FAQs about Delaware Bay Rufa Red Knots and Horseshoe Crabs

1. Why do rufa red knots stop in Delaware Bay each spring?

Thousands of shorebirds migrate through Delaware Bay each spring on their way to nesting grounds in Canada's Arctic tundra. Along their northbound migration from the Southeast U.S., Caribbean, and South America, these birds make only a few stops to rest and feed. Situated between Delaware and New Jersey, Delaware Bay is one of these vital "migration stopovers" where several shorebird species, including rufa red knots, stop in large numbers to "refuel" before the last leg of their journey to the breeding grounds.

While in Delaware Bay, rufa red knots deviate from their normal diet—of mostly clams, mussels, and snails—to feed almost exclusively on the eggs of horseshoe crabs, which spawn in large numbers along the Delaware bayshore. The peak of horseshoe crab egg laying occurs on sandy beaches from late April into June. The birds' visit to Delaware Bay in May and early June is perfectly timed to take advantage of this bounty! Horseshoe crab eggs are a vital and reliable shorebird food supply that is unmatched throughout the Atlantic Flyway. Due to the abundance of horseshoe crab eggs as a food resource, Delaware Bay is considered the single most important spring stopover area for knots, supporting an estimated 50 to 80 percent of all rufa red knots each year. Based on its hemispheric importance to several shorebird species, Delaware Bay was designated the first site in the Western Hemisphere Shorebird Reserve Network[1] in 1985.

2. What other areas are used by rufa red knots throughout the year?

Rufa red knots are among the longest-distance migrants in the animal kingdom! Their nonbreeding range spans from southern Canada to the southern tip of South America, while their breeding grounds cover a vast expanse of Arctic Canada. In spring, rufa red knots use several stopovers along the Atlantic coasts of North and South America, as well as the Caribbean, as they fly north to the breeding grounds, where their nesting season begins while snow still covers the Arctic tundra.

Besides Delaware Bay, major spring stopovers include several bays in Argentina and Brazil; South Carolina; and the Virginia barrier islands. Smaller numbers of rufa red knots migrate overland, moving from the coasts of Mississippi, Louisiana, Texas, and northern Mexico north along midwestern rivers and across the plains to saline lakes in southern Canada before finally arriving on the breeding grounds.

On their southbound migrations, from mid-July through November, rufa red knots use well-known stopover sites such as southwest Hudson Bay, James Bay, and the Mingan Archipelago in

[1] https://whsrn.org/delaware-bay/

Canada; the Atlantic coasts of Massachusetts and New Jersey, and the mouth of the Altamaha River in Georgia in the U.S.; Cuba; and the northern coast of South America from Brazil to Guyana. Cutting-edge tracking technologies, such as satellite transmitters and the Motus Wildlife Tracking System,[2] are revealing new insights into rufa red knot migration every year.

From November through February—winter in the northern hemisphere—rufa red knots stay along the coasts of the U.S. (mainly North Carolina to Texas), the Caribbean, northern South America (particularly the Brazilian State of Maranhão), and southern Argentina and Chile (mainly the island of Tierra del Fuego that spans both countries). Smaller numbers of rufa red knots winter in the U.S. mid-Atlantic, Lagoa do Peixe in Brazil, Uruguay, both coasts of Central America, and the Pacific coast of South America (mainly the Chilean island of Chiloé).

3. How do biologists estimate the number of rufa red knots stopping in Delaware Bay each year?

Since the 1980s, biologists from New Jersey[3] and Delaware[4] wildlife agencies have partnered to survey migrating shorebirds during the spring stopover in Delaware Bay.

The longest-running survey is conducted by airplane, which flies along the entire Delaware Bay shoreline from Cape May to the Cohansey River in New Jersey, and from Woodland Beach to Lewes in Delaware. Aerial surveys are timed to coincide with the anticipated peak of spring migration, and are often supplemented by targeted, concurrent ground surveys done on foot or by boat as a cross-check on the aerial counts. The aerial survey was designed to assess trends in the relative abundance of shorebirds on bayshore beaches, providing an annual "snapshot" of bird numbers at a particular time. The aerial count is not a full population estimate because it does not account for the arrivals and departures of individual birds during May and early June. The aerial survey provides an important index of the rufa red knot stopover population, valuable information about the geographic distribution of knots across the bay, and a long-term perspective spanning four decades.

