

Delaware Bay Horseshoe Crab Adaptive Resource Management Framework

Stakeholder Engagement Final Report

Prepared for

Atlantic States Marine Fisheries Commission

Prepared by

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Executive Summary

Building on feedback from a July 2024 workshop with Delaware Bay stakeholders, the Atlantic States Marine Fisheries Commission (ASMFC) conducted a structured stakeholder engagement process to inform updates to several values-based components of the Adaptive Resource Management (ARM) Framework for horseshoe crab harvest management in Delaware Bay. Compass Resource Management (Compass) was engaged by ASMFC to provide facilitation support for the process. This report documents the outcomes of the full engagement process and presents recommendations for the Horseshoe Crab Management Board's consideration.

The engagement was conducted in three phases: (1) virtual educational sessions held in December 2025 and January 2026; (2) a two-day in-person stakeholder workshop in Ocean City, MD, on January 29 and 30, 2026; and (3) post-workshop activities including a joint review session with the Delaware Bay Ecosystem Technical Committee (DBETC) and ARM Subcommittee on February 23, 2026 and a final meeting with the stakeholder group on April 14, 2026 to finalize recommendations and document any diverging perspectives. Fourteen stakeholder representatives from six broad interest groups participated in the process, alongside technical experts and ASMFC staff.

The process yielded actionable recommendations for updating the core values-based components of the ARM Framework — the Utility (U), Reward (R), and Harvest (H) policy functions. These recommendations reflect elicited stakeholder values and have been reviewed and generally supported by the stakeholder group, DBETC, and ARM Subcommittee. The key recommendations with broad agreement are summarized below:

- Update the horseshoe crab (HSC) harvest utility function to reflect a male-to-female bait harvest value ratio of 2.65 males per 1 female, based on values elicited from bait fishers and dealers.
- Retain the current sex-specific maximum harvest levels (500,000 males and 210,000 females), supporting potential market recovery and the incremental building of public acceptance for female harvest at ARM-recommended levels.
- Update the harvest policy functions to trigger zero female harvest if the CMSA-estimated female horseshoe crab population in Delaware Bay falls below 7 million crabs. Some stakeholders expressed support for a follow-up process to explore a higher threshold.
- Update the red knot (REKN) abundance utility function using values elicited from conservation stakeholders.

- Maintain the current reward function structure, which includes the sum of horseshoe crab harvest utility, red knot abundance utility, and their product. One stakeholder did not support the current reward function and suggested adding a term for horseshoe crab abundance or giving more weight to ecological terms in the function.

Updating the ARM Framework in the five ways described above may improve the level of trust in the ARM among stakeholder participants. Overall, stakeholders expressed broad agreement that the ARM should continue to be used and improved, despite varying levels of trust in the model. Most stakeholders support the use of its harvest recommendations, while others want to see improvements to the ARM's underlying science, or evidence of a stable and thriving ecosystem, before they would fully trust and accept the model's recommendations for allowing female harvest.

The engagement process also surfaced other recommendations regarding scientific uncertainty, process improvement, and public trust that are described in detail in this report.

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1 Background & Context

The ARM Framework

The Horseshoe Crab (HSC) Adaptive Resource Management (ARM) Framework is a decision-support model used by ASMFC to set annual bait harvest levels for horseshoe crabs in Delaware Bay. The framework is designed to balance the commercial harvest of horseshoe crabs with the abundance of migratory shorebirds — in particular, the threatened rufa red knot (REKN) — which depend on horseshoe crab eggs as a critical food source during their migration stopover in Delaware Bay each spring.

At the core of the ARM Framework are three types of mathematical functions that capture stakeholder values and influence annual harvest recommendations (Figure 1):

1. The Utility (U) functions assign quantitative measures of value to different levels of horseshoe crab harvest and red knot stopover abundance, reflecting stakeholder preferences.
2. The Reward (R) function combines the utility values to determine the overall benefit of a given management action, balancing competing objectives.
3. The Harvest (H) policy functions translate long-term model-simulated population trajectories into optimal annual harvest recommendations.

The ARM Framework was last formally revised in 2021. Building on feedback from a July 2024 workshop with Delaware Bay stakeholders, ASMFC determined that several values-based components of the U/R/H functions warranted re-examination through a new structured stakeholder process.

