Student Version

Metal Levels in Whales from the Gulf of Maine: One Environmental Health Approach

Mindy Reynolds, PhD, Washington College, Chestertown, MD
John Pierce Wise, Sr., PhD, University of Louisville, Louisville, KY
Bryanna Rupprecht, Washington College (Class of 2020), Chestertown, MD

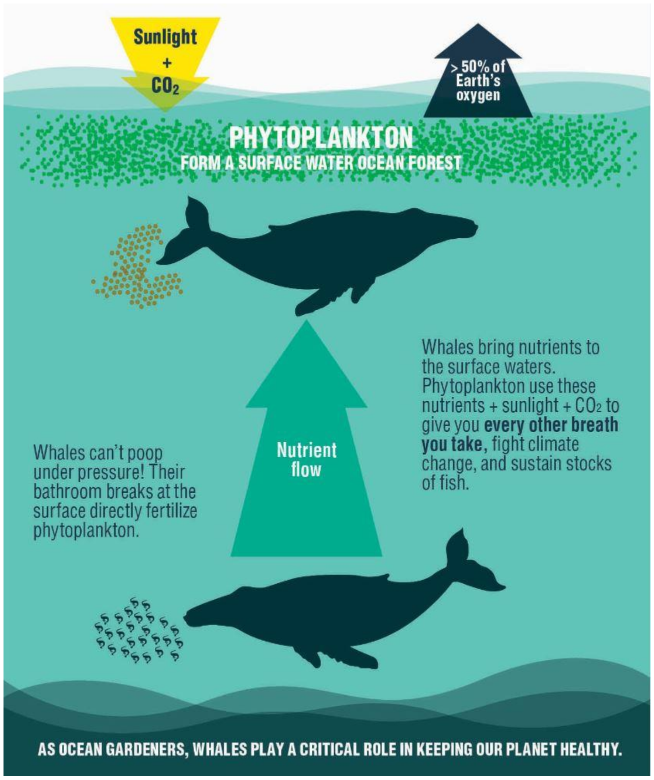


Figure 1: The role whales play in supporting phytoplankton populations.
https://au.whales.org/ecological-whale/

The Gulf of Maine serves as an important aquatic ecosystem for many marine organisms. Whales are one of the most important species in the ocean that migrate there each year; however, scientists have begun to see a drop in their overall fitness. These whales, such as humpback, fin, and minke, play a key role in supporting the phytoplankton population by fertilizing the water (Figure 1).

These plankton absorb copious amounts of carbon dioxide from the atmosphere, which in turn creates a healthier environment. Scientists have put whale health as high priority given their prolonged stretch on the endangered species list. To research whale fitness and health in relation to their connections to the health of their environment, the One Environmental Health approach has emerged.[1]

One Environmental Health recognizes relationships between human health, organism health, and ecosystem health. Scientists are working together with the goal to understand the relationship between the health of an organism and the health of the environment (Figure 2).

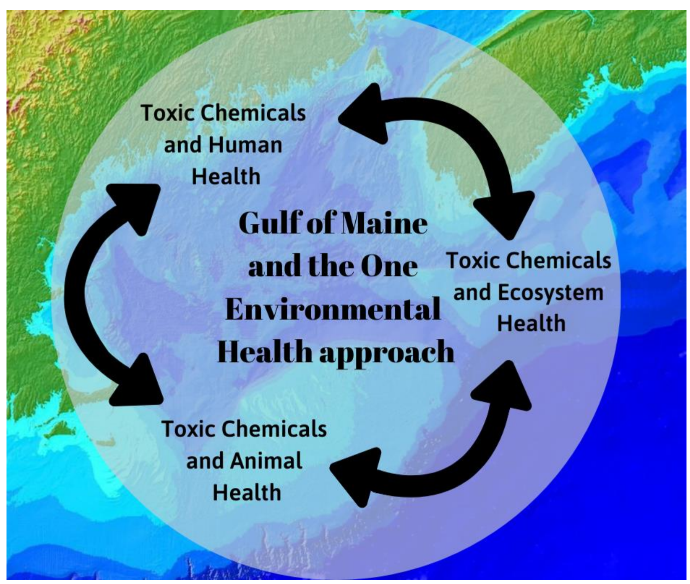


Figure 2. The One Environmental Health approach in the Gulf of Maine

In this case study, researchers focused on the One Environmental Health approach, which investigates the interconnected health of the ecosystem while focusing on the presence of metals. This new approach to research has allowed an assessment of health issues in the environment, such as climate change, by understanding how metals impact human health.