In a separate effort from the aerial survey, scientists calculate an annual estimate of the total rufa red knot stopover population, using sightings of marked birds and statistical models. Each year, biologists mark several hundred rufa red knots with individual, field-readable leg flags. Teams of biologists conduct ground surveys using spotting scopes to identify and record the flag codes of marked birds. These "resighting" data allow biologists to estimate the total (cumulative) number of rufa red knots that visited Delaware Bay during the entire spring stopover season.

4. How has the number of rufa red knots using Delaware Bay changed over time?

Data from the aerial survey (Figure 1, gray bars) are highly variable, sometimes showing large swings from year to year. This is partly because the survey may, by chance, miss the true peak of rufa red knots in some years, and due to variations in factors like tides and weather that affect visibility. Due to the high variability in the aerial counts, wildlife agencies generally do not

[2] https://motus.org/
[3] https://dep.nj.gov/njfw/conservation/delaware-bay-shorebirds/
[4] https://dnrec.alpha.delaware.gov/fish-wildlife/conservation/shorebirds/

consider single years when assessing trends. Instead, we look at multi-year averages (Figure 1, blue line). Comparing the most recent 3-year period (2020-2022) to the earliest period (1981-1983), rufa red knot counts are down nearly 80 percent.

As shown in Figure 1, aerial counts of rufa red knots declined sharply from the late 1990s to 2004. It is noteworthy that counts of five other shorebird species in Delaware Bay also declined by 50 percent from 1998 to 2007, and that the rufa red knot's Argentina/Chile wintering population—which is particularly dependent on Delaware Bay—also declined sharply during roughly this same period. From 2005 to 2011, the aerial counts of rufa red knots in Delaware Bay stabilized at around 15,000, then increased to around 25,000 from 2012 through 2020. For reasons that are still being investigated, aerial counts in 2021 and 2022 were the lowest on record.

Counts from the aerial survey cannot be compared to modeled estimates of the total stopover population because these two scientific methods measure different things (see Question 3). Early efforts using models to estimate the total stopover population size were as high as 77,000 in 1998, and as low as 17,000 in 2004. However, these efforts were not carried out consistently until 2011 when the U.S. Geological Survey partnered with wildlife agencies to produce a robust annual total stopover population estimate using a peer-reviewed and widely accepted methodology. As shown in Figure 1 (red bars), the total stopover population estimates were consistently around 45,000 rufa red knots from 2011 through 2019; they have declined slightly since then but are still within the range of statistical uncertainty associated with the earlier years.