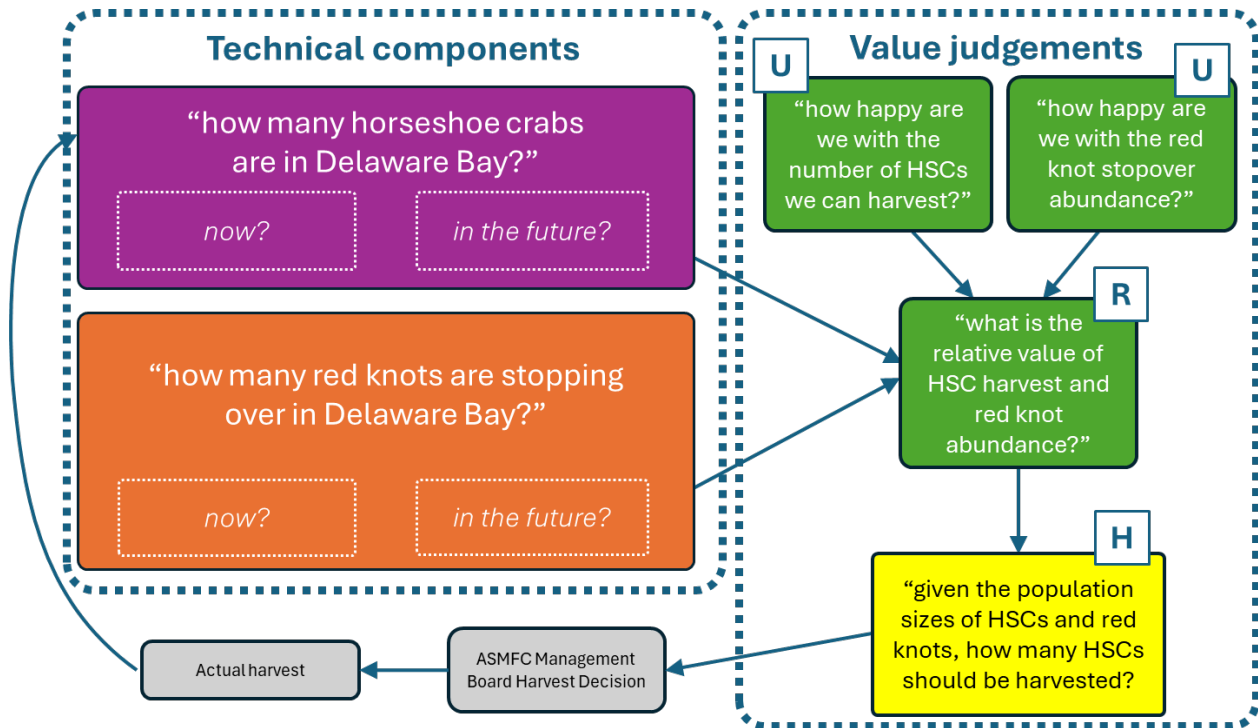
Purpose of this Engagement

ASMFC engaged Compass Resource Management (Compass) to facilitate a structured stakeholder engagement process to develop recommended modifications to the U/R/H functions. The process was grounded in Structured Decision Making (SDM) principles, emphasizing transparency, inclusive participation, analytical rigor, and the integration of diverse values and knowledge systems.

A central objective of the process was to advance the ARM Framework from a perceived "black box" into a more transparent, values-reflective tool — one that stakeholders across a range of interests can trust as a credible basis for management decisions. The process was also explicitly

designed to build understanding among stakeholder groups, technical experts, and ASMFC over the course of the engagement.

Figure 1. Simplified illustration of the Adaptive Resource Management (ARM) Framework and how the technical/science-based and values-based components relate. This engagement process focused on the Utility (U), Reward (R), and Harvest (H) functions.



Participating Groups

The stakeholder engagement process convened representatives from six groups with interests in horseshoe crab harvest management in Delaware Bay: (1) bait fishers, (2) bait dealers, (3) the biomedical industry, (4) ecosystem conservation organizations, (5) horseshoe crab conservation organizations, and (6) shorebird conservation scientists and organizations. Technical experts from the ARM Subcommittee, members of the Delaware Bay Ecosystem Technical Committee (DBETC), and ASMFC staff also participated throughout the process in a technical advisory and facilitative capacity. A full list of participants is provided in Appendix A.

2 Engagement Process

The engagement followed a phased approach, designed to move participants from a shared technical understanding of the ARM Framework toward informed, values-based recommendations for model updates.

Phase 1: Education & Preparation

In October 2025, Compass conducted a series of small group interviews with representatives from each of the six stakeholder interest groups. The purpose of these conversations was to understand each group's key concerns and perspectives on the ARM Framework before designing the educational sessions and in-person workshop. These smaller group settings allowed participants to speak openly among their peers. The insights gathered directly informed both the content of the educational sessions and the structure of the workshop agenda.

Two virtual educational sessions were held in December 2025 and January 2026 to ensure all participants had a foundational understanding of the ARM Framework and the values-based components they would be asked to inform. ASMFC technical staff and ARM Subcommittee members provided background presentations that included the following topics:

- The current structure of the U/R/H functions within the ARM model.
- Key differences between the 2009 and 2021 ARM Framework versions.
- Historical context for why certain thresholds and parameter values were chosen.
- How different function shapes affect harvest recommendations and management outcomes.
- How uncertainty is incorporated in the ARM model and how the model learns over time through an adaptive management cycle.

Each session was recorded for participants unable to attend live. Dedicated time was provided for participants to ask questions of technical experts, promoting open dialogue between stakeholders and the scientific staff.

Phase 2: Stakeholder Values Workshop

A two-day, in-person stakeholder values workshop was held January 29 and 30, 2026, in Ocean City, MD. The agenda was structured around sequential discussions of each U/R/H function component, with structured elicitation exercises embedded throughout.

The elicitation exercises followed best practices for structured expert elicitation: participants responded individually to elicitation questions using an online tool; the facilitator displayed group averages and individual responses; rationale for divergent responses was discussed openly; participants were given the opportunity to revise their responses in light of the discussion; and the group reviewed and confirmed the final group average. This iterative process is designed to reduce anchoring bias, encourage consideration of diverse perspectives, and produce group estimates that genuinely represent the breadth of stakeholder values.

Phase 3: Post-Workshop Activities

The DBETC and ARM Subcommittee met jointly via webinar on February 23, 2026, to review the January 2026 workshop outcomes and develop formal recommendations for the Management Board. The meeting covered each of the major ARM components addressed at the workshop. A summary of the Committee meeting discussions and recommendations was sent to the stakeholder group for review prior to their final meeting, which was held on April 14, 2026, to present draft model updates, collect structured feedback and final recommendations, and document any conflicting perspectives.

3 Stakeholder Engagement Outcomes

The stakeholder engagement process focused on gathering input and recommendations for updating the U/R/H harvest functions within the ARM model. Through these conversations, participants also discussed several topics overarching or intersecting with the ARM Framework. These broader discussions, viewpoints, and possible next steps are summarized below.

