Krill Prefer Chill

How are the inhabitants of a polar ecosystem affected by rising global temperatures caused by climate change?

Overview

Antarctic krill are a keystone species in the Southern Ocean ecosystem and are fed upon by several predators, including whales, penguins, seals and seabirds. As climate change causes temperatures to rise, krill populations are migrating south and becoming less prominent at the Antarctic Peninsula. Can the response of this one species impact an entire ecosystem? Scientists at Oregon State University are studying how changes in the environment, such as temperature rise, impact the survival and reproduction of Antarctic krill. This lesson will introduce middle school students to Antarctic ecosystems and the critical role krill play in the environment. We will look at how krill populations have changed over time in relation to rising temperatures, and dive into the causes of global temperature rise, its effects on polar ecosystems, and what solutions can be implemented to lower our carbon emissions.

Essential Questions

- *What are Antarctic (polar) ecosystems and why are they important?*
- *What kinds of animals live in the Antarctic?*
- *Why are Antarctic krill considered a keystone species?*
- *How can we use math to compare two sets of data?*
- *How can we use a sample to gain information about a population?*
- *How has temperature changed at the Antarctic Peninsula over time and does this relate to changes in krill populations?*
- *What is causing temperatures to rise?*
- *How can we monitor and minimize our impact on the environment?*

Learning Goals

Students will learn the following:

- *Antarctic ecosystems are teeming with life and are structured by the ice that characterizes polar environments.*
- *Random sampling and data collection are critical tools for the scientific process and must be used properly to ensure that results are unbiased.*

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Grade Level
6-7

Time
4-6 class periods

Anchoring Phenomenon
Krill Prefer Chill

Driving Question
How are the inhabitants of a polar ecosystem affected by rising global temperatures due to climate change?

Standards
Next Generation Science Standards
ESS3.C – Human Impacts on Earth's Systems
ESS3.D – Global Climate Change

Common Core Math Standards
7.SP.1
7.SP.3

Antarctic Krill – Photo: Uwe Kils

- *Data representation and visualization can take many forms, and each is important to telling the whole story.*
- *Changes in temperature can impact the population dynamics of the animals that live in Antarctica, including Antarctic krill.*
- *Intensive carbon emissions are resulting in rising global temperatures due to the greenhouse effect. These rising temperatures can cause ice to melt and oceans to warm in polar environments, affecting the animals that live there.*
- *Everyone has a carbon footprint and there are things that you do on a daily basis contribute to your own. By coming up with creative solutions, you can reduce your carbon emissions and negative impacts on polar and ocean ecosystems.*
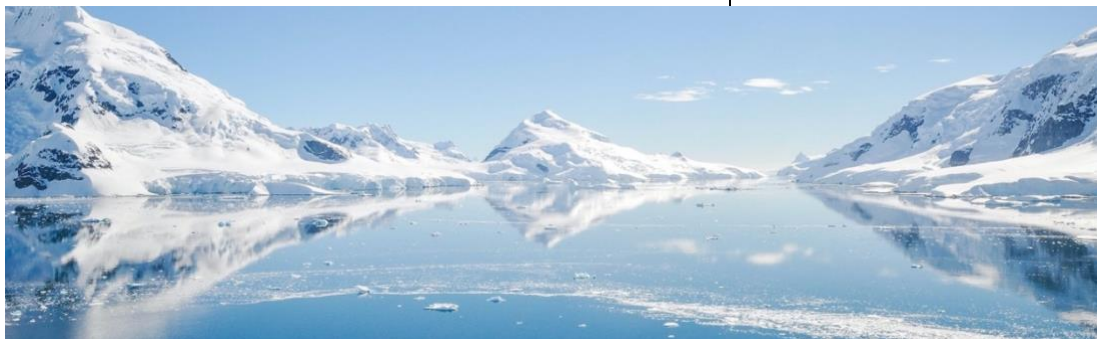

Antarctic Krill – Photo: Norkrill

Learning Objectives

Students will be able to:

- *explain why random sampling and collection are important for data accuracy.*
- *plot data to describe trends in air temperatures and krill populations at the Antarctic Peninsula.*
- *analyze data and create linkages between rising temperatures and changes in krill populations over time at the Antarctic Peninsula, while keeping in mind that correlation does not mean causation.*
- *explore how the greenhouse effect causes temperatures to rise and understand that this phenomenon can have lasting impacts on polar ecosystems.*
- *assess their carbon footprint and relate it to global temperature rise.*
- *formulate a plan to reduce their carbon emissions.*
- *collect accurate data to answer a question about a population.*
- *use dot/box and whisker plots to draw conclusions from a random sample, and draw conclusions about a population given a set of data.*