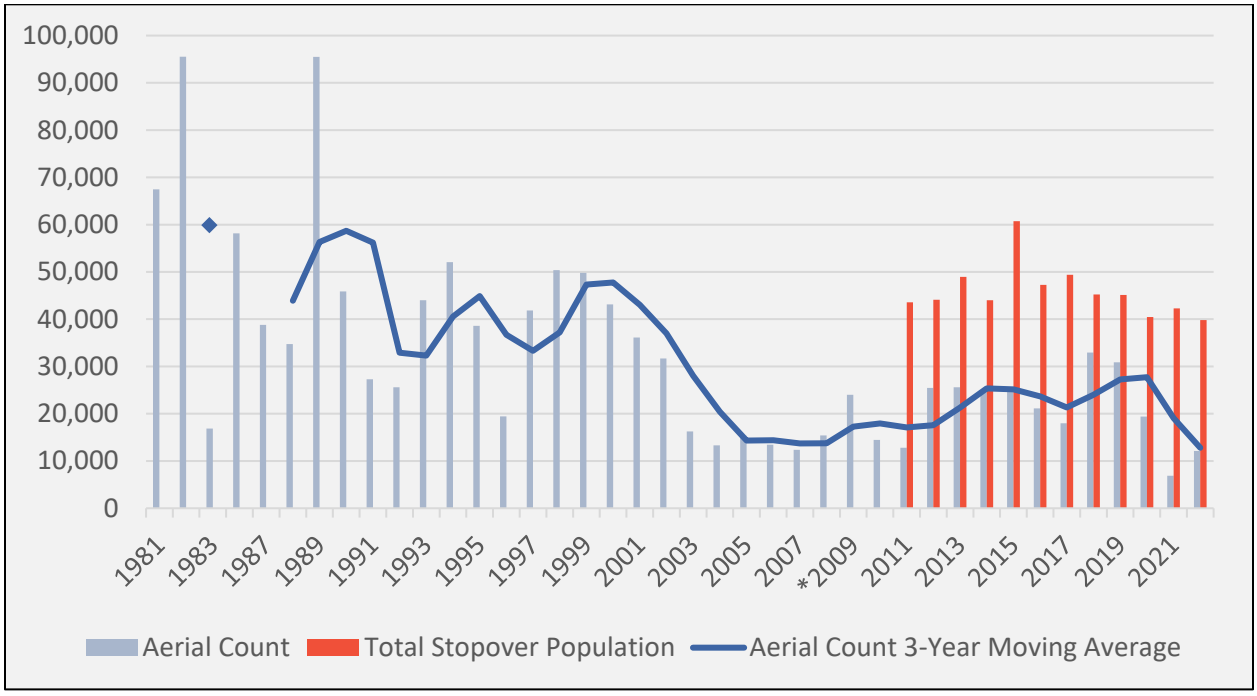

Figure 1. Estimated numbers of rufa red knots in Delaware Bay, 1981–2022.
Notes: (1) Aerial counts (gray bars) and total stopover population estimates (red bars) cannot be compared as they measure different things. (2) Single-year aerial counts at different points in time should not be compared to assess trends; the moving average (blue line) is a more appropriate indication of aerial count trends. (3) Only New Jersey was surveyed in 1981. (4) No aerial counts were conducted in 1984 or 1985. (5) Ground counts were substituted for aerial counts in 2009, 2012, and 2020.

5. Why did the rufa red knot decline and what are the current threats to this species?

Natural resource managers have identified numerous past, ongoing, and emerging threats to the rufa red knot, and several of these threats likely contributed to past declines. However, the States and the U.S. Fish and Wildlife Service[5] have concluded, based on the weight of evidence, that overharvest of the horseshoe crab in Delaware Bay was the key factor leading to rufa red knot declines in the late 1990s and early 2000s. Sharp increases in the harvest of horseshoe crabs in the 1990s reduced crab populations. Shorebird numbers in Delaware Bay saw modest declines in the 1990s, likely related to reduced availability of horseshoe crab eggs.

Coastwide management of the horseshoe crab fishery began in 1998, with an emphasis on Delaware Bay and a recognition of the importance of crab eggs to shorebirds (see Question 11). Unfortunately, rufa red knot numbers in Delaware Bay—and the highly Bay-dependent wintering population in Argentina and Chile—continued to drop through the mid-2000s, leading to the species' listing as "threatened" under the federal Endangered Species Act in January 2015. By 2012, rufa red knot numbers stabilized, though at a lower level compared to the 1980s.

The range wide number of rufa red knots is currently estimated at 63,600, spread across four wintering populations[6] that mix in Delaware Bay during the spring. Two of the wintering populations are considered stable, and one has probably declined. In the fourth wintering population, which spans Argentina and Chile and which is clearly the most depleted and vulnerable, annual counts were low but stable from 2011 through 2022.

Under the current Adaptive Resource Management (ARM) Framework (see Question 12), horseshoe crab harvest in Delaware Bay is not considered a threat to the rufa red knot because harvest levels are tied to knot populations via scientific modeling. The ARM Framework is currently being revised. The U.S. Fish and Wildlife Service conducted an assessment[7] that found harvest levels under the revised ARM Framework pose a negligible risk to the rufa red knot (see Questions 14-16).