3.1 General Views on the ARM Framework

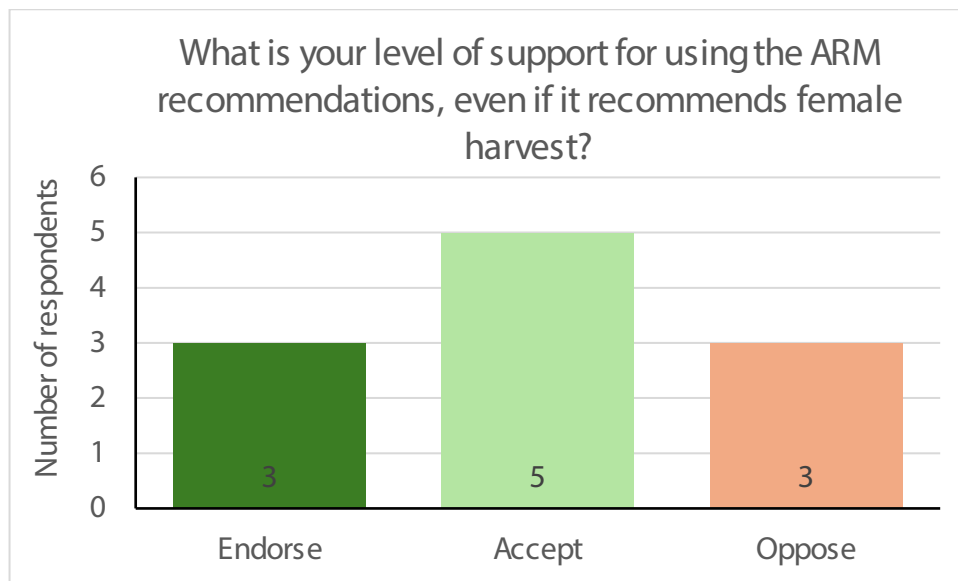
At the stakeholder workshop, there was broad agreement among participants that the ARM Framework should continue to be used and improved as the primary tool for guiding horseshoe crab harvest management in Delaware Bay. However, participants expressed a range of views on the trustworthiness of the current science underpinning the model. Most participants expressed confidence in the current ARM Framework and its recommended harvest policies, while others expressed uncertainty or distrust regarding specific data inputs and model predictions, noting they would not accept ARM Framework recommendations until outstanding scientific disagreements are addressed. This divergence in scientific trust was a recurring theme throughout the workshop.

At the final stakeholder meeting, participants completed a poll around their relative level of support for using the ARM Framework recommendations, even if it recommends female harvest. Levels of support were defined as:

- **Endorse** - I fully support this
- **Accept** - I can live with it; it may not be my first choice, but I will support it here and outside of this group
- **Oppose** - I can't support it

Most participants either accepted or endorsed using ARM Framework recommendations, even if it recommends female harvest, while 3 of 11 respondents opposed this (Figure 2). None of the 3 people who “opposed” using ARM Framework recommendations shared their rationale, but it was likely captured above (e.g., needing to resolve scientific disagreements) or in the next section pertaining to when female harvest would be acceptable. Some participants in support of using the ARM Framework recommendations noted that management under the ARM Framework has resulted in a strong increase in horseshoe crab populations as well as a stable or increased red knot population. Multiple participants mentioned the amount of previous effort and discussion that has gone into building the ARM Framework by modelers and individual stakeholders, and that without using the ARM Framework for management as intended, these efforts are not seen as a valuable use of time and resources.

Figure 2. Stakeholder level of support expressed at the final meeting for accepting ARM recommendations, including female harvest.



3.2 Acceptability of Female Harvest

A portion of the workshop was devoted to discussion of female horseshoe crab harvest, which the ASMFC Board has declined to implement since November 2022 despite the ARM Framework output recommending a limited female harvest. Compass facilitated a structured “debate” exercise in which all participants — regardless of their actual views — were asked to brainstorm arguments for two positions: that female harvest should never be allowed, and that female harvest is acceptable under certain conditions. This exercise was designed to build mutual understanding before moving into values elicitation.

Arguments raised for allowing female harvest included: the potential for harvest displacement to other regions if Delaware Bay remains closed; the operational burden on fishers of discarding females at sea; the fact that recommended harvest levels represent a small proportion of the total horseshoe crab population; and the broader economic value for fishing families and associated businesses.

Arguments raised against allowing female harvest included: the value of a precautionary approach given habitat loss and climate change pressures; the importance of unharvested females’ egg production for supporting broader fish communities in Delaware Bay; and the desire for greater certainty in a harvest policy to support long-term business planning.

Participants suggested several conditions under which female harvest might be considered acceptable, including consistent and sustained population increases for both horseshoe crabs and red knots, and meeting Endangered Species Act recovery criteria for the red knot. This discussion provided important context for the subsequent elicitation of U/R/H recommendations.

3.3 Scientific Considerations

Although the workshop focused primarily on the values-based components of the ARM Framework, participants also discussed the scientific foundations of the model. Some participants expressed concern that the ARM Framework does not fully capture the best available science, particularly regarding the mechanistic relationship between horseshoe crab abundance, egg density on Delaware Bay beaches, and red knot population dynamics.

At the workshop and final meeting, the group identified several potential steps to address scientific topics. These included a working session between ARM modelers and interested parties to discuss horseshoe crab egg density data and model mechanisms; an educational session focused on how uncertainty is incorporated in the model; and increased research and

monitoring on the relationship between horseshoe crab abundance and beach egg density. Participants also suggested exploring how habitat quality and quantity in the Delaware Bay could be better assessed, predicted, and incorporated into the underlying population models in the ARM Framework. Participants recognized that this may be difficult and management decisions surrounding habitat may be outside of the formal scope of the ASMFC; however, they felt that habitat is an important driver to both horseshoe crab and red knot outcomes, as well as the broader ecological system, that should be better understood. Participants noted that some of these activities may not need to be incorporated into the ARM model itself, but would nonetheless contribute to building scientific trust across stakeholder groups.

3.4 Process & Communication

At the workshop and final meeting, participants highlighted opportunities to improve how the ARM process is communicated to the broader public. ASMFC was encouraged to communicate more clearly about its data inclusion policies and the process for updating the science underpinning the ARM Framework. Participants also noted that ASMFC's existing "Stock Assessment Overview" document — designed as accessible public-facing material — could be promoted more proactively to ensure stakeholders and interested members of the public are aware of it. Participants also asked ASMFC to produce and disseminate documents for broader audiences with clear, concise consistent descriptions of the ARM Framework and the decision support process, which would help participants communicate consistently across groups and prevent the spread of misinformation. Participants recognized that all stakeholder group members have a role to play in communicating the ARM process and its outcomes to their own constituents, and that building public trust in the management framework is a shared responsibility.

