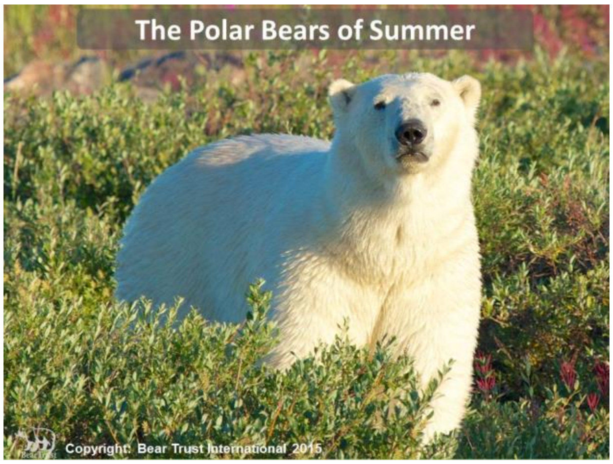
Polar Bears

The Polar Bears of Summer

Teacher's Guide

STEM Lesson Using Real-World Data



By design, this lesson does not require teachers to know anything about polar bears or the effects of global warming on polar bears.   This lesson has been aligned with Next Generation Science Standards, Common Core State Standards, NSES National Science Standards, and NCTM National Math Standards. For a complete description of standards, please see the end of this Teacher's Guide.

Lesson Synopsis

Using real-word data, students evaluate a scientific controversy about polar bears and land-based foraging within the context of global warming.

This lesson plan includes 4 parts:

1. Your students read a story about polar bears called "The Polar Bears of Summer: What Do You Eat While The Ice Is Gone?"
2. Your students work individually on activities that correspond with the story. These data-rich activities are designed to help hone math, science, and critical thinking skill sets.
3. Your students calculate their carbon footprint and compare their footprints with those of students in other cities and countries.
4. Your students work in science teams on a group activity, for which they actively explore the scientific controversy around polar bears and land-based foraging. Each team presents their findings to the rest of the class and participate in a class discussion.

Grade Level: 9-12

Next Generation Science Standards: HS-LS2-2, HS-LS2-6; HS-LS2-7; 12 Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts
Common Core State Standards: MATH: CCSS.Math.Content.HSS-ID.B.5; ID.B.6; IC.B.6; IC.B.9; IC.1; IC.4; IC.5;IC.6;N-Q.1;N-Q.2; Q.A.2; IF.B.4; IF.C.9
LITERACTY: CCSS.ELA Literacy.RST.9-10.1; 9-10.2; .9-10.3;.9-10.4; .9-10.5, .9-10.6, .9-10.7, 9-10.8,.9-10.9,**NSES National Science Standards:** A 1-6, C, and G; **NCTM National Math Standards:** 4, 5 & 6

A complete list of standards are available at the end of this Teacher's Guide

Subjects: Science, Math, and Literacy

Duration: Approximately 3 class periods

All lesson materials are available for free download at: www.beartrust.org

Materials for lesson:
-Story "The Polar Bears of Summer: What do you Eat While the Ice is Gone?"
-Student Pages: Background Information
-Student Pages: Individual Activities
-Student Pages: Carbon Footprint
-Student Pages: Group Activity
-Excel file "Datasets for Students"
-Pdf copies of 4 published papers
-Video of polar bears chasing geese
-Excel software OR calculators and graph paper
-Access to Youtube for 1 video
-2 Answer Keys
-Teacher Guide

Lesson authors: Dr. Melissa Reynolds-Hogland, Dr. Robert Rockwell, and Dr. Linda Gormezano

The Polar Bears of Summer

Written by Dr. Melissa-Reynolds Hogland, Dr. Robert Rockwell, and Dr. Linda Gormezano
Printed by Bear Trust International, 2015

A Bear Trust International Conservation Education Publication

Published by Bear Trust International 2015

This lesson plan, in its electronic form, is provided at no charge to educators, youth, and the public thanks to the generosity of the following sponsors:

Bear Trust International
Hudson Farm Foundation
M.J. Murdock Charitable Trust
Puelicher Foundation

Lesson Objectives

1. Students will actively participate in the process of scientific discovery, using real-world data from research done on wild polar bears in western Hudson Bay, Canada.

2. Students will evaluate hypotheses, analyze real-world data, interpret analyses using models, draw conclusions, and share findings with their peers.

3. Students will learn about scientific controversy and evaluate a current scientific controversy around polar bears and land-based foraging.