The rufa red knot faces a range of ongoing threats.[6]

- Coastal engineering and development since the 1950s caused extensive habitat loss.
- Development is accompanied by high levels of beach recreation and other human activities, which disturb the birds while they are trying to rest and feed. Excessive disturbance can keep knots from gaining enough weight to complete their migrations and can prevent the birds from using their preferred habitats.
- Recovering raptor populations place increasing predation pressure in some knot habitats.
- In various parts of the range, rufa red knots face impacts from oil spills, red tides, aquaculture, hunting in other countries, and collision with human structures.
- Several major threats are linked to global climate change, including accelerating rates of sea level rise and shoreline change, changes in seasonal timing across ecosystems, ocean acidification, changes in prey species, and rapid warming of the Arctic.

[5] https://www.fws.gov/species/rufa-red-knot-calidris-canutus-rufa
[6] See the U.S. Fish and Wildlife Service's 2020 Species Status Assessment (SSA).
[7] https://www.fws.gov/media/us-fish-and-wildlife-service-evaluation-atlantic-states-marine-fisheries-commission-horseshoe

6. Why is Delaware Bay important to horseshoe crabs?

Delaware Bay hosts the largest population of spawning horseshoe crabs in the world. Several factors make the bay premier crab habitat. The bay provides a low-energy environment that is protected from wind and waves and features abundant sandy beaches. Importantly, these beaches are relatively free of hard structures—such as groins, jetties, and seawalls—that accelerate erosion and degrade habitat. Beaches with low-energy waves are preferred spawning habitat, where horseshoe crabs mate in the surf and lay their eggs in the sand. In addition, the Delaware Bay's salinity and tidal conditions provide ideal nursery habitat for baby crabs, which spend several years growing and developing on the tidal flats and shallow waters along the bayshore.

7. Why are horseshoe crabs important to the bay's food web?

Each adult female horseshoe crab lays an estimated 80,000 to 100,000 eggs each spring. This vast supply of eggs forms the base of several interconnected food chains, linking the bay both to the shore and to deeper waters. In addition to rufa red knots, crab eggs support several other shorebird species during their migratory stopovers. The eggs and larvae are also a food resource for many adult and juvenile finfish during the late spring and summer. The crabs themselves, both adults and juveniles, are an important part of the diet of loggerhead sea turtles.

The influence of horseshoe crabs goes beyond serving as food for other fish and wildlife species. The crabs' own diet (*e.g.*, clams, mussels, worms) regulates populations of these invertebrates. Horseshoe crab shells—which are not molted by the long-lived adults—host a number of "hitchhikers," such as slipper shells, sand worms, and on occasion, oysters. Horseshoe crabs are also "ecosystem engineers," reworking a tremendous volume of bottom sediments through their feeding and other activity.

8. How do biologists estimate the number of crabs in the Delaware Bay population?

Most data on horseshoe crab abundance come from trawl surveys, where a net is pulled along behind a boat. Both Delaware and New Jersey wildlife agencies have operated trawl surveys since the 1990s, and the States have refined their survey methods over the years to collect more detailed horseshoe crab data. No survey can cover every inch of the waters where the crabs occur. Thus, trawl survey data provide a representative sample that has to be carefully scaled up using mathematical methods to estimate the total number of crabs in the Delaware Bay population.[8]

As far back as 2000, a group of State and Federal fishery scientists identified the "catch survey model" as the best method for estimating the overall population size. These scientists also identified a need for a new trawl survey that would cover the entire range of the Delaware Bay population and that was specifically designed to sample all sex and age classes of horseshoe crabs. Led by an expert team from Virginia Tech, this comprehensive trawl survey has been carried out from 2002 to 2011, and again from 2016 to present, covering the ocean waters from South Jersey to northern Virginia as well as the lower portion of the bay itself.

[8] Based on reports of tagged animals, genetic studies, and other evidence, the Delaware Bay population is understood to include all crabs in New Jersey and Delaware, and a portion of the crabs in Maryland and Virginia.