4 ARM Component Discussions & Recommendations

The sections below summarize the outcomes and perspectives for each topic discussed in this process relating to potential updates to value-based components of the ARM Framework. Each section generally describes outcomes of conversations in the order they occurred: the January stakeholder values workshop; the February 23 joint meeting of the DBETC and ARM Subcommittee; and the April 14 final stakeholder meeting. Section 5 then summarizes final recommendations and rationales.

4.1 Horseshoe Crab Utility Function

At the workshop, participants from the bait fisher, dealer, and biomedical groups completed an elicitation exercise to update the male-to-female economic harvest value ratio in the horseshoe crab utility function (see Appendix B). The exercise asked participants to estimate how many male horseshoe crabs would be equivalent in value to catching one female, in the context of the bait market over the next five years.

Biomedical participants estimated a 1:1 ratio because there is no difference in the volume or value of blood they take from a female or male and both are needed for LAL production. Fisher and dealer participants estimated a higher ratio, with a group median of 2.65 males per one female. Fishers and dealers cited three reasons for this higher valuation: female crabs are larger, a single female can bait more traps, and the conch and eel fisheries — the primary markets for horseshoe crab bait — are more effective when baited with females.

The group then considered that in the specific context of the ARM Framework, the horseshoe crab utility function is focused on the value associated with bait harvest rather than the biomedical industry. On this basis, all participants — including the biomedical representatives — agreed that the fisher and dealer median response of 2.65 males per one female was the appropriate value for updating the horseshoe crab utility function. The current ARM Framework uses a 2:1 ratio.

The DBETC and ARM Subcommittee supported updating the male-to-female value ratio in the horseshoe crab utility function from the current 2:1 to 2.65 males per one female.

At the final stakeholder meeting, the group also affirmed this update.

4.2 Maximum Harvest Limits

At the workshop, the group explored whether there was interest in updating the current sex-specific maximum harvest limits in the ARM Framework (500,000 males and 210,000 females). Fisher and dealer representatives argued that the current limits should be maintained at a minimum (i.e., not reduced), given that actual harvest has been well below these limits since approximately 2020 due to a bait market downturn, and that maintaining the current limits would allow for sufficient harvest if and when the market recovers. They also noted that the limits represent a small fraction of the total horseshoe crab population size. Fishers and dealers further suggested that limits could be increased to a scientifically defensible level, noting that historical harvest was significantly higher and that growth of the fishery would benefit their livelihoods.

Other participants did not support increasing the harvest limits, citing the absence of broad public acceptance for female harvest even within current limits. They suggested that public trust in current harvest levels should be established before any increase is considered.

Given the absence of group consensus on changing the limits, the facilitation team recommended retaining the current maximum harvest limits. This approach accommodates potential recovery of the bait market while providing a measured pathway toward public acceptance of female harvest at ARM-recommended levels.

The DBETC and ARM Subcommittee supported retaining the current limits of 500,000 males and 210,000 females, recognizing that the absence of stakeholder consensus on this topic argues for maintaining the status quo at this time.

At the final stakeholder meeting, the group agreed to retain the current limits.

4.3 Harvest Policy Functions

At the workshop, participants discussed a structural concern with the current ARM harvest policy functions, which was raised in public comments on the 2021 ARM Framework Revision: these functions do not pass through zero, meaning the model cannot technically recommend zero harvest even at very low horseshoe crab or red knot population levels. Although the modelers described the technical reasons for this (namely that the model is fit to historical data and never predicts near-zero population sizes), some participants wanted an additional precautionary mechanism in the model that triggers no harvest if populations reach some low threshold. Three options for addressing this were presented and discussed:

1. A user-defined abundance threshold within the model, below which zero harvest would be recommended. The harvest policy functions would be updated to reflect this threshold while retaining the ARM model's ability to fit function shapes to observed data.
2. A threshold defined by the model predictions, where the range of ARM-simulated future horseshoe crab abundances (generated from thousands of model simulations) would define a lower population bound. If observed horseshoe crab abundance fell below this range, zero harvest would be recommended.
3. A Board-based harvest control rule, established outside the ARM model (e.g., through an Addendum to the management plan), requiring zero harvest if the horseshoe crab abundance estimate falls below a specified threshold.

Participants expressed a preference for the first two options, which preserve the ARM Framework's adaptive management learning process — a key structural advantage over simpler



rule-based approaches — and are more data-driven and technically defensible. The group recommended that the ARM modelers explore the feasibility of these options and return with proposals at the virtual follow-up session.

The DBETC and ARM Subcommittee recommended updating the harvest policy function to include an explicit zero-harvest threshold for female crabs. This approach was preferred over a model-defined threshold because it connects more directly to stakeholder input in the form of a numeric threshold. This method was also seen as promoting confidence in the ARM harvest recommendations, since it is easier to understand and communicate. Specifically, if the Delaware Bay population of female horseshoe crabs, as estimated by the Catch Multiple Survey Analysis (CMSA), falls below 7 million females, the ARM Framework will recommend zero female harvest for the upcoming year. This threshold was established through an elicitation of DBETC and ARM Subcommittee members and represents the median of the values provided (see Appendix B). This change directly addresses the stakeholder-identified concern that the current harvest policy functions do not technically permit a recommendation of zero harvest, even at critically low population levels. The ARM Subcommittee explained how the 7 million threshold will be incorporated into the next optimization of the ARM to revise harvest policy functions. The DBETC discussion focused on setting a female harvest threshold given female harvest has been the primary concern for stakeholders versus male harvest; the group did not discuss a method for setting a threshold for male crabs, but this could be addressed later if desired.

