Conservation STEM in the Classroom: North Atlantic Right Whale

March 2025

New England Aquarium

Protecting the blue planet

ACKNOWLEDGEMENTS

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SECTION 1

Importance of North Atlantic Right Whales within the Atlantic Coast Ecosystem(s)

2023 calf of Catalog #1208 photographed about 40 to 70 miles south of Long Island, N.Y., by the Aquarium's Anderson Cabot Center for Ocean Life aerial survey team. New England Aquarium under NMFS Permit # 25739

DRIVING QUESTIONS AND CONTENT OVERVIEW

What are North Atlantic Right Whales (NARWs) and how do they contribute to a healthy ocean ecosystem? Why is it important to conserve them?

NARWs are a cetacean species that inhabit the Atlantic coastal and offshore waters from eastern Florida to Canada. Like other whales, NARWs are valuable in maintaining ocean health and biodiversity, including through their role in nutrient dispersal and cycling, which contributes to the biological carbon pump that enhances phytoplankton growth and sequesters carbon at depth. They do so by redistributing some nutrients through their fecal plumes after feeding on nutrient-dense copepods as well as by providing nutrients to the deep-ocean ecosystem when they sink after death. Overall, NARWs and other whales benefit ecosystems by helping to sustain productivity in regions where they occur in high densities. Learn more throughout this curriculum and in this brief overview: Components of a Healthy Ocean Ecosystem.

STANDARDS & PRACTICES ADDRESSED

NGSS Standards

- **HS-LS2-6:** Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
- **HS-LS2-8:** Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.

Massachusetts 2016 STE Standards

- **HS-LS2-1:** Analyze data sets to support explanations that biotic and abiotic factors affect ecosystem carrying capacity.
- **HS-LS2-6:** Analyze data to show ecosystems tend to maintain relatively consistent numbers and types of organisms even when small changes in conditions occur, but that extreme fluctuations in conditions may result in a new ecosystem. Construct an argument supported by evidence that ecosystems with greater biodiversity tend to have greater resistance to change and resilience.

Science/Engineering Practices

- Asking questions (for science) and defining problems (for engineering)
- Constructing explanations (for science) and designing solutions (for engineering)
- Obtaining, evaluating, and communicating information

DESIRED OUTCOMES

- Students will learn about healthy ocean ecosystems, including how nutrients such as carbon, nitrogen, and phosphorus move within them.
- Students will note the ways in which nutrients are transferred between different parts of the environment, from living things to living things, and ways in which they are stored, and the role that NARWs play in this process.
- Students will understand and be able to explain the role of the Biological Carbon Pump in the maintenance of a healthy ocean ecosystem as well as the role that upwelling and the whale pump provide.

A surface active group with right whales Cascade and Catalog #3740. Photo: New England Aquarium under NMFS Permit #25739.

EDUCATOR BACKGROUND INFORMATION

Important Terms and Concepts

Term	Definition
Euphotic Zone	"Sunlight zone," up to 200-meter depth. This is where photosynthesizing organisms can function in the ocean ecosystem. Also called the "photic zone."
Disphotic Zone	Depths ranging from 200–1,000 meters where light penetration decreases in intensity with increasing depth. Photosynthesis is possible in this zone, but its productivity is very low, so this zone relies on primary productivity from the euphotic zone. Also called the "twilight zone."
Aphotic Zone	1,000 meters and below that represent depths with little to no penetrating sunlight. There is no primary productivity on average, and food and nutrients fall into this zone as "marine snow." Also called the "midnight zone."
Whale Falls	The sinking of deceased whales to the ocean bottom.
Marine Snow	Particulate organic material falling from shallow depths to the deep ocean. This material is composed of feces, leftover food from consumption, dead organisms, suspended sediments, and various other organic materials.
Zooplankton	A diverse group of mostly tiny animals, such as fish crustaceans, jellies, and protists, found in the water of oceans, bays, and estuaries. Zooplankton includes krill, copepods, isopods, and even jellyfish.
Phytoplankton	Microscopic plants and other photosynthetic organisms, like cyanobacteria and algae, are capable of converting sunlight and carbon dioxide into food and produce oxygen.
Continental Slope	A steeply sloping seafloor that lies between a continental shelf and a deep ocean basin.
Biological Carbon Pump	The sequestration of carbon and other nutrients from the atmosphere, land runoff, and living organisms in the ocean's depths and sediment on the seafloor. Carbon and other nutrients are removed from the euphotic zone through the sinking of organic particles and animal waste, and the vertical movement of marine animals through their activity or sinking after death.
Whale Pump	The cycling of nutrients by whale feeding and waste elimination enhances the primary productivity in feeding areas by concentrating nitrogen near the surface through the excretion of wastes (e.g., feces, urine).
Sequestration	The process of capturing and storing nutrients, often in large quantities over long periods of time. Such nutrients are stored in cold water, soil and rocks, and living plants and animals, for example.
Upwelling	Occurs when winds push surface seawater away from the shore and colder, deeper, nutrient-rich seawater moves upward to replace the displaced water.

BIOLOGICAL CARBON PUMP AND PROCESSES

The whale pump and upwelling play a crucial role in enhancing the biological carbon pump by delivering essential nutrients to the euphotic zone, where they fuel photosynthesis. These processes ensure the continuous flow of energy from surface waters to deeper ocean zones and higher trophic levels, sustaining marine ecosystems. Additionally, they support coastal species by maintaining nutrient availability, which stimulates primary productivity and preserves the food web. Understanding these mechanisms helps students appreciate the delicate balance required to keep our ocean vibrant and thriving.

Protecting and conserving healthy whale populations is essential for maintaining biodiversity and the overall health of ocean ecosystems. Whales contribute significantly to nutrient and energy cycling by transporting nutrients from deep waters to the surface, boosting phytoplankton productivity. Similarly, upwelling—an oceanic process—brings deep-sea nutrients to sunlit surface waters, providing a vital resource for photosynthetic organisms. These nutrient cycling processes sustain primary production, fueling marine food webs and transferring energy through higher trophic levels. Additionally, the biological carbon pump moves carbon to the ocean floor, supporting long-term carbon sequestration. By enhancing nutrient cycling and phytoplankton growth, the whale pump and upwelling play a critical role in maintaining a productive and resilient marine ecosystem.