4. Students will evaluate an ecological process within the context of global warming.

5. Students will use mathematics and computational thinking to calculate ecological match/mismatch of polar bears and nesting snow geese (all equations provided) and the energy available in snow goose colonies in terms of Kcal and # of Seal Days. Students will create graphs and critically evaluate/interpret graphs and tables.

6. Students will use mathematical and statistical representations of phenomena with 95% confidence intervals to support explanations.

7. Students will construct explanations supported by multiple and independent student-generated sources of evidence.

8. Students will hone skills in communication as they engage in a range of collaborative discussions.

9. Students will present findings to their peers(via in-class presentations and discussions), emphasizing important facts with relevant evidence.

10. Students will work individually and cooperatively as they solve problems, construct explanations, hone critical thinking skills, and design solutions.

Acknowledgements

Special thanks to Dr. Robert Rockwell and Dr. Linda Gormezano for sharing some of their research data and published papers with Bear Trust International. Special thanks to Dr. Ian Stirling, Dr. Derocher, and Dr. Karen Rode for sharing some of their published papers with Bear Trust International.

Lesson Materials

All lesson materials are available for free download on Bear Trust International's website:
www.beartrust.org

- Story about polar bears, "The Polar Bears of Summer: What Do You Eat While The Ice Is Gone?"
- Teacher Guide (i.e., the guide you are reading)
- "Student Pages: Background Information"
- "Student Pages: Individual Activities"
- "Student Pages: Carbon Footprint Activity"
- "Student Pages: Group Activity"
- Excel Data File: "Datasets for Students"
- Answer Keys
    - "ANSWER KEY for Datasets", an excel file which provides all graphs and missing cell values in the excel data set
    - "ANSWER KEY for Individual Activities", a word document
- Excel graphing software, or graph paper and calculators for each student
- Pdf copies of 4 published papers
- Video of polar bears chasing geese (on the Bear Trust website)
- Access to Youtube to watch a video of polar bears climbing a cliff to eat eggs (this video is not on the Bear Trust website)

Background Information for Teachers

This lesson plan includes 4 parts:

1. Your students read a story about polar bears called "The Polar Bears of Summer: What Do You Eat While The Ice Is Gone?"
2. Your students work individually on activities that correspond with the story. These data-rich activities were designed to help hone math, science, and critical thinking skill sets.
3. Your students calculate their carbon footprint and compare their footprints with those of students in other cities and countries.
4. Your students work in science teams on a group activity, for which they actively explore the scientific controversy around polar bears and land-based foraging. Each team presents their findings to the rest of the class and participate in a class discussion.

Bears Worldwide

There are 8 species of bears worldwide: American black bear, Asiatic black bear, brown bear, giant panda bear, polar bear, sloth bear, spectacled bear, and sun bear. Of these 8 species, 6 are listed as Endangered or Vulnerable (not endangered, but facing high rate of extinction in the wild) by the International Union for Conservation of Nature (IUCN). Only the American black bear and brown bear are considered species of Least Concern globally by the IUCN.

Polar Bears

- Polar bears are listed as Vulnerable on the IUCN (International Union for the Conservation of Nature) Red List of Threatened Species. Vulnerable means that the species is not currently Endangered, but facing high rate of extinction in the wild.

- In the US, polar bears are listed as threatened and protected by the Endangered Species Act.

- Scientists estimate that there are between 20,000-25,000 polar bears worldwide today.

- There are 19 sub-populations of polar bears. Of these 19 sub-populations, 3 are declining, 6 are stable, 1 is increasing, and scientists do not have sufficient data to estimate how the other 9 subpopulations are doing.

- There is a Polar Bear Specialist Group of the IUCN Species Survival Commission. This group is the "authoritative source for information on the world's polar bears, and one of IUCN/SSC's more than 100 specialist groups that work to produce and to compile scientific knowledge about the world's species and give independent scientific advice to decision-makers and management authorities"*.
  *The text in quotes came from the PBSG/IUCN webpage on 5.18.15: http://pbsg.npolar.no/en/index.html

- To learn more about the current status of polar bears, please visit the PBSG website: http://pbsg.npolar.no/en/index.html

Scientific Controversy

As part of this lesson plan, your students will be using real-world data from some studies done on polar bears in western Hudson Bay, Canada. The data from these studies show that some polar bears in some polar bear subpopulations are consuming land-based foods during the ice-free period.

Currently, there is some **scientific controversy** around the topic of polar bears eating land-based foods, like snow goose eggs. Scientific controversy is a healthy part of the scientific process.