From 2013 through 2022, only the Virginia Tech data were used to estimate crab numbers, extrapolating the area covered by the trawl samples to produce an overall population estimate. But as part of a 2019 Stock Assessment,[9] fishery scientists revisited the catch survey model that had been originally recommended back in 2000. Although the strength of the Virginia Tech survey is widely recognized, biologists concluded that an index combining both the State data (Delaware and New Jersey) *and* the Virginia Tech data produces the most robust and accurate estimates of crab numbers. Thus, they developed a catch multiple survey analysis (CMSA)—a type of catch survey model—to do just that. No survey is perfect, and by combining all three data sources into a single index, the CMSA largely offsets any weaknesses, biases, or gaps in any one of the surveys. The CMSA accounts for natural mortality, crabs that die in both the bait and biomedical harvests (see Question 10), and crabs that die as a result of bycatch in other fisheries. The CMSA was endorsed by peer review panels in 2019 and again in 2021 as the best method for estimating the size of the Delaware Bay horseshoe crab population.

9. How has the number of crabs in the Delaware Bay population changed over time?

The Delaware Bay population of horseshoe crabs has increased since 2002. As shown in Figure 2, the Virginia Tech trawl data show an overall increasing trend in both male and female adult crabs, particularly considering the most recent results from 2021. Similar to the Virginia Tech results, the two State trawl surveys have both shown increasing trends since the early 2000s.

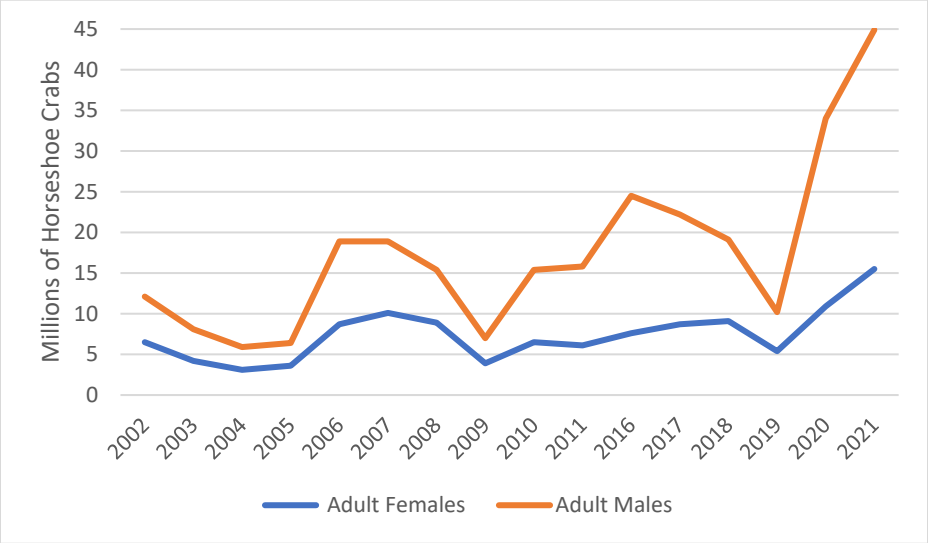

Figure 2. Estimated numbers (millions) of adult horseshoe crabs in the ocean waters from southern New Jersey to northern Virginia based on Virginia Tech trawl data, 2002-2021.
Notes: (1) This chart shows only adult crabs. The complete Virginia Tech report also presents data on younger age classes, as well as levels of statistical certainty associated with these estimates. (2) This chart shows only crab estimates for the ocean waters. The complete Virginia Tech report also presents crab numbers within the lower portion of the Delaware Bay. (3) Going forward, fishery managers are expected to adopt a new method, CMSA, that combines these Virginia Tech data with data from two State surveys to produce a single estimate of population size.

[9] http://www.asmfc.org/uploads/file/5ccae597HSC_StockAssessmentOverview2019.pdf

Going forward, fishery managers are expected to adopt the CMSA as the standard method for estimating crab abundance. Population estimates from the CMSA were relatively low following the period of high bait harvest in the 1990s, averaging approximately 5.1 million females and 9.7 million males from 2003 to 2012. Abundance then increased and has averaged 9.8 million females and 22.4 million males from 2013 to 2021. The 2019 Stock Assessment[9] looked at data from 1998 to 2017 and found the Delaware Bay population to be in "Neutral" condition; however, survey results since that time provide evidence of a long-term population increase.