The Biological Carbon Pump

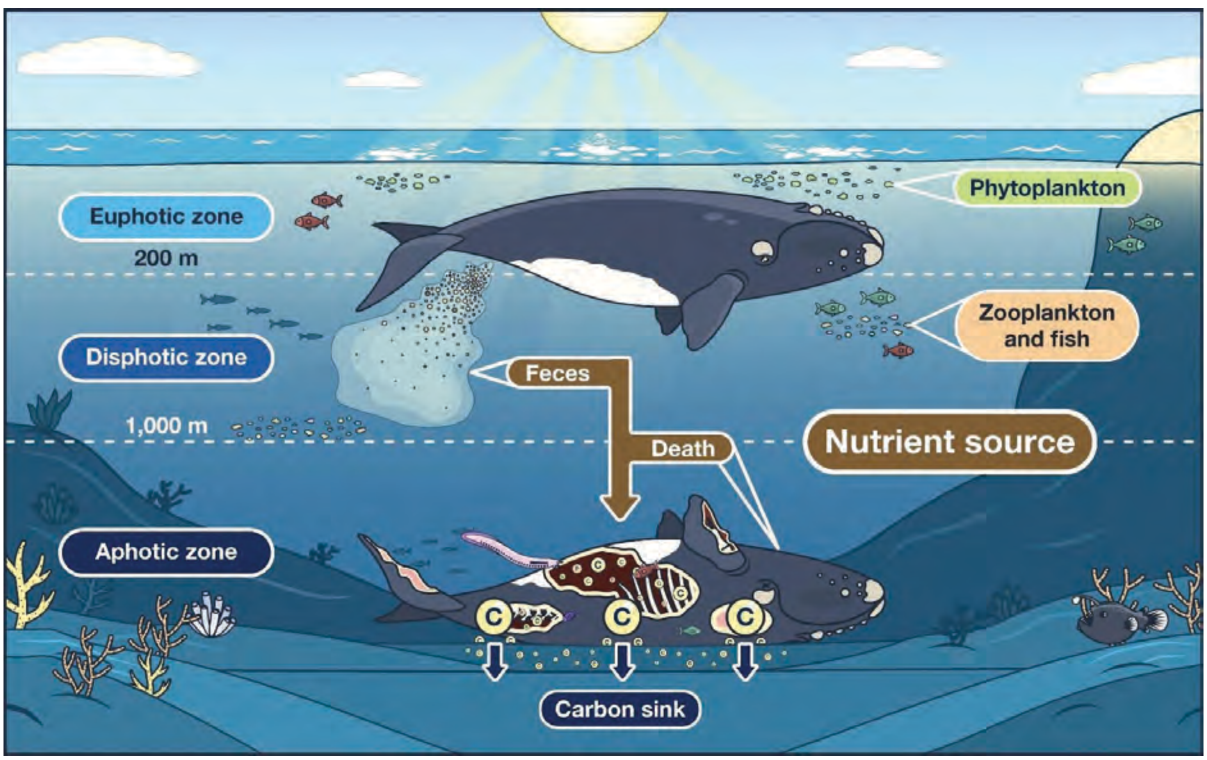


Figure 1: The biological carbon pump removes nutrients from the euphotic zone. Nutrients that are stored in the cells and tissues of living things and in feces sink to the ocean floor when organisms die or excrete waste. Large animals like whales store a lot of nutrients, which sink to the deep ocean floor when the animal dies. These whale falls are rare and create an oasis for marine life. Deep-sea organisms, including microorganisms like bacteria, use the carcass as a habitat and feed on and degrade, or break down, its organic matter. This process takes nutrients that were once in the euphotic zone and moves them to the aphotic zone, where they can be used by deep-sea organisms. Some of the nutrients will be released to the nearby deep seawater during the bacterial degradation of the whale carcass.

The Whale Pump (Animation)

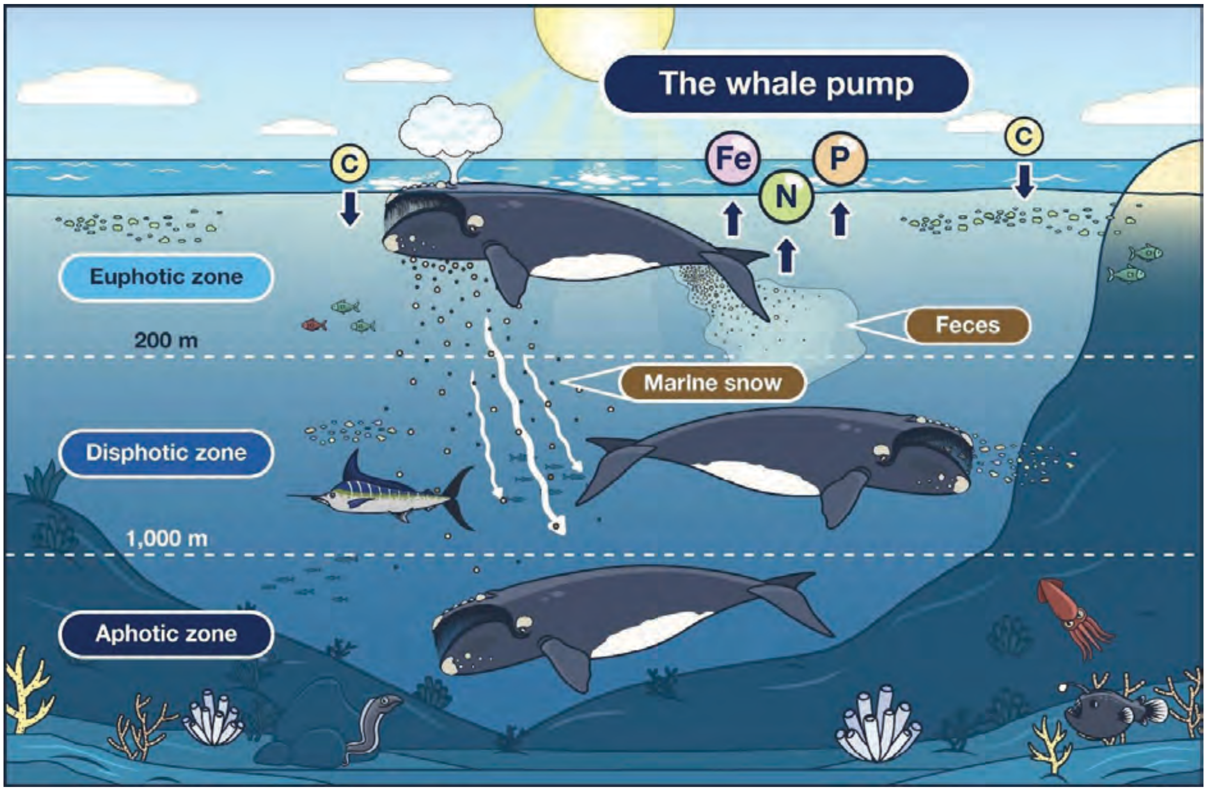


Figure 2: The process of the whale pump enriches the surface waters with essential nutrients, enhancing the ocean's biological carbon pump. Whales primarily feed in the euphotic and disphotic zones. However, some species can feed much deeper. They consume zooplankton and other prey that have nutrients from phytoplankton. When whales return to the surface to breathe, they defecate and release nutrient-rich waste. This waste enriches the surface waters with essential nutrients, promoting phytoplankton production. Please note, NARWs do not dive deep into the water column, while other whale species, such as sperm whales, can dive upwards of 2,000 meters.