What is **scientific controversy**?

Dr. Anne Egger, Ph.D. and Dr. Anthony Carpi explain **scientific controversy** on the Vision Learning website (http://www.visionlearning.com/en/library/Process-of-Science/49/Scientific-Controversy/181). Here's what they say:

"Scientists can disagree about lots of things, from the mundane (like what is the best kind of analytical instrument to use) to the profound (whether or not string theory, a recently developed theory in physics, is an accurate representation of reality). Two scientists disagreeing over an instrument or string theory – or even the interpretation of data – does not count as a controversy, however. A true scientific controversy involves a sustained debate within the broader scientific community (McMullin, 1987). In other words, a significant number of people must be actively engaged in research that addresses the controversy over time. No matter what the content of the disagreement, the scientists involved all share some fundamental knowledge and agree that the subject matter is worth being concerned about and that the various arguments are legitimate.

What makes the arguments legitimate is that they are based on data. It is not enough for scientists to simply say, "I don't agree with you." Instead, they must conduct the research to garner enough evidence to support their claim. An argument must explain the majority of data available – not just the data collected to support one side. This is not necessarily the case in public controversies such as that over offshore drilling, where a group or individual can decide that some data are more important than other data – the number of birds that died or the economic impact of drilling or the percentage of oil imports. In a scientific controversy, all of the data must be explained and taken into account.

Though controversies are often discussed in informal settings (the same way you might discuss a controversial issue with your friends), the real debate is carried out at research meetings and through the publication of journal articles (see the "Scientific Journal Articles module" created by Vision Learning to learn more). It is only through this process that the debate becomes part of the scientific literature (see the Utilizing the Scientific Literature module created by Vision Learning to learn more) and helps science progress. There is no authoritative body in science that decides what the right answer in a controversy is, nor does it require complete consensus among all scientists. The resolution to a controversy comes when one argument is widely accepted and other arguments fade away. Often, the evidence in favor of one side of the controversy becomes so overwhelming that people simply stop arguing about it. Usually, that happens when multiple lines of evidence coming from multiple research methods (and perhaps multiple disciplines) all converge".

What is the **scientific controversy** surrounding polar bears and land-based foods? First, let's make sure we all know the issues that are **NOT** part of the scientific controversy:

1. Scientists **AGREE** that global warming is occurring and that much of this global warming is human-caused (for example, human-caused CO_2 emissions).
2. Scientists **AGREE** that global warming is reducing the Arctic sea ice. The duration of the ice-free period is increasing due to earlier break-up and later freeze up of Arctic sea ice.
3. Scientist **AGREE** that the increasing loss of Arctic sea ice affects polar bears because polar bears need ice platforms to hunt their primary prey, seals. Historically, polar bears gained most of their annual fat reserves during spring by hunting seals from the ice. Because Arctic sea ice is becoming less available, polar bears are spending increasingly more time on land. This is especially true for polar bears in western Hudson Bay and James Bay, at the southernmost part of the polar bear's range.
4. Scientists **AGREE** that some polar bears in some areas eat land-based foods, including eggs, caribou, fish, etc.

Hypotheses About the Scientific Controversy

Okay, we know that polar bears are spending increasingly more time on land due to increasing loss of sea ice as a consequence of global warming. What do polar bears DO on land during this ice-free period?

THAT is the crux of the **scientific controversy**. We can evaluate this **scientific controversy** as two competing hypotheses:

Hypothesis 1A: Overall, land-based foraging by polar bears will not help offset lost opportunities to hunt seals and land-based foraging will not help the polar bear population cope with continuing loss of Arctic sea ice.

More Information about Hypothesis 1A: When polar bears are forced ashore, they have historically used the fat stores they've accumulated from ice-based hunting of seals to survive the ice-free period. The period polar bears spend on land is often referred to as a "fasting period" or "walking hibernation". Polar bears don't den up during this ice-free period, but most bears reduce their activity presumably to reduce energy expenditure. Because the duration of the ice-free period is increasing, the duration of the fasting period by polar bears is also increasing. During this fasting period, it is recognized that some individual polar bears might opportunistically eat some land-based foods but, overall, any land-based foraging will have minimal effect on individuals and on the polar bear population. Some evidence to support this hypothesis comes from scientific studies that show a decrease in Arctic sea ice in western Hudson Bay has been linked to: 1) decreased survival of some age classes of polar bears, 2) a decline in mean body condition index of polar bears, and, 3) a decline in mean weights of suspected pregnant females.