10. Why are horseshoe crabs harvested from the Delaware Bay population?

Horseshoe crabs are primarily harvested for use as bait by the commercial American eel and whelk/conch fisheries. New Jersey has had a continuing moratorium on the bait harvest since 2008. Since 2013, only male crabs have been allowed to be harvested from the Delaware Bay population for use as bait.

In addition, both male and female horseshoe crabs are collected by the biomedical industry. Biomedical collection, which has not been permitted in Delaware, involves extracting a portion of each animal's blood in a laboratory setting. Following bleeding, the crabs are released alive, and most (70 to 96 percent) are believed to survive the process. Biomedical companies use the blood to produce a product called Limulus Amebocyte Lysate (LAL). In many countries including the U.S., a test using LAL is currently the standard method for screening medical equipment and injectable drugs for bacterial contamination. Next time you get a shot, you can thank a horseshoe crab for making sure it was not contaminated!

11. Who manages horseshoe crab harvest in Delaware Bay?

Since 1998, horseshoe crabs have been managed under an Interstate Fishery Management Plan that covers the Atlantic coast from Maine to Florida. The Plan was developed and adopted by the Atlantic States Marine Fisheries Commission (ASMFC)[10] and carried out by the States. Since 2012, bait harvest in the Delaware Bay Region has been managed under an Adaptive Resource Management Framework (see Question 12). Rules governing crab harvest, as well as annual bait harvest levels, are set by the ASMFC's Horseshoe Crab Management Board, which includes representatives from the relevant Atlantic coast States and Federal agencies. Each State must set fishery regulations that are at least as restrictive as those enacted by the Board, and may voluntarily set more restrictive regulations at its discretion. The Board is advised by several committees and panels, which include agency biologists, other experts, and various stakeholders.

12. What is the Adaptive Resource Management (ARM) Framework?

The ARM Framework is an integrated set of scientific models and fishery management policies used to make annual recommendations that the Board considers when setting horseshoe crab bait harvest levels for the Delaware Bay Region. The ARM Framework uses scientific modeling to guide harvest levels that take the needs of migratory shorebirds into account. The ASMFC, the U.S. Fish and Wildlife Service, the U.S. Geological Survey, and state agencies jointly developed the ARM Framework in recognition of the importance of horseshoe crab eggs to migratory

[10] http://www.asmfc.org/species/horseshoe-crab

shorebirds stopping over in Delaware Bay. The annual recommendation of the ARM Framework is based on the current sizes of the horseshoe crab and rufa red knot populations. A computer model integrates best available scientific information on how horseshoe crab numbers influence knot populations, and how the harvest of crabs in a given year is likely to impact the populations of both species in the future. Based on these forecasts, and on certain embedded value judgements informed by stakeholders, the model recommends an optimal level of harvest. One key value judgement underpinning the ARM Framework is that bait harvest in the Delaware Bay Region must not limit or slow rufa red knot population growth. After a decade of use, the ARM Framework is currently being updated (see Question 14.)

13. How many Delaware Bay horseshoe crabs are harvested for bait each year under the existing ARM Framework?

Under the existing ARM Framework, bait harvest recommendations to the Board are capped at 210,000 female and 500,000 male horseshoe crabs per year. From 2013 to 2022, the existing ARM Framework recommended a harvest of 0 females and 500,000 males, and the Board has adopted these recommendations every year. However, due to a large increase in female horseshoe crabs shown by the Virginia Tech trawl survey in 2021 (see Question 9), the existing ARM Framework now recommends a harvest of 210,000 females and 420,000 males for the 2023 harvest season. The 2023 harvest levels have not yet been set by the Board.

14. Why is the ARM Framework being revised?

Biologists revised[11] the ARM Framework for several reasons: (1) we have gained more data and a better understanding of population dynamics (*e.g.*, birth and death rates) of both species over the last decade; (2) our knowledge and experience with adaptive management and scientific modeling have increased; (3) we identified mathematical problems in the original ARM Framework that needed to be addressed; and (4) the computer software that the original ARM Framework used is obsolete and can no longer be run on current computer operating systems. The ARM Revision includes several important scientific and statistical advances. For example, the revised ARM Framework is now able to explicitly account for horseshoe crab mortality from the biomedical harvest and from bycatch, which the original ARM could not.