Upwelling

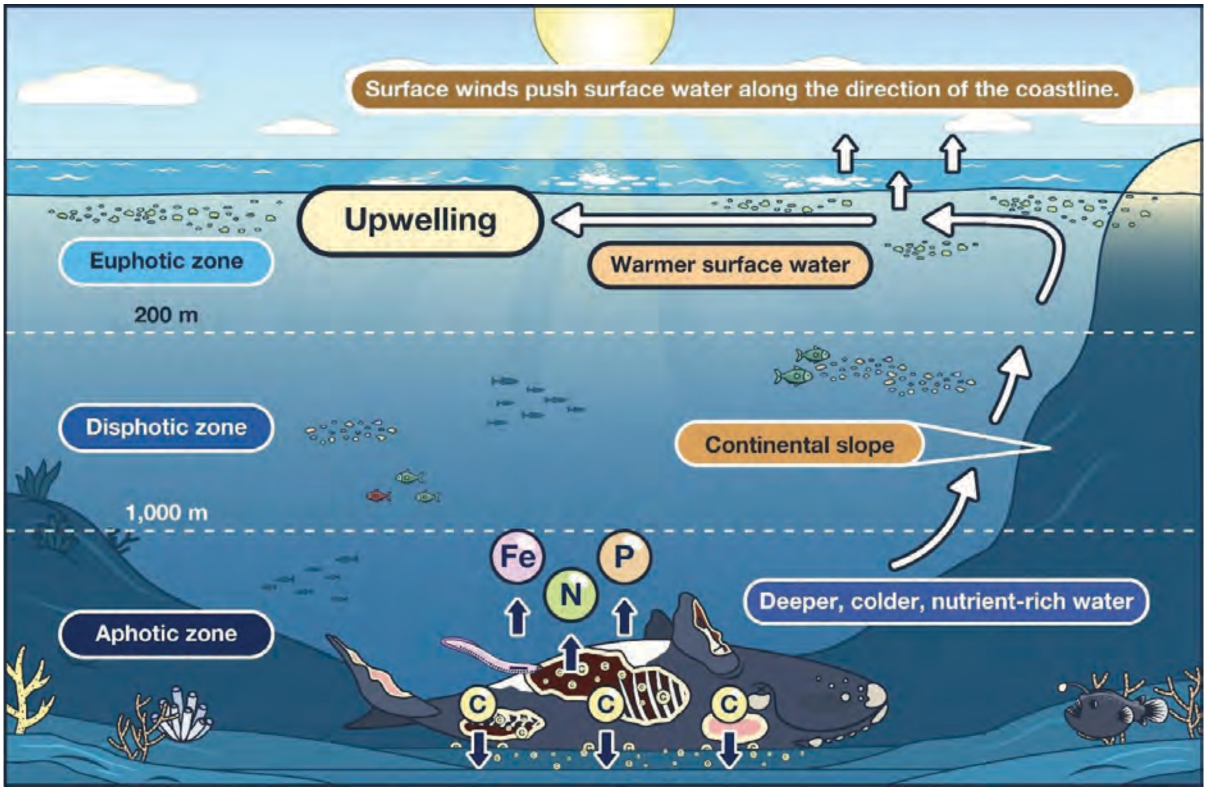


Figure 3: Upwelling brings ocean floor nutrients from the aphotic zone to the euphotic zone. Upwelling is the process by which nutrient-rich water from the deep aphotic zone rises to the surface when air-driven ocean currents move surface water along the coast. This causes cold, salty, deep seawater to rise and flow up the **continental slope** to coastal waters and replace the water that was pushed away. On its path, this influx of deep seawater moves along the ocean floor of the continental slope, where it is further enriched with nutrients that are released from the microorganism degradation of organic matter deposited on the ocean floor. The upwelled seawater supports large populations of phytoplankton in the euphotic zone, which in turn sustains a healthy ecosystem.

LEARNING PLAN

1. Build background knowledge of ocean ecosystems

a. Jigsaw Reading

- Print copies of pages 7–12 of the Ocean Literacy Student Pages.
- Assign students to jigsaw groups. Each “home” group will read one page of this resource and discuss the content.
- Now have students work in jigsaw groups. These jigsaw groups will each have one student per page represented so that the content of the full packet is represented. Students will share the most essential information that was discussed with their “home” group.
- Have students share as a whole class what they learned about the ocean and why this information is important. Record student answers on an Anchor Chart.

North Atlantic right whale "Butterfly" (Catalog #1425) and her calf were spotted 15 miles SE of Jonesport, Maine by the Aquarium's Anderson Cabot Center for Ocean Life aerial survey team. NMFS permit #25739

2. Understand the importance of North Atlantic Right Whales to healthy ocean ecosystems

a. Show aerial photo of cows and calves to introduce NARWs to students. Share with students that these whales were named Right Whales because, historically speaking, they were considered "the right whales" to hunt. They are relatively slow moving, live close to the shore, and their blubber and baleen were profitable, making them valuable to whale fishermen.

b. While projecting the image, ask students, "What can you notice about these animals?" Allow students to discuss in pairs. Record students' observations on Anchor Chart labeled North Atlantic Right Whales.

c. Provide students with the North Atlantic Right Whale Basic Biology handout (see Appendix; adapted from NOAA Fisheries) as a resource. Explain to students that this is our state marine mammal, and an important part of our ocean ecosystem.

d. Present this animation provided by the New England Aquarium to the whole class about healthy ocean ecosystems, the whale pump, upwelling, and the overall biological carbon pump. Ask students to take notes on how nutrients are being cycled within the ecosystem.

e. Provide a word bank that includes the terms upwelling, whale pump, and biological carbon pump to assist students with their note taking.

f. Pause for questions and observations from students and include these observations on the NARW Anchor Chart.

Allow students to explore the following curated resources and collect the observations using their notebooks:

1. Figures 1–3 (above)
2. Table of Important Terms and Concepts (above)
3. NARW critical habitat map from NOAA
4. Right Whale FAQs from New England Aquarium
5. North Atlantic Right Whale Calving Season Page from NOAA
6. North Atlantic Right Whale Information Page from Marine Mammal Commission

Provide students with the following questions to guide their research:

- Why are NARWs important to the ecosystem?
- How do NARWs contribute to nutrient cycling in the ocean?
- What other factors contribute to nutrient cycling in the ocean?
- Why should we work to protect this species and attempt to recover their population numbers?

3. Summarize using Chalk Talk

a. Write one guiding question from above on each large chart paper. Allow students time to engage in a Chalk Talk to collect their ideas. Remind them that even though this is a silent protocol, they can add on and react to each other's comments on Chalk Talk. Have students read what others wrote and ask them to summarize ideas from the Chalk Talk.

4. Think, Write, Pair, Share Protocol: Go to this webpage about our National Marine Sanctuary, Stellwagen Bank. Choose an animation, image, or video to project to your class from the provided resources on the website. Have students do a quick write to record thoughts, questions, and reactions in their science notebook for 3–4 minutes. Allow them a few minutes to discuss after writing and collect questions that they have. Remind them of the term "upwelling" from the animation provided earlier and explain that this area, Stellwagen Bank, has abundant sea life because of its unique geology and productive ecosystem.

5. Fishbowl Reflection: In a Fishbowl format, have students discuss the following guiding questions and resources:

Guiding questions:

- How do NARWs contribute to the health of their ocean ecosystem?
- How do the whale pump and upwelling provide nutrients to the ecosystem?
- What does that make you think about or want to do?
- Why should we work to protect NARWs and attempt to recover their population numbers?

Suggested Student Resource for Fishbowl Discussion

- Right Whale FAQs from New England Aquarium (see especially the General and Saving the Species sections)

Have students add new thinking to the Chalk Talk posters.

SECTION 2

Current Threats to the North Atlantic Right Whale Population

"FDR" (Catalog #4057) photographed on August 13, 2016, in the Bay of Fundy. FDR was entangled in a large amount of fishing gear but was successfully disentangled by the Campobello Whale Rescue Team. Unfortunately, FDR had suffered a previous severe entanglement in 2014 as well. He has not been seen since he was freed of this gear. Photo: Brigid McKenna. Photo: New England Aquarium collected under permits issued by Canadian DFO under the Species at Risk Act.

DRIVING QUESTIONS AND CONTENT OVERVIEW

- What are the current threats to NARWs? How do these threats impact NARW populations?
- North Atlantic Right Whales are critically endangered with approximately 370 individuals left in the population (as of October 2024), including about 70 reproductively active females.
- The biggest current threats to NARW populations are entanglements in fishing gear and vessel strikes throughout their migratory range.
- NARWs are found in near-coastal waters, which have high levels of vessels and fishing activities. Their proximity to these activities has given them the nickname of "Urban Whale."
- NARWs feed mainly on copepod plankton patches, which can be found throughout the water column and sometimes at the surface. This feeding approach of slowly "grazing" on these plankton patches contributes to their susceptibility to threats.
- Climate change has impacted the range and habitat use patterns of NARWs, which has increased the frequency of negative impacts.
- These factors threaten NARW populations and their ability to survive and reproduce.

STANDARDS & PRACTICES ADDRESSED

NGSS Standards

- **HS-LS2-1:** Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.
- **HS-LS2-2:** Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.
- **HS-LS2-6:** Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

Massachusetts 2016 STE Standards

- **HS-LS2-1:** Analyze data sets to support explanations that biotic and abiotic factors affect ecosystem carrying capacity.
- **HS-LS2-2:** Use mathematical representations to support explanations that biotic and abiotic factors affect biodiversity, including genetic diversity within a population and species diversity within an ecosystem.
- **HS-LS2-7:** Analyze direct and indirect effects of human activities on biodiversity and ecosystem health, specifically habitat fragmentation, introduction of non-native or invasive species, overharvesting, pollution, and climate change. Evaluate and refine a solution for reducing the impacts of human activities on biodiversity and ecosystem health.

Science/Engineering Practices

- Asking questions (for science) and defining problems (for engineering)
- Developing and using models
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations (for science) and designing solutions (for engineering)
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

DESIRED OUTCOMES

- Students will determine that the natural behavior of NARWs, specifically their habitat use, migration routes, and tendency to live and travel near the coastlines and near the surface, greatly increases their risk of vessel strikes.
- Understand anthropogenic (human-caused) threats to NARWs that impact NARW populations as well as the cultural, societal, and economic issues related to conservation.
- Students create a model using given resources to predict outcomes related to extinction for the species.

