Abstract

Imagine you are standing on a boat. You look out, searching in all directions for a glimpse of a whale. But you can’t find any. Your excitement fades. Where are the whales?

Many years ago, an ocean without whales was a real concern because we hunted them too much. Then we banned whaling and their populations grew. Yet some whale species are declining again. Why?

To find out, we analyzed data from the feeding grounds of the North Atlantic Right whale. We found that warmer ocean temperatures made food harder to find. Without enough food, fewer whales were born. Also, whales started swimming north to find more food. This puts them in danger from getting hit by ships and tangled in fishing nets. So now they face a new threat from humans: climate change.

Introduction

Whales are an important part of the ocean! Scientists classify them as ecosystem engineers. They support and maintain the ocean ecosystem because their feces (poop) contains important nutrients. Phytoplankton, microscopic organisms in the ocean, use these nutrients to grow. Fish and other animals then eat the phytoplankton.

Phytoplankton also help regulate the Earth’s climate. They use carbon dioxide from the atmosphere for photosynthesis and fill our atmosphere with oxygen. Less carbon dioxide means the Earth doesn’t get as warm. So without whales, the ocean would not be healthy. And an ocean without whales is a growing concern.

Currently, North Atlantic Right whales are critically endangered. Scientists estimate that there are only 336 of them left. We hypothesized that warmer ocean waters mean the whales will have to go to new places to find food. If there is less food, it’s harder for the whales to reproduce. Also, the new places where they seek food don’t have the same rules that protected the whales before, like:

- speed limits for ships,
- shorter fishing seasons, and
- fishing gear that is safer for them.

So can human-driven climate change explain our current loss of whales? We hoped to use ocean and population data to find out.
Methods

We analyzed ocean data near the Gulf of Maine, the feeding ground of the whales, to see if it is warming. We looked at the slope water temperature. This is the deep water temperature over the continental slope. This water advects (pushes) into the Gulf of Maine, affecting, in turn, its temperature. The slope water temperature can change based on the position of the Gulf Stream. The Gulf Stream is an ocean current. It brings warm water from the equator northward through the Atlantic Ocean. We looked at how the location of the Gulf Stream has changed over the last thirty years (Fig. 1).

Next, we looked at population data for the whales and their food. The primary food source for the North Atlantic Right whale is a type of copepod. Copepods are crustaceans, like shrimp and crabs, but about the size of a grain of rice. We determined how plentiful they were during the last thirty years. We also estimated how the whale population changed over time by looking at the number of:
- whale sightings,
- whale births, and
- whale carcasses.

Finally, we analyzed how the change in the water temperature related to the change in the whale population.

Results

Our analysis showed that since 2010, the Gulf Stream has been farther north than it has been in 30 years. The data also showed that the region’s slope waters started warming in 2010. They have since remained warmer than at any other time in 30 years (Fig. 2).

Our analysis of the population data shows a significant decrease in the copepod population beginning in 2010. This means there has been less food available for the whales.

- Between 2010 and 2019, only 15% of adult females gave birth, compared to 47% the decade before.
- During this same period, there were fewer whale sightings in the Gulf of Maine and more sightings farther north, in the Gulf of St. Lawrence.
- The number of whale carcasses was very high in the Gulf of St. Lawrence in 2017 and 2019.

Figure 1:
This map shows how the Gulf Stream can affect the water temperatures in the Gulf of Maine. The Gulf Stream warms the slope water, which advects into the Gulf of Maine, warming it.

Figure 2:
The slope water temperature for each year compared to the long-term average. The orange bars (above the line) mean that the water that year was warmer than the average. The purple bars (below the line) mean that the water that year was colder than the average. The longer the bar, the more degrees warmer or colder it was.
Discussion

We found that ocean and population data support our hypothesis. The best explanation for the slope water warming we observed is the shift of the Gulf Stream to the north. This shift is consistent with climate change models. That means global warming is causing it to move and make the slope waters near the Gulf of Maine warmer.

Copepods prefer cold water. We think warmer water wakes them too early, so they miss the nutritious spring phytoplankton bloom, which they need to grow and reproduce. Also, they tend to be advected into the Gulf of Maine from the colder waters up north. When the Gulf Stream is farther north, less cold water comes down into the Gulf of Maine, bringing fewer copepods.

With food levels too low, fewer whales are born, and fewer survive. To find enough food, some whales swim north to the Gulf of St. Lawrence. This is why there were more whale sightings there than in the Gulf of Maine after 2015. It also explains why there were more whale deaths in the area in 2017 and 2019. By looking at the carcasses, scientists know that ships hit the whales, or they get tangled in fishing gear. So, climate change both makes the whales’ food scarcer and causes them to move to new habitats, making it harder to protect them from ships and fishing gear.

Conclusion

Global warming doesn’t only change the weather; it changes the ocean. To protect ocean species and keep our oceans healthy, governments need to adjust how they manage the ocean. And they have to keep adjusting since the ocean will keep changing as the Earth continues to warm. You can also help protect whales and other ocean organisms from climate change. You can do that by:

- Reducing your energy use at home.
- Using less fuel for transportation, by walking, biking, or taking the bus.
- **Buying less stuff.** Follow the 4 Rs: refuse, reduce, reuse, and recycle.
- Only eating seafood that has been caught **sustainably and ethically.**

REFERENCES


NOAA Fisheries: North American Right Whale
https://www.fisheries.noaa.gov/species/north-atlantic-right-whale

IUCN: Red List of Threatened Species
https://www.iucnredlist.org/

https://www.energy.gov/eere/femp/home-energy-checklist

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Glossary of Key Terms

**Advection** – the transfer of heat or matter because of the movement of a fluid. For example, copepods get advected (pushed) into the Gulf of Maine by moving currents.

**Carcass** – a dead body.

**Continental slope** – the steeply sloped sea floor that connects the continental shelf with the deep ocean floor. When you stand in the ocean near the beach, you are standing on the continental shelf.

**Copepods** – a small water animal that is the primary food source for North Atlantic Right whales. A copepod is a type of zooplankton.

**Critically endangered** – this classification indicates that a species has an extremely high risk of extinction. It is determined by the International Union for the Conservation of Nature (IUCN).

**Ecosystem engineer** – a species that modifies the environment to create new habitats or maintain existing ones for other species in the ecosystem.

**Gulf Stream** – the ocean current that brings warm water from the equator northward through the Atlantic Ocean.

**Phytoplankton** – microscopic water organisms similar to plants that use photosynthesis to live and grow.

**Slope water temperature** – the temperature of the deep water over the continental slope.

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Check your understanding

1. What happened to the slope water temperatures after 2010? What effect did this have on the whales’ food source?

2. What caused the change in the slope water temperature in the Gulf of Maine?

3. How are the North Atlantic Right whales affected by this water temperature change?

4. Identify one way that your government can improve things for the North Atlantic Right whale. Describe an advantage and disadvantage of this solution.

5. Develop an energy conservation plan for your home or your school.