15. How will Delaware Bay bait harvest levels change if the ARM Revision is implemented?

The ARM Revision will maintain the same maximum annual cap on the horseshoe crab bait harvest in the Delaware Bay Region (210,000 females and 500,000 males). However, the ARM Revision will result in more gradual adjustments in harvest levels, based on fluctuations in the numbers of both horseshoe crabs and rufa red knots. Under the original ARM Framework, the harvest of females would increase rapidly if crab or knot populations reached specific thresholds. An abrupt jump from zero to the maximum female harvest level is, in fact, poised to occur if the existing ARM Framework remains in place for one more year (see Question 13). Changes in harvest levels will be much less abrupt if the ARM Revision is implemented. Table 1 compares the recommended bait harvest levels from the existing versus the revised ARM Framework for selected years.

[11] http://www.asmfc.org/uploads/file/61f2f18aHSC_ARM_RevisionOverview_Jan2022.pdf

Table 1. Existing versus revised ARM Framework bait harvest recommendations for select years (hindcast, 2017–2019, based on information available in the ARM Revision report)

Year	Existing ARM Females	Existing ARM Males	Revised ARM Females	Revised ARM Males
2017	0	500,000	150,000	500,000
2018	0	500,000	100,000 to 125,000	450,000 to 475,000
2019	0	500,000	100,000 to 125,000	450,000 to 475,000
2023	210,000	420,000	100,000 to 125,000	450,000 to 475,000

16. Is the horseshoe crab harvest impacting rufa red knots under the current ARM Framework? How will that change going forward?

Under the current ARM Framework, horseshoe crab harvest in Delaware Bay is not considered a threat to the rufa red knot because harvest levels are tied to knot populations via scientific modeling. In response to the proposed revision of the ARM Framework, the U.S. Fish and Wildlife Service conducted an Endangered Species Act assessment[7] and found that harvest levels under the ARM Revision pose a negligible risk to the rufa red knot. The assessment compared the model-predicted size of the rufa red knot stopover population under two scenarios: one scenario where bait harvest is guided by the ARM Revision and another scenario where there is no bait harvest at all. The Service found less than a 1 percent chance that bait harvest under the ARM Revision would result in lower knot numbers compared to the "full moratorium" scenario.

Because there is high uncertainty in population projections, the Service's confidence in these model outputs relies on frequent updates. The ARM Revision model is easily updated, and fishery managers have laid out a schedule for regular updates. Data inputs to the model will continue to be updated annually. The fish and wildlife agencies remain committed to ongoing and active participation on ASMFC bodies to ensure that rufa red knot recovery is not hindered by horseshoe crab harvest.

17. What else is being done to conserve horseshoe crabs?

Shortly after development of the Horseshoe Crab Fishery Management Plan, "bait saving" devices were widely adopted by fishers and were credited with reducing harvest levels. In 2001, the National Marine Fisheries Service established the Carl N. Shuster Jr. Horseshoe Crab Reserve,[12] as recommended by the ASMFC. About 30 nautical miles in radius and located in Federal waters off the mouth of the Delaware Bay, the reserve is closed to commercial horseshoe crab harvest except for limited biomedical collection. In 2011, ASMFC issued voluntary Best Management Practices[13] for the biomedical industry, which are currently under review for potential updates.

Various agency review processes, at both the State and Federal levels, often trigger protective measures for horseshoe crabs (*e.g.*, project timing restrictions, ensuring crabs have free passage to and from the beaches, minimizing entanglement hazards) as part of permitting or other government actions. Several States have identified horseshoe crab conservation as a priority in

[12] https://www.govinfo.gov/content/pkg/FR-2001-02-05/pdf/01-2120.pdf
[13] http://www.asmfc.org/uploads/file/5baba561biomedAdHocWGReport_Oct2011.pdf

their Wildlife Action Plans, making the species eligible for various conservation funding programs. Environmental groups are partnering with government agencies to restore many Delaware Bay spawning beaches. Volunteers participate in efforts to count and tag the bay's spawning crabs, as well as programs to rescue crabs that get stranded on the beach or entangled in human debris. Outside of Delaware Bay, agency and non-governmental partners are increasing efforts to document and protect important spawning habitats.