EDUCATOR BACKGROUND INFORMATION

Important Terms and Concepts

Term	Context/Meaning
Unusual Mortality Event (UME)	• The Marine Mammal Protection Act defines a set of multiple strandings to be part of a UME if it is unexpected, involves a significant die-off of any marine mammal population, and demands immediate response. • Increased efforts to examine carcasses and live stranded animals, and new diagnostic capabilities have improved knowledge of mortality rates, patterns, and causes, allowing a better understanding of population threats and stressors and better ability to determine when a situation is "unusual." • According to the Working Group on Marine Mammal Unusual Mortality Events, any of the following seven criteria may indicate a UME: 1. A marked increase in the magnitude or a marked change in the nature of morbidity in regard to mortality or strandings when compared with prior records. 2. A temporal change in morbidity, mortality, or strandings is occurring. 3. A spatial change in morbidity, mortality, or strandings is occurring. 4. The species, age, or sex composition of the affected animals is different than that of animals that are normally affected. 5. Affected animals exhibit similar or unusual pathologic findings, behavior patterns, clinical signs, or general physical condition (e.g., blubber thickness). 6. Potentially significant morbidity, mortality, or stranding is observed in species, stocks, or populations that are particularly vulnerable (e.g., listed as depleted, threatened, or endangered or declining). For example, stranding of three or four right whales may be cause for great concern whereas stranding of a similar number of fin whales may not. 7. Morbidity is observed concurrent with or as part of an unexplained continual decline of a marine mammal population, stock, or species. 8. More info available at: https://www.federalregister.gov/documents/2006/12/14/E6-21300/marine-mammals
Climate Change	A long-term change in the average temperature, wind, humidity, and precipitation that an area receives over a decade. This is caused by natural processes and human activities. (New England Aquarium Resource: Climate Change and the Ocean)
Potential Biological Removal (PBR)	The potential biological removal level is the maximum number of deaths annually, not including natural deaths, that a marine mammal population may experience and still reach and/or maintain its optimum sustainable population size.

Researchers with the New England Aquarium's Anderson Cabot Center for Ocean Life conduct fieldwork to study North Atlantic right whales. Photo: Lauren Owens Lambert

HYPOTHESIZED COMPONENTS OF UME

Since mortalities and serious injuries contributing to the UME are occurring in both Canada and the United States, both countries are using mitigation measures to conserve NARWs. This curriculum is focused on U.S. actions. Hypothesized causes of the UME include climate change and resulting distribution shifts as well as increased vessel strikes and entanglements due to distribution shifts and the distribution of NARWs in areas with high densities of fixed fishing gear and vessel traffic, leading to strikes and entanglement throughout their range (brief animation).

The data suggest (but are not corroborated yet) that climate change is increasing the amount of vessel strikes that NARWs are facing. Due to oceanic temperature changes, the timing of their habitat use is changing, and they are being found to congregate in new areas where seasonal protections may not be in place. This can result in increased interactions between vessels and the whales, increasing the frequency of vessel strikes and potential threats to individuals and the population as a whole.

While entanglements have been a consistent threat to NARWs, distribution shifts into areas with no or ineffective mitigation measures present additional challenges to the recovery of this species. Even when strikes and entanglements do not result in death, they can still have sublethal impacts on the whales, including infection, reduced reproductive output, and reduced long-term survival.

Contributors to UME

Climate Change:	Whale Distribution Shift:
Climate change is altering ocean temperatures and currents, which affects the distribution of the NARWs’ primary food source, copepod blooms.	The Gulf of Maine, located on the northeastern coast of North America and a historically important feeding area for NARWs, warmed quickly, and as a result, copepod blooms declined. In response, the whales shifted to more northern feeding habitats, including the colder, more nutrient-rich waters of the Gulf of St. Lawrence, located off the coast of eastern Canada, as well as to areas off southern New England and the mid-Atlantic coast of the U.S.
Increased Vessel Strikes and Entanglements:	**Overlap between NARW Distribution and Fishing Gear/VesselTraffic:**
When NARWs shifted their distribution to the Gulf of St. Lawrence and southern New England, they left a habitat with established protection measures for areas with little to no protections. As a result, they experienced a higher number of fatal or serious vessel strikes and entanglements in fishing gear over a relatively short period of time (e.g., five vessel-strike deaths, four documented entanglement deaths, and six entanglement-related injuries in 2017).	The threat of vessel strikes and entanglements in fishing gear for NARWs is not only due to their shifting distribution. Historical and emerging NARW distributions overlap with both high densities of fixed fishing gear and high densities of vessel traffic, leading to entanglements and vessel strikes throughout their range, which have been occurring for decades.

Impacts

Lethal Impacts:

- Death from vessel strike and entanglement trauma, infection, exhaustion, starvation, or orphaning (inability to survive without mom due to starvation or predation)

Sublethal Impacts:

- Open wounds and risk of infection
- Reduced mobility
- Inability to feed properly
- Lower reproductive ability of impacted females (increased stress causes lowered reproductive output)
- Lower reproductive potential (losing potential calves that mother could have had in the future)
- Low genetic diversity

Potential Biological Removal (PBR)

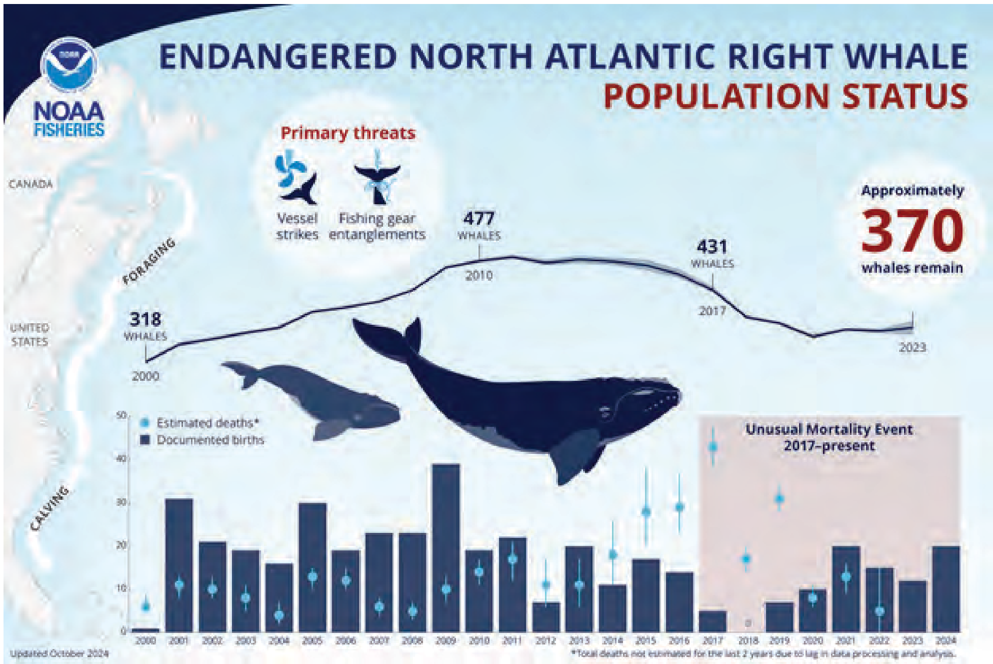
PBR is the product of the following factors: (A) The minimum population estimate of the stock, and (B) One-half the maximum theoretical or estimated net productivity rate of the stock at a small population size.

- More simply, PBR is the maximum number of deaths annually, not including natural deaths, that a marine mammal population may experience and still reach and/or maintain its optimum sustainable population size.
- Current NARW PBR is 0.7 individuals. A single loss of a whale due to human causes in a given year is considered too great for species recovery.