Antarctica – Photo:Henrique Setim

Introduction

Antarctic krill are a keystone species in the Southern Ocean ecosystem and their populations have been declining at the Antarctic Peninsula as a result of rapid regional warming and other environmental changes. In this unit, students will be exploring the Antarctic ecosystem and the species that live there. Classroom conversations will focus around the environment that the species live in and the temperatures they require to thrive. Then, students will use a dot-plot activity to graph historical versus modern day temperature recordings in the polar region, followed by an introduction to box-and-whisker plots using data from past and present krill populations. The emphasis of discussion will focus on the relationship between rising temperature and changes in Antarctic krill populations. At the conclusion of the unit, students will learn about sources of greenhouse gas emissions, calculate their carbon footprint, and identify ways in which they can reduce their impact on the environment.

Lesson Procedure

ENGAGE

Begin the unit by showing students the Netflix video *Our Planet: Frozen Worlds* so they can see the Antarctic ecosystem and the importance of krill. The first 20 minutes introduces krill and features multiple different animals that eat krill. If time is very limited, focus on time 7:43 – 9:20.

Lesson 1: Random Samples
Researchers are interested in measuring krill abundance, but how can they determine krill population sizes without directly counting every individual? Lesson 1 in the *Teacher Guide* provides instructions for the following activity. Structure the lesson using the *Collecting Data presentation* which includes not only a link to the video above, but also to a video from the Austrailian Antarctic Program called *Getting the Measure of Krill* which describes the reasons, techniques, and challenges involved in estimating krill populations. Then students learn about random samples and how to collect them using COVID-19 as an example scenario.

EXPLORE

In this section, students learn more about how temperatures in the Antarctic have changed over time. Students will need to have an understanding of temperature and how different objects conduct heat differently. To help review these concepts, have students use an infrared thermometer to measure temperatures of different objects the teacher has placed around the room. Alternatively, have students use liquid thermometers to

Kirsten Steinke sorts Antarctic Krill

Thermometer – Photo: Andy Melton

measure the temperatures of cups of water (or other liquids) that have been set out in different locations the night before.

Lesson 2: Dot Plot
Students will use dot plots to compare temperatures from 20 years ago to today's temperatures. Instructions for the following activity can be found in Lesson 2 of the *Teacher Guide*.

First, share the *Dot Plot presentation* which includes a *Frequency Tables and Dot Plots* video from Khan Academy. Next, students will use a *Dot Plot Packet* to explore average temperature data collected over a span of several years throughout Antarctica. This packet is also provided in *Spanish* and a *Teacher Answer Key* is provided.

EXPLAIN
How have temperatures affected different species and animals? In this section, students will research different animals and share their findings in a jigsaw activity. Students will analyze the effects temperature has had on krill populations using a box and whisker plot.

Lesson 3a: Box and Whisker Plot
The Lesson 3 *Teacher Guide* provides instructions for this activity. First, share the *Box and Whisker presentation* which introduces box and whisker plots. The presentation includes an *Antarctic Krill* video and a *Construct a Box and Whisker plot* video from Khan Academy.

Next, students will use a *Box and Whisker Packet* to create box and whisker plots for krill population *data*. They will then draw conclusions about the krill population and be asked to defend and explain their conclusion using the data. This packet is also provided in *Spanish* and includes a *Teacher Answer Key*.

Lesson 3b: Jigsaw – Antarctic Species
The *Jigsaw Teacher Guide* provides guidance for this activity. Divide the class into four groups, and each group will become an 'expert' on a different Antarctic species that feeds on krill. Students will use a *Jigsaw worksheet* to record the information they research for their species, and then share what they have learned about their species with other students in the class.

Lesson 3c: Food Web
The *Food Web Teacher Guide* provides guidance for this extension activity, which further supports student understanding of the importance of krill to the food web. Students use the *Food Web worksheet* to create their web.

Lesson 2: Dot Plot
- *Teacher Guide, Lesson 2 (pdf)*
- *Presentation: Dot Plot (ppt)(pdf)*
- *Khan Academy: Frequency Tables and Dot Plots [7:18]*
- *Student Dot Plot Packet English (pdf)(doc) Spanish (pdf)(doc)*
- *Teacher Dot Plot Packet Answer Key (pdf)*

Concepts and Vocabulary:
Mean, Median, Mode, Box and Whisker Plot, Dot Plot, Data (Trends), Climate Change, Impacts, Environmental Impact, Ecosystem, Temperature, Fahrenheit, Celsius, Sample, Population,Fishery, Krill, Pollution, Carbon

