework would recommend zero female harvest.