18. What else is being done to conserve rufa red knots?

Environmental groups, researchers, and all levels of government collaborate across borders to identify and address threats to the rufa red knot. For example, efforts are under way to protect and restore habitats, reduce disturbance from human activities, assess collision risks from wind energy development, minimize impacts from aquaculture, reduce hunting and predation pressure, minimize risks from oil spills, abate impacts from red tides, monitor prey resources, characterize red knot genetics, and use the latest technologies to track these wide-ranging travelers on their migratory journeys. Conservation efforts are underway in nearly every part of the range. Many nations, States, and local governments have conservation plans to guide recovery on appropriate geographic scales. For example, the U.S. Fish and Wildlife Service released a draft Recovery Plan[14] in 2021, and the final plan is expected soon. The Service also published a proposed rule in 2021 to designate Critical Habitat[15] for the rufa red knot under the Endangered Species Act.

19. What is being done to improve our understanding of the link between these two species?

The ARM Revision report includes a number of research recommendations to continue refining our understanding of the link between horseshoe crabs and rufa red knots. Horseshoe crab egg data is one prime area for future study. This may include developing standardized methods to reliably sample egg densities on the beaches, and to mathematically relate egg data to other parameters such as horseshoe crab abundance, rufa red knot weight gain, or knot survival. Outside of Delaware Bay, research is underway to identify other areas where horseshoe crab eggs feature prominently in the rufa red knot diet.

20. How can I help rufa red knots and horseshoe crabs?

- Give shorebird flocks plenty of elbow room! Afford rufa red knots a buffer of at least 400 feet when walking, fishing, beach combing, or engaged in other passive activities. This is roughly the length of a football field. Birds need even more space around large crowds of people, vehicles, motorized boats, and aircraft including drones. Never walk, run, or drive through flocks of shorebirds, and don't allow children or dogs to chase birds.

- Respect and adhere to signage limiting certain activities on the beaches, including seasonal beach closures. This also includes obeying signs restricting dogs and vehicles on the beach.

[14] https://www.fws.gov/node/255358
[15] https://www.fws.gov/species-publication-action/endangered-and-threatened-wildlife-and-plants-designation-critical-183

- Obey signs restricting motorized boats in remote coastal areas. If boats are allowed, try to keep at least 500 feet away from bird flocks along the shoreline, and avoid creating wakes at natural inlets.

- We all love our pets! But they can be very intimidating and disruptive to wildlife. If dogs are allowed on the beach, keep them leashed especially when shorebird flocks are present. Even where dogs are allowed, consider leaving your pooch at home when visiting the Delaware bayshore in May or early June.

- Where vehicles are allowed on the beach, avoid driving during the horseshoe crab spawning season from late April through mid-June. Ruts can degrade spawning habitat or unearth crab nests, and vehicles can crush developing crab larvae. And, of course, never run over spawning or stranded crabs!

- If you're a bird watcher or photographer, you can resight and report red knots. But never disturb the birds by getting too close for the sake of that "perfect shot!"
  - Report leg flags at bandedbirds.org, and if you're really enthusiastic also at reportband.gov.
  - Especially outside of Delaware Bay, record all rufa red knot observations at ebird.org.

- Report tagged horseshoe crabs at https://www.fws.gov/crabtag/.

- Do not feed gulls or other wildlife. Don't leave or bury trash or food scraps on the beach.

- Keep cats indoors.

- Volunteer!

  - Volunteer for the Shorebird Project in Delaware

  - Volunteer for the Shorebird Project in New Jersey

  - Help build oyster reefs in New Jersey

  - Count spawning horseshoe crabs[16]

  - Tag horseshoe crabs[16]

  - Flip/rescue horseshoe crabs in New Jersey[16]

  - Flip/rescue horseshoe crabs in Delaware[16]

  - Especially outside of Delaware Bay, volunteer for the International Shorebird Survey.

[16] Due to State regulations, individuals should only handle horseshoe crabs when officially volunteering as part of an organized program.