Hypothesis 1B: Land-based foraging by polar bears might help offset lost opportunities to hunt seals and such behavior by polar bears might reflect a flexible foraging strategy that could help the polar bear population cope with continuing loss of Arctic sea ice.

More Information about Hypothesis 1B: Some scientists question the use of the term "fasting" to describe polar bears in western Hudson Bay during the ice-free period. Some evidence to support this hypothesis comes from scientific studies showing polar bears consume land-based foods. Evidence to support the hypothesis that land-based foraging might help polar bears cope with continuing loss of Arctic sea ice comes from a recent scientific DNA study showing polar bears have been distinct from brown bears for much longer than previously thought (at least 600,000 years). Assuming results from this new DNA study are accurate, this means polar bears found a way to persist through 4 warming periods on par with current day conditions: 150,000BP; 240,000BP; 325,000BP; 410,000BP. Presumably, polar bears did not have access to seals during the 4 previous warming periods. Populations of polar bears were no doubt reduced during these warming periods, but the species did not go extinct.

In the Student Pages, we will not tell your students what to think. Rather, we will provide evidence from both sides of this controversy and let your students decide for themselves.

Lesson Procedure

1. Ask your students to read the story called, "The Polar Bears of Summer; What Do You Eat While the Ice is Gone?"

2. After they've read the story, hand out the "Student Pages: Background Information" to each student. Ask them to read this information carefully. Reserve extensive discussion about the scientific controversy until AFTER students have completed the Individual and Group Activities.

3. Next, hand out the "Student Pages: Individual Activities" to each student. Give each student access to the excel file called "Datasets for Students". Tell students that they need to work on these activities individually. This can be assigned as homework, or they can do these activities during class. For these activities, your students will be using real-world data to answer real-world conservation questions. They will be doing mathematical calculations, creating graphs, and interpreting graphs. All equations are provided within the cells in the excel file.

4. Ask students to turn in a digital copy of their answers to their questions from the "Student Pages: Individual Activities".

   All answers and graphs are provided to you in the Teacher Answer Keys.

5. Hand out the "Student Pages: Carbon Footprint Activity" to each student. Tell them to complete this activity. For this activity, your students will be calculating their carbon footprints by using a carbon calculator provided by Stanford University:

   http://footprint.stanford.edu/calculate.html

   Your students do NOT need to download the calculator, just tell them to go to the bottom of the webpage and click on: "Calculate My Footprint Now".

   You do not need to have your students register to participate. Ask them to register ONLY if you wish them to.

   To compare results with those of other students worldwide, have your students click on "Compare footprint" at the top of the webpage.

   The Stanford website offers several ways to extend this activity if you are interested. For example, your class can participate in discussion forums with other classrooms around the world, if you want.

6. Group your students into 4 Science Teams. Hand out the appropriate "Student Pages: Group Activity" to each group. For example, Team 1 will get "Student Pages: Group Activity for Team 1". Team 2 will get "Student Pages: Group Activity for Team 2", etc. Ask them to follow instructions on their Student Pages and prepare a presentation that they will give to the rest of the class. The Student Pages for each group includes specific instructions about what should be included in each presentation.

7. Have each of the 4 Science Teams give their presentations

8. Have a class discussion. Below, find some examples of guiding questions you can ask your students:

   - What is a scientific controversy?
   - What is the scientific controversy around polar bears and land-based foods?
   - What information do both sides of this scientific controversy AGREE on?
   - What do the two sides of this scientific controversy DISAGREE on?
   - What evidence is there to support Hypothesis 1A?
   - What evidence is there to support Hypothesis 1B?

- Currently, is there enough evidence to know whether Hypothesis 1A or Hypothesis 1 B is refuted? If not, how would you design a field study to evaluate these 2 competing, alternative hypotheses?
- Based on evidence from BOTH sides of this scientific controversy, do you think the term "fasting" applies to the polar bear subpopulation that lives in western Hudson Bay?
- Polar bears, as a species, have survived at least 4 climate warming periods previous to the one our earth is experiencing now. What do BOTH sides of this scientific controversy say about this topic?
- There have been many studies showing that loss of sea ice correlates with reduced polar bear survival, body condition, and weight. Dr. Robert Rockwell points out that most of these studies were done BEFORE he and Dr. Gormezano did their study on polar bear diets in 2006-2008. What does this mean in terms of how we can estimate the effect that land-based foraging by polar bears might have on population demography?
- What do BOTH sides of this scientific controversy state about the energy in the colony of nesting snow geese in western Hudson Bay in terms of "seal days"?
- What is an ecological mismatch? What is the current ecological mismatch for polar bears? What is a new **potential** "match" for polar bears?
- Why are polar bears an iconic symbol of climate warming?
- What was the average carbon footprint for students in your class? How did it compare with students in other states, the US, and around the world?
- How can you reduce your carbon footprint?
- If you were in charge of everything (wow, wouldn't that be great?), how would you incentivize wise use of natural resources?