Solutions

Both the U.S. and Canada have responded to mitigate whale losses:

- Canada has implemented mandatory speed restrictions, including in the Gulf of St. Lawrence, in response to the increased presence of whales there.
- In the U.S., the National Oceanic and Atmospheric Association (NOAA) aims to implement additional mandatory speed restrictions in broader areas (a maximum of 10 knots over the ground), change the timing of restrictions (when in the year they occur), and require vessels as small as 35 feet to abide by these restrictions.
- Both Canada and the U.S. are working with fishers and researchers to develop and test on-demand (also known as "ropeless") fishing gear to reduce the amount of rope used in fishing, as well as "weak" rope that breaks apart more easily, to reduce the risk of severe injury.



Potential Challenges

Some students may not agree with the assessments and ideas that are developed. They may argue that whales can always dive below the surface and/or can hear/see ships moving in the water and simply get out of the way. Encourage students to explore these ideas using these considerations:

- The limited depth of the coastline;
- Individual whales may be too young to understand the risk ships present;
- Sound travels long distances in water, and coastlines will be very noisy for whales, making it difficult to determine if boats are close or present imminent danger;
- Whales may not be fast enough to get out of the way in time;
- Whales may be too young to dive deep enough to get out of the way; and
- Cows may be more concerned with protecting their young or may be in a situation where they cannot flee, such as when nursing, defending against calf predators, or in the process of giving birth.

LEARNING PLAN

1. Summarize previous learning and introduce a new topic: We have been exploring how NARWs are critical to the biodiversity of a healthy and thriving ocean. NARWs are considered critically endangered, meaning they have a high risk of extinction. Now we will identify their greatest threats and consider some sustainable solutions to their potential extinction.

2. Introduce the concept of Unusual Mortality Events using New England Aquarium's Unusual Mortality Event animation. Project animation and pause for questions as needed. Have students discuss in pairs or small groups: What is an Unusual Mortality Event? What appear to be the primary threats to NARWs according to this animation?

3. Record ideas on an Anchor Chart labeled "NARW Unusual Mortality Event." Include a definition of UME as well as what students have learned from the animation.

Consider creating a visual word wall, or having students create one, to support learners with UME vocabulary:

- Unusual mortality event
- Vessel strike
- Entanglement
- Critical habitat
- Migratory route
- Climate change

4. Provide students with guiding questions to help them focus their research. Furnish them with the curated resources that show UMEs of NARWs.

Guiding Questions:

- What are the critical threats to NARW survival?
- What factors have contributed to the trend of NARW mortality from 2017 to the present?
- How are human interactions with NARWs impacting their survival and reproduction?
- NARWS are critically endangered. How likely is it, given the data, that they will be extinct in the next 20 years? How does the data support your answer?

Suggested Student Resources:

- Population Status graphic (above)
- NOAA North Atlantic Right Whale: Road to Recovery
- 2017–2025 NARW Unusual Mortality Event Website NOAA
- Right Whale FAQs from New England Aquarium (see especially the Pregnancy and Calving, Entanglement, Vessel Strikes, and Science and Research sections)
- NOAA Reducing Vessel Strikes webpage
- WhaleMap

5. Develop a mathematical model to predict outcomes for NARWs.

Please consider:

- NARWs are critically endangered, with approximately 370 individuals left in the wild (as of October 2024), including about 70 reproductively active females.
- The potential biological removal level (PBR) is the product of the following factors: (A) The minimum population estimate of the stock, and (B) One-half the maximum theoretical or estimated net productivity rate of the stock at a small population size.
  - » More simply, PBR is the maximum number of deaths annually, not including natural deaths, that a marine mammal population may experience and still reach and/or maintain its optimum sustainable population size.
  - » Current NARW PBR is 0.7 individuals. A single loss of a whale due to human causes in a given year is considered too great for species recovery.

Guiding questions:

- How likely is it, given the data, that NARWs will be extinct in the next 20 years? How does the data support your answer?

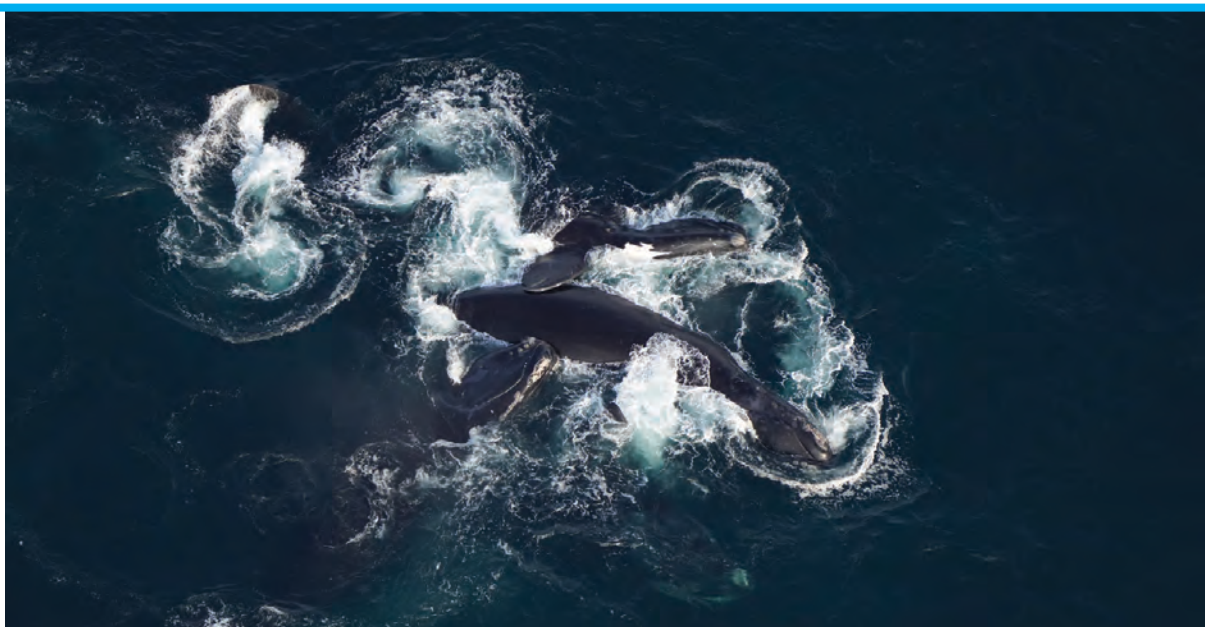
Ask students to share their answers as well as the model they created and evidence they used.

**For examples and guidance with population-based mathematical models, please consider these resources:*

- Population Growth from MishDoesMath
- Learning the Math of Population Models from LibreTexts Biology

SECTION 3

The Future of North Atlantic Right Whales



A surface active group with right whales Giza (#3020), Tux (#3401) and #3611. Photo: New England Aquarium under NMFS Permit # 25739

DRIVING QUESTIONS AND CONTENT OVERVIEW

- How do we conserve NARWs? What actions are currently taking place by conservation scientists? What more can be done? How do we protect and conserve a critically endangered species while still meeting societal needs?
- NARW population size is low, and the species is classified as critically endangered, according to the Endangered Species Act and the International Union for Conservation of Nature, due to human activities. Fishing gear entanglements and vessel strikes impact whales both directly and indirectly by either killing individuals, lowering general health, or lowering reproductive ability.
- The National Oceanic and Atmospheric Administration (NOAA) is charged by the Marine Mammal Protection Act (1972; MMPA) and the Endangered Species Act (1973; ESA) to create policies that protect endangered marine animals, such as NARWs.
- NOAA has developed recovery strategies that attempt to address threats to NARWs and, therefore, increase their population and improve their health. NOAA's existing vessel speed restrictions (since 2008) mandates that vessels greater than or equal to 65 feet long must slow to 10 knots or less in seasonal NARW active areas. Due to limited effectiveness of the current restrictions, changing migratory patterns, and other factors, NOAA has recommended expanding the current restrictions to more effectively protect NARWs.
- Efforts are also underway to improve fishing gear and implement measures that will reduce the risk of whale entanglement.

STANDARDS & PRACTICES ADDRESSED

NGSS Standards

- **HS-LS2-6:** Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
- **HS-LS2-7:** Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
- **HS-LS4-6:** Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.