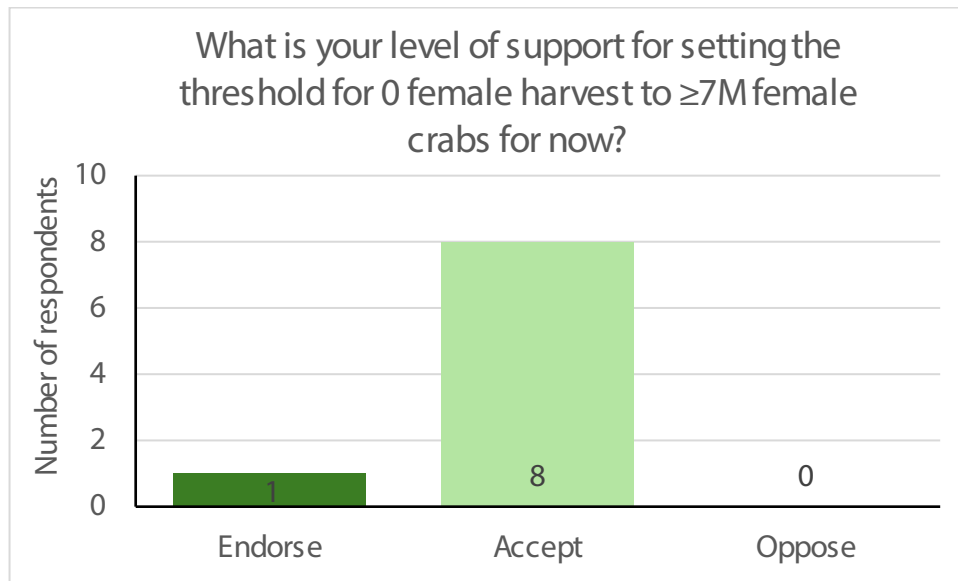
At the final stakeholder meeting, participants completed a poll around their relative level of support (endorse, accept, or oppose) for updating the ARM Framework to include a threshold for zero female harvest of 7 million female horseshoe crabs. Two participants initially “opposed” this update, explaining that they wanted to explore setting a threshold higher than 7 million females that would better account for uncertainty of population estimates and year-to-year variability, the need to maintain a thriving horseshoe crab population, and prevent major declines from current abundance – noting that a threshold of 7 million females is roughly a 63% decline from the current estimated population of ~19 million.

Participants were reminded that the ARM harvest policy function currently does not have any threshold that would trigger zero harvest, and a new question was asked to explore near-term recommendations. Specifically, participants were asked about their level of support for updating the ARM in the near-term to include a threshold for zero female harvest below a population of 7 million female crabs.

All respondents either accepted or endorsed this update (Figure 3). For at least two participants, they only accepted this as a short-term change and requested a process to explore a zero-harvest threshold higher than 7 million females that is more precautionary against uncertainty.

They recommended this process to happen soon, but could accept a threshold of 7 million females in the near-term.

Figure 3. Stakeholder level of support expressed at the final meeting for updating the ARM in the near-term with a threshold of at least 7 million female horseshoe crabs that would trigger 0 female harvest.



4.4 Red Knot Utility Function

At the workshop, the group reviewed the current red knot utility curve, which gives “0” utility for low abundances, rises quickly at 90% of a threshold abundance, and reaches “1” at the threshold abundance of 81,900 birds. Seven participants from the horseshoe crab conservation, shorebird conservation, and ecosystem conservation groups completed two elicitation exercises to update the red knot abundance utility curve (see Appendix B). Both exercises asked participants to rate their level of satisfaction — on a scale of 0 to 100 — at a range of red knot Delaware Bay stopover population sizes, from zero (total extirpation) to 152,900 birds (the highest published population estimate).

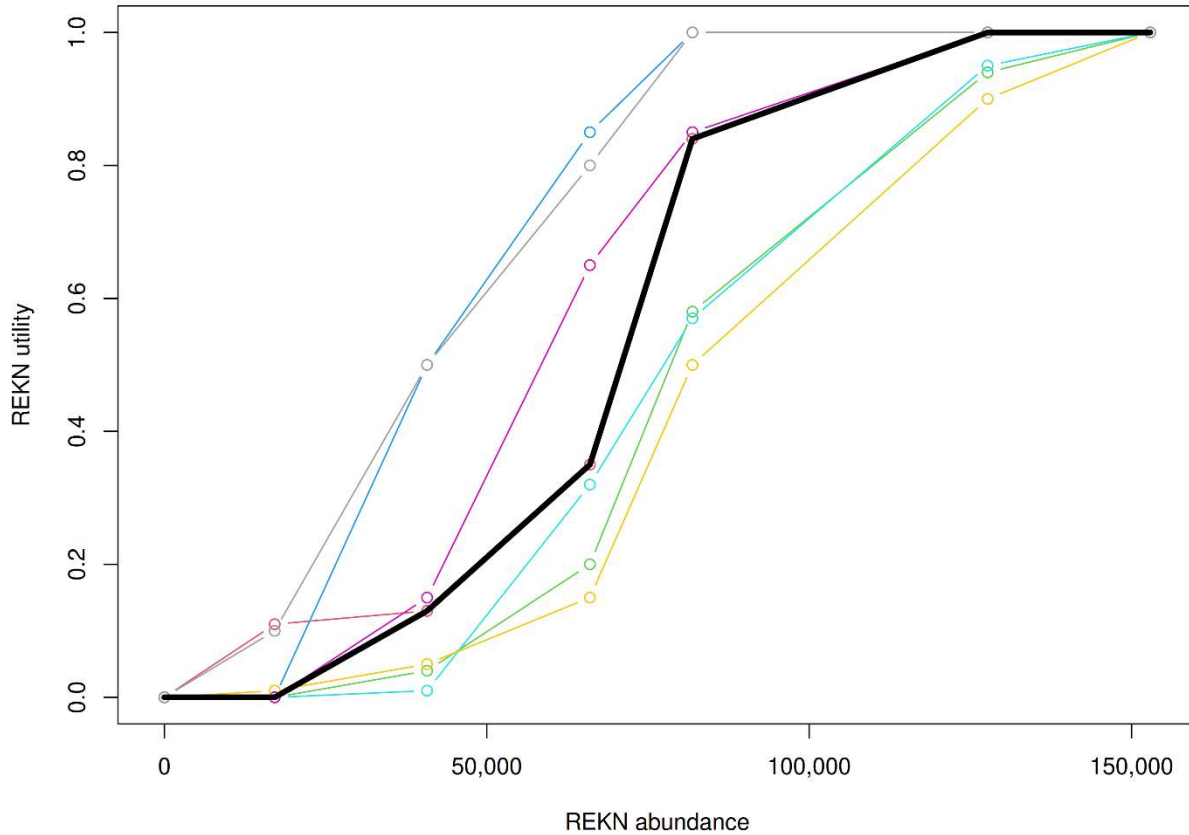
The first exercise asked participants to rate their satisfaction at different red knot population levels in general terms. A second, refined exercise asked: “What is your level of satisfaction at different levels of red knot stopover abundance in 2050?” This question was framed relative to the current estimate of approximately 40,000 to 50,000 birds (relatively stable over the past ten years) and was designed to better capture participants’ risk attitudes about long-term population losses or gains.