Human exposure to toxic metals has been linked to diseases such as organ failure, blood disorders, and death. In this study, scientists compared human health impacts from these metals to the whale population living in the Gulf of Maine. Metals in the water are naturally occurring and are sometimes overlooked as environmental threats.[2] There are some metals in the water, such as magnesium, iron, copper, and zinc, that are essential for organisms; however, when they are in excess the same essential chemicals can become toxic. An imbalance of metals may be caused by industrial or consumer waste from various sources.[2] When this occurs, the health impact can vary from reduced function of the nervous system to organ failure. If exposed for a long period of time, these damages increase to degenerative processes throughout the body.[2]

To analyze the metal levels present in the Gulf of Maine with respect to their effect on whale health, scientists took skin samples from the backs of whales by inserting a metal tip and removing a skin sample to analyze for metal levels and genomic data[3] (Figure 3). The skin acts as a barrier and is responsible for the absorption of toxic compounds. The scientists from this study would like to present the One Environmental Health data to the community in Maine, but they would like a fresh set of eyes to help with data analysis. In examining the data, keep in mind the One Environmental Health approach and how these metals could change the fitness of the ecosystem and whales.

Figure 3. Procedural methods of extracting skin samples.

References

1. Pérez, A., and Wise, J. P., Sr (2018). "One Environmental Health: An Emerging Perspective in Toxicology." *F1000Research*, *7* (F1000 Faculty Rev), 918. https://doi.org/10.12688/f1000research.14233.1.
2. Verma, R. and Dwivedi, P. (2013). "Heavy Metal Water Pollution–A Case Study." *Recent Research in Science and Technology.* no. 5(July): 98-99. https://updatepublishing.com/journal/index.php/rrst/article/view/1075.
3. Wise, J.P., Jr, et al. (2019). "Metal Levels in Whales from the Gulf of Maine: A One Environmental Health Approach." *Chemosphere.* 216 (February): 653-660. https://doi.org/10.1016/j.chemosphere.2018.10.120.

Student Version

Data Set 1.

A.

Whale skin biopsies collected.

Whale	2010		2011		2012	
	Female	Male	Female	Male	Female	Male
Humpback	3	3	2	6	9	10
Fin	2	0	0	4	1	2
Minke	0	0	0	0	1	0

B.

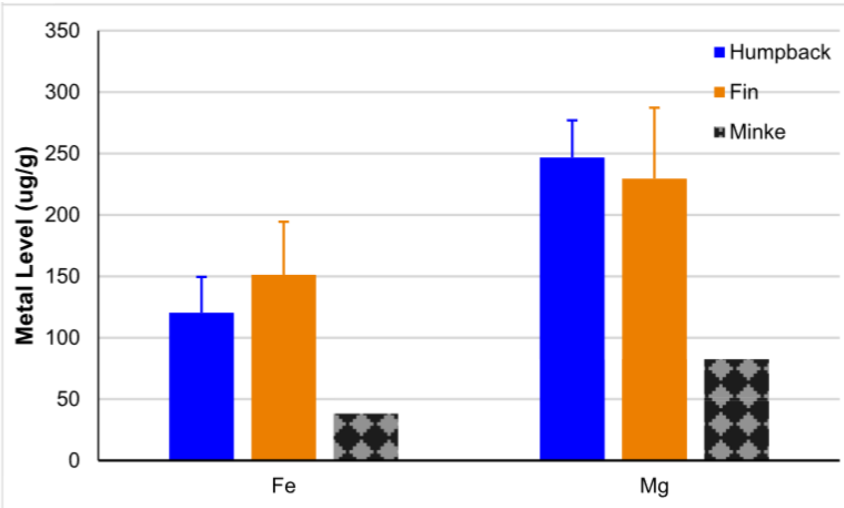


Figure Description:

A: The table depicts the sample size and gender of each species of whale for each year.

B: The graph shows the concentration of iron and magnesium for each species of whale.