Lesson 3a: Box and Whisker Plot
- *Teacher Guide, Lesson 3 (pdf)*
- *Presentation: Box and Whisker (ppt)(pdf)*
- *Video: Antarctic Krill [1:27]*
- *Khan Academy: Construct a Box and Whisker plot [8:17]*
- *Student Box and Whisker packet English (pdf)(doc) Spanish (pdf)(doc)*
- *Data for Box and Whisker (xls)*
- *Teacher Answer Key (pdf)*

Lesson 3b: Jigsaw – Antarctic Species
- *Jigsaw Teacher Guide (pdf)*
- *Student Jigsaw worksheet (pdf)(doc)*

Lesson 3c: Food Web
- *Food Web Teacher Guide (pdf)*
- *Student Jigsaw outline worksheet (pdf)*

Career Connections
Introduce students to krill ecologist Kirsten Steinke from Oregon State University. Explore her *Researcher Bio* to learn about where, how, and why she studies krill in the southern hemisphere. Kristen provided the krill data used in this lesson.

ELABORATE
In this section, students learn more about why global temperatures are rising by connecting carbon emissions with the greenhouse effect. Then they collect data on their own carbon emissions to see how they contribute to rising temperatures.

Greenhouse Effect
Students can learn more about how carbon emissions are connected with rising global temperatures by watching a NASA video *What is the Greenhouse Effect?* and then complete the Ward's World Science *Greenhouse Effect activity* individually or as a class, depending on supply availability.

Lesson 4a: Carbon Footprint
The Lesson 4 *Teacher Guide* provides guidance for this activity. First, share the *Carbon Footprint* slideshow, which includes a short simpleshow video called *The Carbon Footprint Explained*. Then, students will practice collecting their own data by using an online *Carbon Footprint Calculator* to estimate their own carbon footprint. Use a spreadsheet (Excel or Google Sheets) to collect data from individuals in the class (see *example*). Once everyone has submitted their carbon footprint data, create a class spreadsheet from the responses (dataset *example*) and share with students.

EVALUATE
Students will generate a random sample of their peers' carbon emissions and create a plot to visually analyze the average carbon emissions in their grade level. Students will then complete an exit ticket on how they can help monitor the impact of carbon emissions.

Lesson 4b: Carbon Footprint Poster
Divide students into groups of 3-4 and provide them with a *Poster Rubric*. Randomly assign each group to create either dot plots OR box and whisker plots. The teacher can either have the students analyze the entire dataset, or you can have students use a *random number generator* to create a random sample of the dataset. If you choose to have students use a random number generator, provide them with a copy of the *Random Sample Tracker* to keep their data organized.

Career Connections
- *Researcher Bio: Kirsten Steinke (pdf)*

Researcher Kirsten Steinke

Greenhouse Effect
- *Video: What is the Greenhouse Effect? [2:30]*
- *Ward's World Science Greenhouse Effect activity*

Lesson 4a: Carbon Footprint
- *Teacher Guide, Lesson 4 (pdf)*
- *Slideshow: Carbon Footprint (ppt)(pdf)*
- *Video: The Carbon Footprint explained [2:00]*
- *Carbon Footprint Calculator*
- *Class Data collection process (pdf)*
- *Class dataset example (xls)*

Lesson 4b: Carbon Footprint Poster
- *Poster Rubric (pdf)(doc)*
- *Random number generator*
- *Random sample tracker (pdf)*

Low carbon activity

Finally, have students work in their groups to create their posters. At the end, provide opportunities for students to see each other's work and conclusions.

At the end of the lesson, students will complete a final *Exit Ticket worksheet* to explain what they have learned about monitoring and minimizing carbon emissions.

Next Generation Science Standards
Performance Expectations:
MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing human impact on the environment.
MS-ESS3-5: Ask questions to clarify evidence of the factors that have caused the rise in global temperature over the past century.

Science & Engineering Practices:
Asking Questions and Defining Problems
Constructing Explanations and Designing Solutions

Disciplinary Core Ideas:
ESS3.C – Human Impacts on Earth's Systems
ESS3.D – Global Climate Change

Crosscutting Concepts:
Cause and Effect
Stability and Change

Common Core Math Standards
Math Practices:
MP. 4 Model with Mathematics

Common Core Math Standards:
7.SP.1 - Understand that statistics can be used to gain information about a population by examining a sample of the population; generalizations about a population from a sample are valid only if the sample is representative of that population. Understand that random sampling tends to produce representative samples and support valid inferences.
7.SP.2 - Use data from a random sample to draw inferences about a population with an unknown characteristic of interest. Generate multiple samples (or simulated samples) of the same size to gauge the variation in estimates or predictions.