Participants felt the second exercise more accurately reflected their values, including a desire to avoid red knot abundances lower than current estimates. The group also supported a more gradual increase in utility as abundance increases from current estimates. After reviewing individual and group average responses and discussing rationales, the group confirmed they were comfortable using the average of responses from the second exercise to update the red knot utility curve in the ARM Framework.

The DBETC and ARM Subcommittee also supported updating the red knot abundance utility function to be more representative of stakeholder values elicited in this process.

Following the DBETC and ARM Subcommittee meeting, the ARM modeling team developed a revised utility curve using the median utility values from participants – which were elicited at 5 stopover abundances – and connected these values to represent utility (satisfaction) across the full range of possible red knot abundances (Figure 4). The revised curve appeared to better reflect stakeholder values for avoiding low abundance and increasing utility more gradually as abundance increases from current estimates.

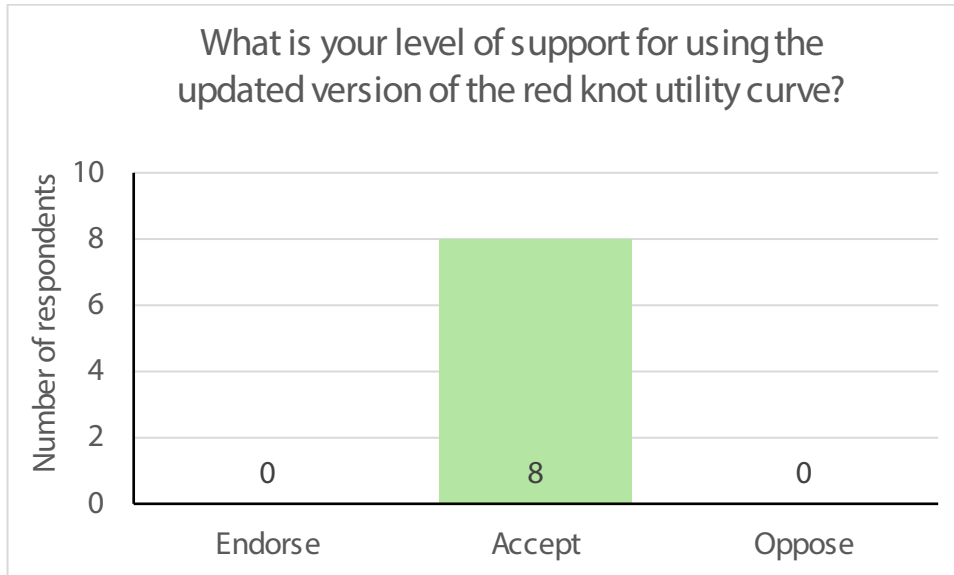
Figure 4. Utility curve (black line) updated by the ARM modeling team and reviewed and approved by the stakeholder group. The curve relates utility (level of satisfaction) with future red knot stopover abundance. The black line shows the median of individual stakeholder responses (colored lines).



At the final stakeholder meeting, participants reviewed the updated utility curve and how it was constructed. The group completed a poll around the level of support for using this updated curve in the ARM Framework.

All respondents accepted this update (Figure 5) and noted that it captured their interest in avoiding red knot stopover abundances decreasing from current estimates.

Figure 5. Stakeholder level of support expressed at the final meeting for using the updated version of the red knot utility curve in the ARM.



4.5 Reward Function

At the workshop, participants discussed options for restructuring the reward function. The current reward function is: Annual Reward = HSC harvest utility + red knot abundance utility + (HSC harvest utility × red knot abundance utility). The multiplicative term gives additional value to management actions that simultaneously achieve both objectives and ensures that maximum reward cannot be gained solely from HSC harvest or red knot abundance.

Some participants were satisfied with the current reward function structure. Other participants proposed adding terms reflecting broader ecosystem values, including habitat quality, horseshoe crab abundance, other shorebird species, and other metrics of ecosystem integrity. One suggestion was to add a term for uncaught female horseshoe crabs as an indicator of egg availability supporting fish communities and other fisheries in Delaware Bay. As an alternative, some participants suggested adjusting the existing utility weights (currently 1:1 for horseshoe crab harvest and red knot utility) to give greater weight to red knot utility as a proxy for broader ecosystem values not directly captured in the model.

ASMFC and technical staff noted that any new terms to the reward function would need to be measurable (with available data), predictable (with a model capable of forecasting the response to management actions), and within the current scope of the ARM Framework. Facilitators posed questions to the group when considering adding new terms, including: Does the new term represent a value already captured in the reward function or another part of the ARM? Is it fair

to put more weight on the ecological outcomes, and could everyone agree? And if we made these changes, would everyone agree to accept the ARM Framework recommendations even if it still recommended female harvest in some years?