1. What concerns might analysts have after looking at the data above, given the information we know about whales?

2. If data were collected in more regions, would you expect similar data? Explain.

3. Heavy metals are fat soluble. Briefly explain what that means in the context of the metals present in the Gulf of Maine ecosystem.

Student Version

Data Set 2.

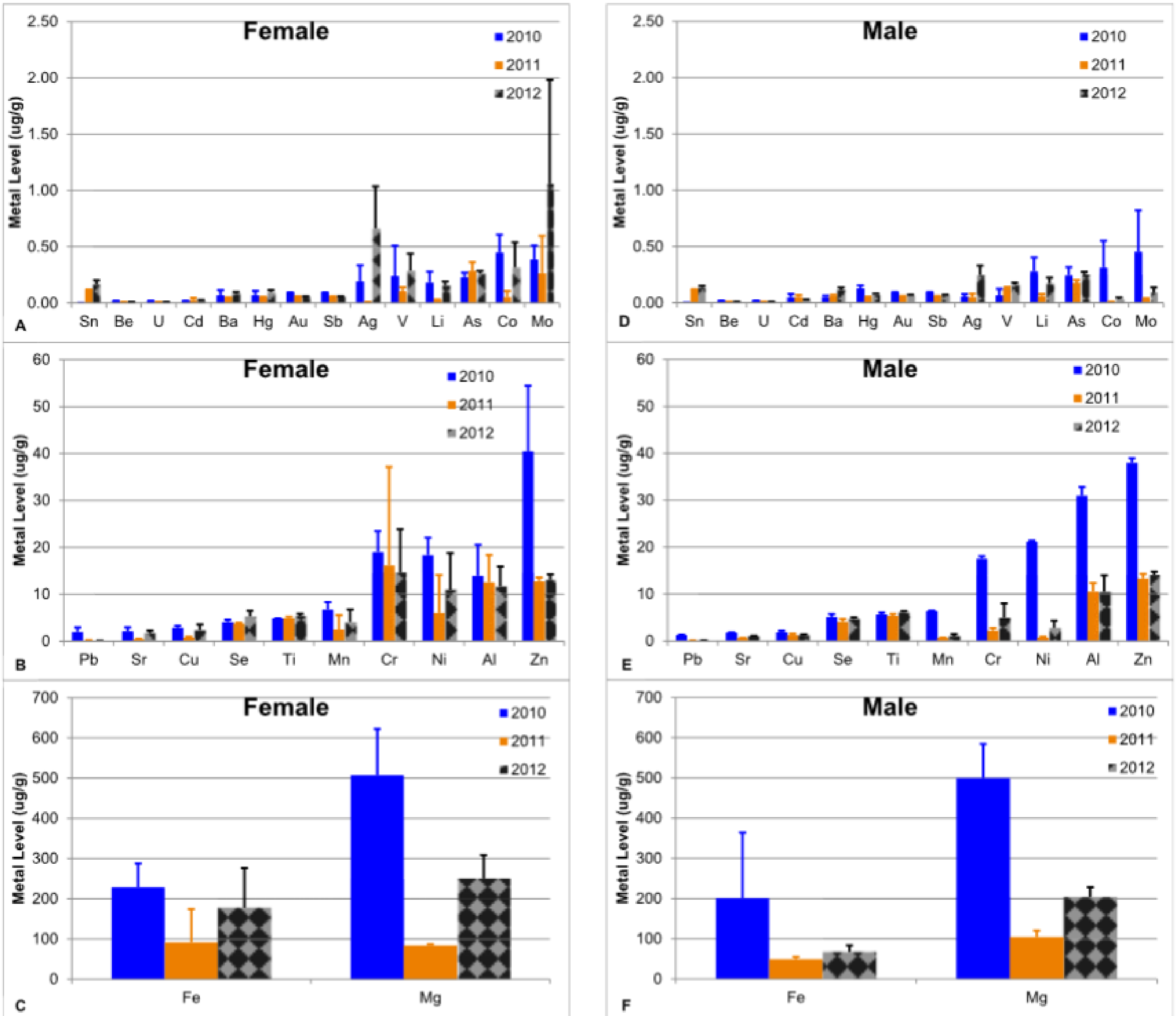


Figure Description: The graphs illustrate the metal concentrations in female and male humpback whales over a period of two years.