Massachusetts 2016 STE Standards

- **HS-LS2-6:** Analyze data to show ecosystems tend to maintain relatively consistent numbers and types of organisms even when small changes in conditions occur but that extreme fluctuations in conditions may result in a new ecosystem. Construct an argument supported by evidence that ecosystems with greater biodiversity tend to have greater resistance to change and resilience.
- **HS-LS2-7:** Analyze direct and indirect effects of human activities on biodiversity and ecosystem health, specifically habitat fragmentation, introduction of non-native or invasive species, overharvesting, pollution, and climate change. Evaluate and refine a solution for reducing the impacts of human activities on biodiversity and ecosystem health.

Science/Engineering Practices

- Asking questions (for science) and defining problems (for engineering)
- Analyzing and interpreting data
- Constructing explanations (for science) and designing solutions (for engineering)
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

DESIRED OUTCOMES

- Review and evaluate current and proposed mitigation strategies for NARW conservation.
- Investigate stakeholder perspectives on restrictions and policies.
- Analyze the role of governmental and non-governmental organizations in conservation policy.
- Debate proposed policy changes and develop evidence-based arguments.
- Develop solutions that support conservation efforts with economic considerations.

EDUCATOR BACKGROUND INFORMATION

Important Terms and Concepts

<table>
<tr><th>Term</th><th>Context/Meaning</th></tr>
<tr><td>Marine Mammal Protection Act (MMPA)</td><td>Enacted in 1972 in response to increasing concerns among scientists and the public that significant declines in some species of marine mammals were caused by human activities.
MMPA established a national policy to prevent marine mammal species and population stocks from declining beyond the point where they ceased to be significant functioning elements of the ecosystems of which they were a part.
MMPA was the first legislation to mandate an ecosystem-based approach to marine resource management.
Among other directives, MMPA prohibits, with certain exceptions, the “take” of marine mammals in U.S. waters and by U.S. citizens on the high seas.
Under MMPA, “take” means to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill marine mammals.
NOAA is responsible for the protection of whales, dolphins, porpoises, seals, and sea lions.
The U.S. Fish and Wildlife Service (USFWS) is responsible for the protection of walruses, manatees, sea otters, and polar bears.</td></tr>
<tr><td>Endangered Species Act (ESA)</td><td>Enacted in 1973 in recognition that the natural heritage of the U.S. is of “esthetic, ecological, educational, recreational, and scientific value to our nation and its people” and due to the understanding that many of our nation’s native plants and animals would become extinct without protection.
ESA protects critical habitats of species determined to be threatened or endangered.
Critical habitats are geographical areas occupied by or otherwise essential to conservation of those species.
Endangered species are in danger of extinction throughout all or a significant portion of their range.
Threatened species are likely to become endangered in the foreseeable future throughout all or a significant portion of their range.
ESA also prohibits the unauthorized “take” of endangered/threatened species.
Under the ESA, “take” means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct.
NOAA is responsible for protection of marine and anadromous species.
USFWS is responsible for protection of terrestrial and freshwater species.</td></tr>
</table>

NOAA VESSEL SPEED RESTRICTION RULE

<table>
<tr><th>Existing Rule (source)</th><th>Proposed Changes to Rule (source)</th></tr>
<tr><td>

Vessels 65 feet or longer are already required to slow to 10 knots (about 11.5 mph) when NARWs are expected to be present in an area.
Vessels 65 feet or longer must adhere to speed limit rules in Seasonal Management Areas (SMAs), areas that are likely to have NARWs present due to their use of this environment through their life cycles, such as critical habitats and migratory routes.

Established SMAs:

» Calving grounds: South Carolina, Georgia, eastern side of Florida
» Feeding grounds: New England to Canada
» Within 20 nautical-mile radius of port entrances along migratory route between two above critical habitats

Vessels 65 feet or longer are suggested but not required to adhere to speed limit restrictions in Dynamic Management Areas (DMAs), voluntary slow zones that are triggered when a group of three or more NARWs are sighted in close proximity. A slow zone is triggered and vessels are requested to reduce transit speeds to 10 knots or avoid the area for 15 days, but that timeframe may be extended if there is continued whale activity in the area.

</td><td>

Expand the areas and timing of seasonal speed restrictions and SMAs to better reflect NARW habitat use.
Extend the restrictions to vessels measuring 35 feet and longer.
Implement mandatory speed restrictions in DMAs.

</td></tr>
</table>

NOTE: Currently, mandatory speed restrictions for vessels 65 feet long or longer of 10 knots or less are required in SMAs along the U.S. East Coast during seasons when NARWs are likely to be present. Safety considerations allow vessels to exceed this speed to maintain safe maneuvering speeds in SMAs but must enter the following into their logbook: reason for deviation, speed at which vessel was operated, and latitude/longitude at time of deviation. The master of the vessel must sign and date logbook entry. Some vessels are exempt from the speed rule: military vessels; vessels owned, operated, or contracted by the federal government; and state law enforcement vessels engaged in enforcement or search and rescue activities.

SUMMARY OF STAKEHOLDERS

- **Congress:** Members of the U.S. House of Representatives and U.S. Senate, which authorized the MMPA and ESA. Specifically, the House Committee on Natural Resources and the Senate Committee on Commerce, Science, and Transportation oversee the proposed legislation that may affect NOAA and actions by NOAA. Through this oversight authority and the Congressional Review Act, these congressional committees may review NOAA's regulatory decisions.

- **The White House:** Prior to final publication, the White House, specifically the Office of Management and Budget's Office of Information and Regulatory Affairs, reviews all rulemaking to ensure the parent agency, in this case NOAA, has complied with relevant regulatory requirements and reviews alignment with the President's policies.

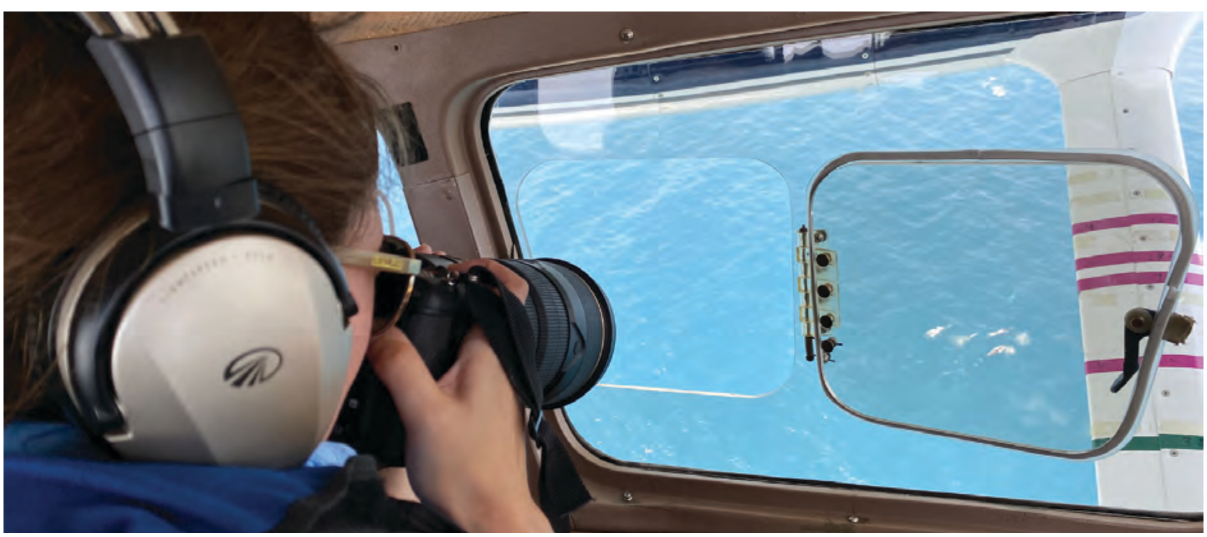
- **NOAA:** The National Oceanic and Atmospheric Administration's mission is to understand and predict changes in climate, weather, ocean, and coasts; to share that knowledge and information with others; and to conserve and manage coastal and marine ecosystems and resources.