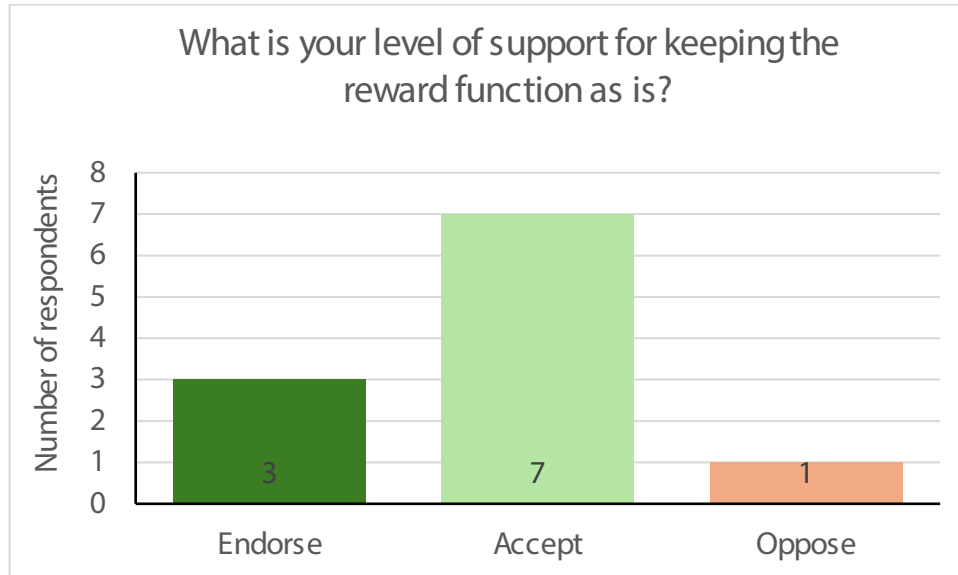
After discussing the technical and philosophical challenges of adding other terms or reweighting them, most participants were satisfied with the current reward function structure. Some were still interested in exploring additional ecological terms but acknowledged the substantial technical requirements.

The DBETC and ARM Subcommittee recommended maintaining the current reward function structure. The Committees reached near consensus on this recommendation. While some members expressed interest in restructuring the function to incorporate additional ecosystem values, it was noted that adding new factors beyond horseshoe crab harvest and red knot abundance would require additional data sources, modeling work, and a formal peer review process. Such changes may be considered in future ARM Framework revisions.

At the final stakeholder meeting, the group reviewed the DBETC and ARM Subcommittee recommendation and rationales. The group completed a poll around the level of support for maintaining the current reward function.

The group showed near consensus, with all but one respondent either accepting or endorsing to keep the current structure of the reward function (Figure 6). The one participant who opposed this expressed interest in adding a term for horseshoe crab abundance and/or giving more weight to ecological terms in the function (i.e., red knot abundance).

Figure 6. Stakeholder level of support expressed at the final meeting for keeping the current structure of the reward function in the ARM Framework.



5 Recommendations to the Horseshoe Crab Management Board

Based on the stakeholder engagement process and the subsequent technical review by the DBETC and ARM Subcommittee, the following recommendations for updates to values-based components of the ARM should be considered by the Horseshoe Crab Management Board. These recommendations reflect areas of stakeholder consensus as well as the Committees' technical judgments where stakeholder consensus was not fully achieved.

Table 1. Recommendations and basis for updating values-based ARM Framework components from the stakeholder engagement process.

ARM Component	Status	Recommendation	Basis
HSC Harvest Utility Function	Update recommended	Change female-to-male value ratio from 2:1 to 2.65:1	Stakeholder elicitation (fishers/dealers); confirmed acceptance by DBETC/ARMSC and stakeholders
Maximum Harvest Levels	No change	Maintain current maximum levels:	No consensus to increase or decrease at stakeholder workshop; confirmed

		500,000 males and 210,000 females	stakeholder acceptance of no change at final meeting; topic not formally reviewed by DBETC/ARMSC
Harvest Policy — Female HSC Threshold for Zero Harvest	Update recommended	Add zero-harvest threshold: no female harvest when estimated female HSC abundance < 7 million crabs	DBETC/ARMSC elicitation (median value); informed by stakeholder workshop discussion; confirmed stakeholder acceptance at final meeting as a near-term update to the ARM, with some participants requesting a process to explore higher abundance thresholds to trigger zero harvest
Red Knot Abundance Utility Function	Update recommended	Replace current curve using median values elicited from stakeholders	Stakeholder elicitation (conservation groups); confirmed acceptance by DBETC/ARMSC and stakeholders
Reward Function	No change	Maintain current reward function (HSC utility + REKN utility + HSC × REKN utility)	Near consensus at stakeholder workshop, DBETC/ARMSC meeting, and final stakeholder meeting; one participant requested adding a term for horseshoe crab abundance and/or giving more weight to ecological terms in the function

Additional recommendations to improve the ARM’s science, process, and buy-in

This section describes additional recommendations about the ARM Framework, science, and process from the stakeholder engagement process.

- Consider facilitating additional engagement to address scientific concerns about the ARM model, including a working session on horseshoe crab egg density data and model

mechanisms and an educational session on how the model handles uncertainty around current estimates and future predictions. Building scientific credibility with all stakeholder groups is essential for the long-term legitimacy and effectiveness of the ARM Framework.

- Consider facilitating an additional working session to explore how habitat quality and quantity in Delaware Bay could be better assessed, predicted, and incorporated into the ARM's underlying population models, recognizing that habitat is an important driver of both horseshoe crab and red knot outcomes even where direct model integration may be outside the ARM's formal scope.
- Consider developing clearer ASMFC messaging and broader dissemination of data inclusion policies and science update procedures.
- For existing public-facing documents such as the "Stock Assessment Overview," consider improving methods to promote and disseminate them to increase the awareness of interested parties.
- Develop concise, consistent plain-language materials describing the ARM and its decision support process to help stakeholders communicate accurately with their own constituents and prevent the spread of misinformation. ASMFC could also work with stakeholder groups to develop or review public-facing documents.

Appendix A: Workshop Participants

Table A-1. Stakeholder participants at the January 29–30, 2026 stakeholder values workshop.

Stakeholder Group	Name	Organization
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
Ecosystem Conservation	Danielle McCulloch	American Littoral Society
	Lisa Ferguson	The Wetlands Institute
	Carly Toulan	Maryland Coastal Bays Program
HSC Conservation	Glenn Gauvry	ERDG
	Susan Linder	Wildlife Restoration Partnerships
Shorebird Conservation	Joanna Burger	Rutgers University
	David Mizrahi	NJ Audubon

Table A-2. Technical participants and ASMFC staff who attended the January 2026 workshop.