1. Can any trends be found in this short-term data collection?

Student Version

2. If this environment were left unregulated by government agencies, predict whether these trends would increase, decrease, or stay the same. Why?

3. What was the average concentration of iron in 2010? How does that compare to the average in 2012? What about the concentrations of magnesium over this study?

4. Define *bioaccumulation*. How can this term be related to the Gulf of Maine?

a. Could these chemical accumulations produce a negative effect on the ecosystem? Positive effects?

Data Set 3.

Whale vs Human Hypothetical Comparison of Ambient Air Cr Exposure.

Species	Chromium Concentration in Air (ug/m^3)	Lung Volume (m^3/breath)	Breathing Rate (breath/h)	Exposure Time (h/day)	Daily Cr(VI) Exposure (ug/day)
Fin Whale	5.5	2	24	24	2217.6
Human Cr(VI) Worker	5	0.0005	1200	8	24

Figure Description: The table compares fin whales and human workers.

1. How much chromium per one breath is the whale receiving from the air? Look at the lung volume and the concentration of chromium in the air.

2. What concerns may analysts have after looking at this data with the One Environmental Health approach in mind?

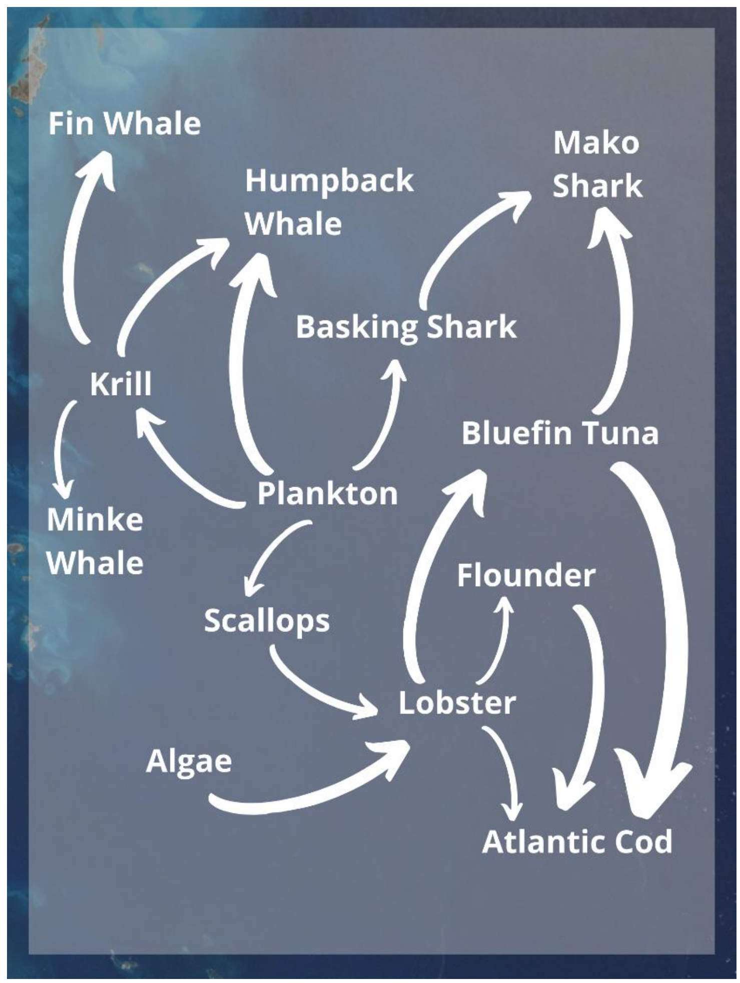
3. Given prior knowledge of the circulatory system, how might these metals travel through the human body once they are absorbed?

Data Set 4

1. Define *biomagnification* and explain how it can affect the Gulf of Maine whale populations.

a. Which organisms are most susceptible to the effects of biomagnification?

2. Create a trophic level pyramid for fin whales given the food web.



Gulf of Maine food web.

Student Version

a. Using prior knowledge of the relationship between whales and plankton, what would happen if the fin whales were removed from the environment?

b. Is this an example of top-down or bottom-up trophic cascade? Why?

c. Predict how this would impact the entire ecosystem in Maine.

3. How can biomagnification and tropic cascade impact human health in Maine?