- **Shipping Industry:** These are businesses and organizations that contribute to the import and export of goods through ports along the U.S. coast.

- **Fishing Industry:** These are businesses and organizations that collect wild and farmed fish, crustacean, mollusk, and seagrass species.

- **Maritime Community:** Members of the public including those that live, recreate, or rely on the coastal ecosystem. This includes small businesses that operate on the coast (such as chartered tour and fishing vessels) or interact with coastal-dependent industries and individuals with personal interest in coastal policy.

- **Conservation Organizations:** These include advocacy, research, and scientific organizations (such as the New England Aquarium) that are dedicated to scientific research and/or advancing environmental, ocean, and animal conservation.



A researcher with the Aquarium's Anderson Cabot Center for Ocean Life aerial survey team takes photos during a June 2020 aerial survey. Photo: Orla O'Brien

SUMMARY OF ARGUMENTS FOR AND AGAINST THE PROPOSED SPEED RULE MADE AT CONGRESSIONAL HEARING

NOAA	Opposition(s) to Proposed Rule

• A single human-caused death per year is considered too high for supporting the recovery of NARWs. Increasing restrictions to limit vessel strikes is NOAA's obligation under the Endangered Species Act and Marine Mammal Protection Act.
  ◦ If more than one NARW dies per year, we can expect functional extinction (population too small to recover) by 2037
  ◦ Vessel strikes disproportionately impact cows/calves (due to spending more time at the surface resting), and females have biggest impacts in a population (for example, one mother produced at least 30 whales into the population in the form of children/ grandchildren/great- grandchildren)
• Documented vs Actual Mortality: Documented Mortality is estimated as only representing 1/3 of the Actual Mortality
• No evidence that boating industry has been negatively impacted by seasonal restrictions since its implementation in 2008
• At least 18 vessel strikes, including 15 lethal strikes, in U.S. waters from 2008 through 2024 have led to death or serious injury. At least 5 were from vessels under 65 feet
• Restriction is based upon the best available science, and models are developed using the standards for the field and incorporate as much real-world data as possible
	• Claims of massive economic impact:
	  ◦ $84 billion in jeopardy
	  ◦ 63,000 recreational saltwater vessels will be impacted by restriction
	  ◦ 340,000 jobs across the range of the restriction (Gulf of Maine to Jacksonville)
	  ◦ Lack of sufficient economic impact analysis
	• Pilot boat concerns:
	  ◦ Restrictions create significant risk (need higher speed to keep level surface for pilot transfer and to navigate narrow dredged shipping lanes in high wind).
	  ◦ Instead, suggest whale detection technology, exempt federal navigation channels, exempt pilot boats, and other alternatives
	• Private business concerns:
	  ◦ Safety (coming in from storms or other cases where being fast is necessary to avoid catastrophe)
	  ◦ Abuse of Automatic Identification System (AIS) for enforcement of restrictions
	  ◦ Gross misrepresentation of economic impacts (10 knots is too slow to complete trips, resulting in many cancellations)
	  ◦ Reduced access to the ocean for the public
	• Claims that NOAA did not ask for advice/data/ input from impacted stakeholders (e.g., pilot's associations, boating/charter businesses) before releasing the proposal

Potential Challenges

Some students may not agree about whether the proposed rule should be adopted based on the information provided and the subset of stakeholder perspectives included here. Encourage students to investigate these ideas using such considerations as:

- The relevant science, economic arguments, and regulatory responsibilities to make the best and most effective policy decision for ***both*** stakeholders and NARWs;
- The importance of the protective policies in MMPA and ESA;
- The responsibilities of NOAA and other governmental bodies;
- The potential negative and positive impacts of the proposed rule on vessel operators and the economy;
- The potential effectiveness of the proposed rule for conserving NARWs.

LEARNING PLAN

Present to students: we have previously been learning about the importance of and threats to the North Atlantic Right Whale. Now we will learn about what protections have been put into place, some of the government and non-government stakeholders involved and impacted, and proposed updates to restrictions to more effectively protect NARWs.

Vessel Strikes

We will start by looking at rules and regulations related to vessel strikes, and then we'll explore resources related to entanglements.

- Reference the table provided above that compares the existing rule to the proposed changes to help students get the gist of current restrictions on vessels meant to limit vessel strikes.
  - Ask students to do a second reading of the table and consider the following questions:
  - How are these policies working to reduce vessel strikes on NARWs?
  - Do they seem reasonable?
  - What impact do you think they might have on NARW survival?
  - What challenges do you foresee with compliance and regulation?
- Have students discuss and share their ideas.

Present to students the following background knowledge about a recent hearing involving changes to current vessel strike regulations:

> In 2023, a congressional hearing was held to discuss current vessel speed reductions meant to prevent vessel strikes on NARWs. At the hearing, NOAA presented the findings of their assessment of the current vessel speed restrictions, which have been in place since 2008. Their research documented that these restrictions are helping to reduce strikes, but that additional restrictions are needed to better protect NARWs, including expanding the geographic areas where speed restrictions are needed and that such restrictions should apply to some smaller vessels. (Additional background information provided in tables above, if needed.)

We will watch some video clips from the hearing that captures the different perspectives of some relevant stakeholders. Please record your thoughts in your notebooks as we watch, and we will discuss them after the clips have ended.

Create an Anchor Chart with a section for each of the following stakeholders and their perspectives on the proposed expanded restrictions. The chart will serve as a place to collect student ideas during discussions.

- Video clips from 2023 hearing:
  - Janet Coit, NOAA Fisheries: Summary of NOAA proposed rule and rationale
  - Dr. Jessica Redfern, New England Aquarium: Scientific argument and testimonial on the best available science regarding whale protections
  - Captain Fred Gamboa: Discussion of impacts to charter fishing and how this rule could impact his business and the economy of his area
  - Rep. Garret Graves, Subcommittee Member: Argument on boating safety and whale data
- Visualization of a NARW in vessel traffic

Ask students to share what they noticed and recorded from each person's testimony. Have them add to their notes if they heard something they missed or didn't write down. Record these observations on the Anchor Chart as well.

Have students reflect on their notes and, using two different colors (or circle/underline):

- In one color, underline words or phrases related to whale conservation
- In the other color, underline ideas related to economic considerations

Reflect:

- What patterns are you noticing about the different-colored words?
- What do they help us understand about what is driving the different arguments?
- What questions do you now have that you need to know more about to decide whether these additional regulations should be adopted into legislation?

Record student questions and determine how to provide resources. See section below for possible ideas if you would like them to do further research on vessel strikes.

Discuss: Given what you now know, should legislators update the vessel speed and geographic area of the restrictions? Why or why not?

Entanglements
Present to students: In this next lesson, we will be learning more about entanglement events and solutions. As you have learned, entanglements are one of the major threats to NARWs and are often related to lobster/crab traps and other similar gear. Show the entanglement simulation video on this website.

North Atlantic right whale Snow Cone (Catalog #3560) spotted south of Nantucket on Sept. 21, 2022, dragging heavy fishing gear and in poor health. Photo: New England Aquarium, taken under NOAA permit #25739

Traditional lobster traps are designed for sustainability of the lobster population and to reduce impacts on fish populations. Display this image (photo credit: NOAA) of a lobster trap. Point out the largely open design to allow fish to swim out. What might be less noticeable is that the hole to enter is a very specific size so that larger lobsters who are helping maintain the population cannot get in. Lobsters that are too small have a pathway to crawl out of the trap. Ideally, only lobsters of a certain size end up trapped inside.

Commercial fisherman put many traps like these into the ocean so they can catch enough lobster or crab to make a profit. The traps might be in a line or scattered and look a little like this (see scrolling graphic). There are lines of rope extending from a buoy at the top of the water column to the bottom so that fishermen can find their traps below. Unfortunately, the many lines running through the water column are responsible for the whale entanglements.