Group	Name	Organization
DBETC	Wendy Walsh	USFWS
	Jordan Zimmerman	DNREC
ARM Subcommittee	John Sweka	USFWS
	Jim Lyons	USGS
	Bryan Nuse	Bird Conservancy of the Rockies

Group	Name	Organization
	Conor McGowan (virtual)	USGS
ASMFC Staff	Caitlin Starks	ASMFC
	Toni Kerns	ASMFC
	Samara Nehemiah	ASMFC
	Madeline Musante	ASMFC

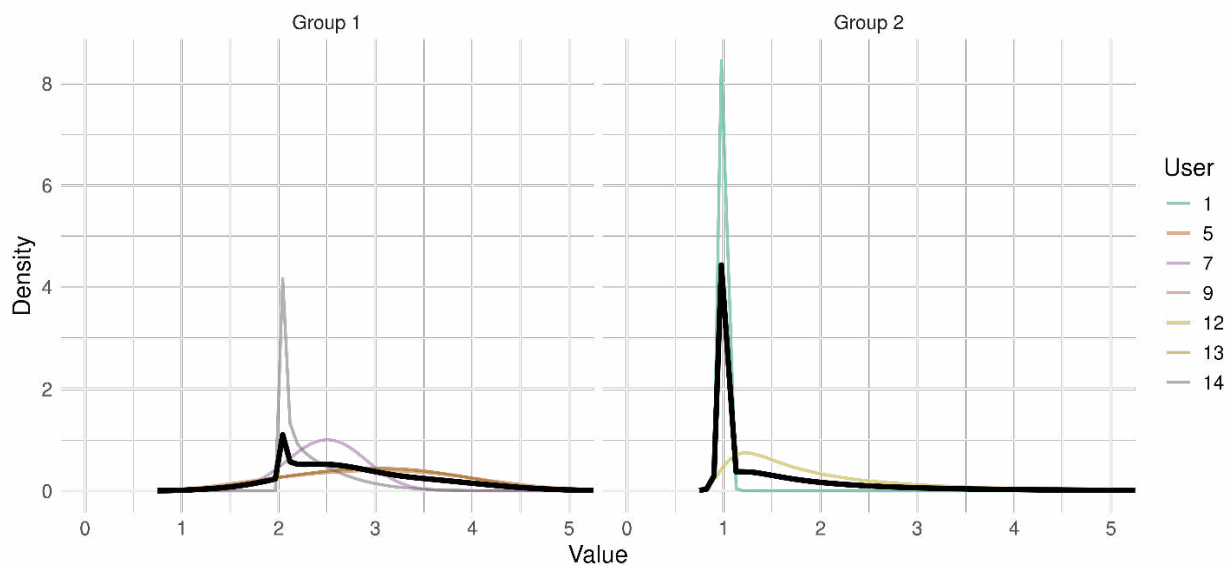
Appendix B: Elicitation Details

Horseshoe Crab Utility Elicitation

Seven participants from the bait fisher, dealer, and biomedical groups completed the horseshoe crab harvest value elicitation exercise. The exercise asked: "Considering the horseshoe crab bait market over the next five years, catching one female is worth catching how many males?" To capture uncertainty, participants provided four responses for each estimate: the lowest plausible value, the highest plausible value, the best estimate, and their level of confidence that the true value lies between their lowest and highest values.

Results showed a clear divergence between groups. Biomedical participants estimated a 1:1 ratio (median: 1.0), reflecting equivalent blood yield from male and female crabs for LAL production. Fisher and dealer participants estimated a median best estimate of 2.65, with individual best estimates ranging approximately from 2 to 3. The group consensus was to use the fisher and dealer median best estimate of 2.65 to update the horseshoe crab utility function, given that this function specifically addresses the bait harvest context.

Figure B-1. 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).



Harvest Policy Function Discussion & Threshold Elicitation

Three options for ensuring zero harvest is recommended at critically low population levels were presented and discussed at the workshop (described in Section 3.4 of this report). Participants expressed a preference for the first two options — a user-defined threshold or a model policy-based threshold — over a Board-based harvest control rule, on the grounds that the first two preserve the adaptive learning properties of the ARM Framework. These options were referred to the ARM modelers for feasibility analysis.

Following the workshop, the DBETC and ARM Subcommittee conducted an elicitation among their members to identify an appropriate threshold value for the zero-harvest policy.

Table B-1. Benchmark abundances of CMSA female horseshoe crab abundance estimate (millions) in the Delaware Bay presented at the DBETC and ARM Subcommittee meeting for elicitation.

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 median of the elicited values was 7 million female horseshoe crabs, and this value was adopted as the recommended threshold. If implemented, this threshold would mean that if the CMSA-estimated Delaware Bay female horseshoe crab population falls below 7 million, the ARM would recommend zero female harvest for the upcoming year.

Red Knot Utility Elicitation

Seven participants from the horseshoe crab conservation, shorebird conservation, and ecosystem conservation groups completed the red knot utility elicitation exercises. The exercises asked participants to rate their level of satisfaction (on a scale of 0 to 100) at a range of red knot Delaware Bay stopover population sizes. The following population benchmarks were presented as reference points during the elicitation:

Table B-2. Benchmark abundances of the total rufa red knot stopover population in Delaware Bay presented at the stakeholder workshop. Abundances in yellow 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 <i>et al.</i> 2009 reporting on 2004 data).
17,108	Lowest published value for stopover population size (Cohen <i>et al.</i> 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).

Two elicitation exercises were conducted. The first asked participants to rate their satisfaction at different population levels in general terms. The second, refined exercise asked: "What is your level of satisfaction at different levels of red knot stopover abundance in 2050?" This exercise

was anchored to the current population estimate of approximately 40,000 to 50,000 birds and was designed to better capture participants' values toward long-term population recovery. Participants confirmed that the second exercise better reflected their values, and the group average responses from this exercise will be used to update the red knot utility curve.

Figure B-2. Utility curve elicited during the stakeholder workshop relating utility (level of satisfaction) with red knot stopover abundance. Curves are shown for seven individual participants (colored lines) and the group average (black line).