Efforts are underway to improve fishing gear and implement measures that will allow people to continue to fish for lobster while reducing the risk of whale entanglement. The one you will explore for this lesson is on-demand ("ropeless") fishing gear:

- Ropeless Fishing Gear, Center for Biological Biodiversity
- The Case for Ropeless, National Fisherman
- On-Demand Fishing Systems are Available at "Gear Libraries" in the US and Canada (including still image and videos), New England Aquarium

Record your findings in your notebook and report on the benefits as well as challenges in a Chalk Talk. We'll reflect together on why these could be helpful, what the barriers to implementation are, and how those barriers can be addressed.

Share the website links above with students in Google Classroom or another classroom management platform. Give students 25 minutes to look at the sites and choose one to research. Have them record their findings on one of the chart papers that you have created for Chalk Talk. Each chart paper should list one of the technologies and have a T-chart: one side for benefits, the other for challenges.

When students have completed their research and have recorded their ideas on the appropriate Chalk Talk, remind them to review the other Chalk Talks as well. Prompt them to notice if there are any patterns they notice between the different technologies.

Have students share their findings in pairs and then as a whole class.

Pose new questions:

- What were the most promising technologies?
- What barriers exist to widespread implementation, and what are some solutions?
- Have students talk in groups of 3 or 4 and then call on a representative from each group to share possible solutions they suggest.

CULMINATING ACTIVITY

We have looked at some possible solutions to two major threats to NARWs, vessel strikes and entanglement. Now, you have two options for your culminating task:

Claim-Evidence-Reasoning (CER): Determine one solution that you thought made the most sense to support and why that is. Write a CER to present your claim, present supporting evidence, and provide reasoning that helps the reader understand how your evidence supports your claim. You will share your CERs with a small group of students.

Letter to a Representative: Determine one solution that you thought made the most sense to support and why that is. You will craft a well-written letter to a federal representative explaining the action that you would like them to take. If you are not familiar with our federal representatives, I can help you figure out whom you can choose as your audience. This letter will be shared in small groups, but it will also be mailed to the representative of your choice.

Suggestion: Create a rubric for each of these assignments and provide peer editing time as well as one-on-one conferences with you to help students improve their writing.

APPENDIX

North Atlantic Right Whale (NARW) Basic Biology

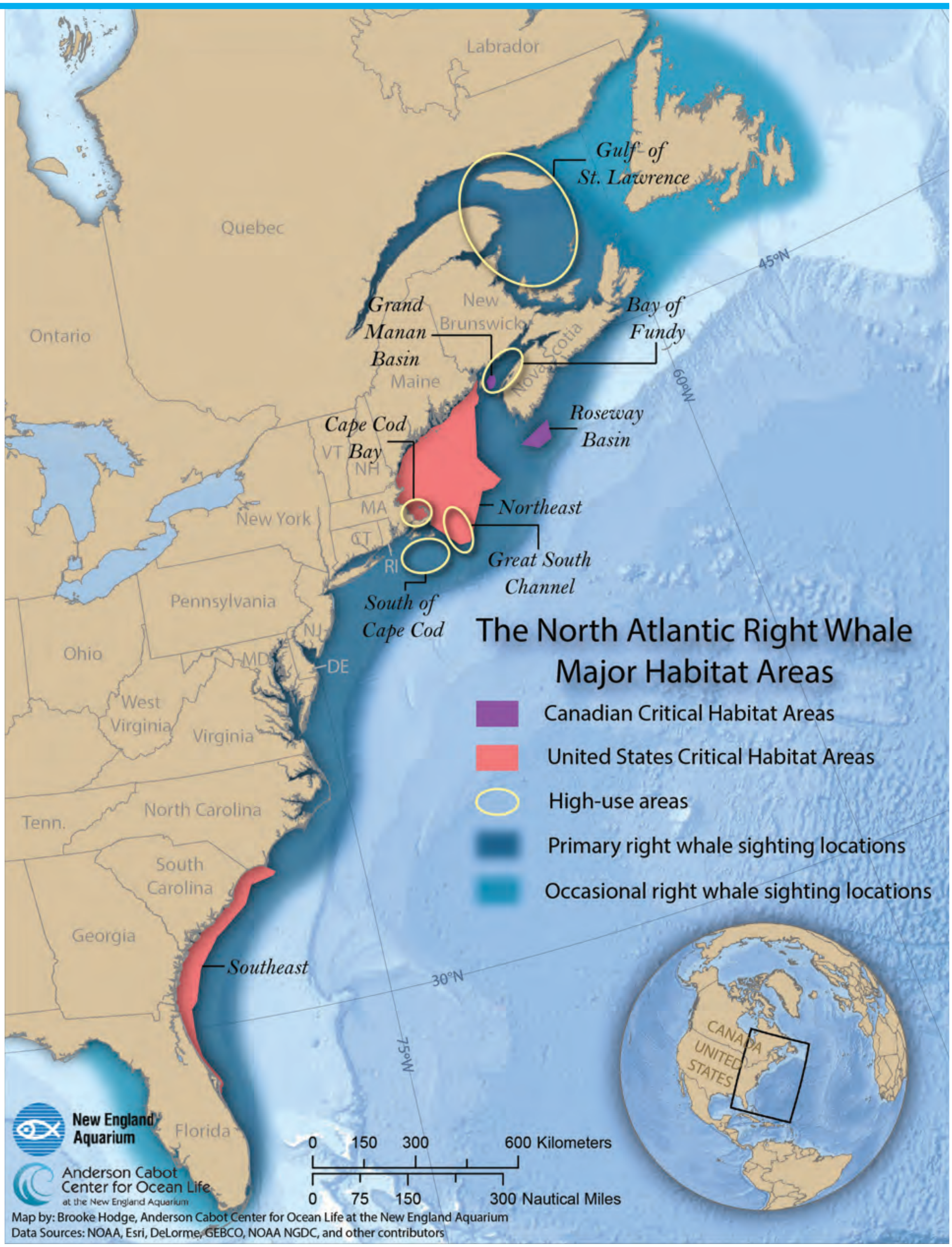
BASIC SPECIES INFORMATION

- **Species:** Eubalaena glacialis
- **Size:** 45–52 ft; up to 70 tons
- **Diet:** Copepods (2000 lbs or 900 kg per day); NARWs are skim feeders, finding their copepod prey close to the ocean's surface
- **Lifespan:** 70+ years, but it has been decreasing (currently, the median lifespan is just 22 years)
- **Range:** Full range covers about 2000 miles, from eastern Florida to Canada's Gulf of St. Lawrence (see map below). NARWs are found in near-coastal waters, which have high levels of vessels and fishing activities; their proximity to these activities has given them the nickname "Urban Whale."
- **Conservation status:** Classified as critically endangered with approximately 370 individuals left in the population (as of October 2024)

SPECIES REPRODUCTION

- **Female sexual maturity:** First birthing event (parturition) averaged at 8 years with calving interval ranging between 3 and 7 years, with longer hiatus possible
  - Annual calf counts have ranged from 0 (in 2018) to 39 (in 2009) and are quite variable
  - Gestation period is at least 1 year and may be longer
  - No evidence that NARWs go through menopause, which halts female reproductive ability
  - Calves stay with cow (their nursing mother) for approximately 1 year after birth
  - Due to human impacts, evidence that females are experiencing a decreased life expectancy (from over 70 years to a median of 22 years) and are calving less often or not at all, lowering lifetime reproductive contribution to the population
  - Only approximately 70 reproductive females left in the population
- **Male sexual maturity:** at about 15 years old
- **Calving season/grounds:**
  - Give birth during the late fall through late winter months in warm, shallow southeastern waters of the U.S. (North Carolina, South Carolina, Georgia, and Atlantic Coast of Florida), then cow-calf pairs migrate north to feeding grounds in early spring
- **Feeding season/grounds:** Primarily feed late winter through early fall in northern areas from southern New England to the Gulf of St Lawrence; feeding has also recently been documented in the mid-Atlantic during winter months

MAJOR HABITAT AREAS



New England Aquarium

Protecting the blue planet