Note: this lesson is specifically designed using the flipped learning model. Rather than asking teachers to lecture, we ask students to discover the answers and share findings. As such, most of the informational content (including definitions and explanations) are included in the Student Pages and in the Datasets.

Next Generation Science Standards: High School

Performance Expectations:

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 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

Science and Engineering Practices:

Asking questions and Defining Problems

Developing and Using Models

Using Mathematics and Computational Thinking

Constructing Explanations and Designing Solutions

Engaging in Argument from Evidence

Scientific Knowledge is Open to Revision in Light of New Evidence

Analyzing and Interpreting Data

Disciplinary Core Ideas:

Interdependent Relationships in Ecosystems

Developing Possible Solutions

Ecosystem Dynamics, Functioning, and Resilience

Crosscutting Concepts:

Cause and Effect

Systems and System Models

Common Core State Standards: Math

CCSS.Math.Content.HSS-ID.B.5: Summarize categorical data for two categories in two-way frequency tables. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies). Recognize possible associations and trends in the data.

CCSS.Math.Content.HSS-IC.B.6: Evaluate reports based on data.

CCSS.Math.Content.HSS-IC.B.9: Distinguish between correlation and causation.

CCSS.Math.Content.HSS-IC.1: Understand statistics as a process for making inferences about population parameters based on a random sample from that population.

CCSS.Math.Content.HSS-IC.4: Use data from a sample survey to estimate a population mean or proportion; develop a margin of error through the use of simulation models for random sampling.

CCSS.Math.Content.HSS-IC.5: Use data from a randomized experiment to compare two treatments; use simulations to decide if differences between parameters are significant.

CCSS.Math.Content.HSS-IC.6: Evaluate reports based on data.

CCSS.Math.Content.HSS- N –Q1: Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

CCSS.Math.Content.HSS-N-Q2: Define appropriate quantities for the purpose of descriptive modeling.

CCSS.Math.Content.HSN-Q.A.2: Define appropriate quantities for the purpose of descriptive modeling.

CCSS.Math.Content.HSF-IF.B.4: For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship

CCSS.Math.Content.HSF-IF.C.9: Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions).

Common Core State Standard Connections: Literacy

CCSS.ELA-Literacy.RST.9-10.1: Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

CCSS.ELA-Literacy.RST.9-10.2: Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.

CCSS.ELA-Literacy.RST.9-10.3: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text

CCSS.ELA-Literacy.RST.9-10.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context

CCSS.ELA-Literacy.RST.9-10.5: Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., *force, friction, reaction force, energy*).

CCSS.ELA-Literacy.RST.9-10.6: Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address.

CCSS.ELA-Literacy.RST.9-10.7: Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

CCSS.ELA-Literacy.RST.9-10.8: Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.

CCSS.ELA-Literacy.RST.9-10.9: Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.

NSES National Science Standards

Standard A: Science as Inquiry 1-6

1. Identify questions and concepts that guide scientific investigations (STEM)
2. Design and conduct scientific investigations (STEM)
3. Use technology and mathematics to improve investigations and communications (STEM)
4. Formulate and revise scientific explanations and models using logic and evidence (STEM)
5. Recognize and analyze alternative explanations and models (STEM)
6. Communicate and defend a scientific argument (STEM)

Standard C: Life Science 6; Students will understand the behavior of organisms (STEM)

National Math Standards NCTM

Standard 4: Measurement (STEM)

a. Understand measurable attributes of objects and the units, systems and the processes of measurement (STEM)

Standard 5: Data Analysis and Probability

a. Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them

b. Select and use appropriate statistical methods to analyze data

c. Develop and evaluate inferences and predictions that are based on data

Standard 6: Process

- Build new mathematical knowledge through problem solving
- Solve problems that arise in mathematics and in other contexts
- Apply and adapt a variety of appropriate strategies to solve problems
- Monitor and reflect on the process of mathematical problem solving

Reasoning and Proof

- Make and investigate mathematical conjectures
- Develop and evaluate mathematical arguments and proofs
- Select and use various types of reasoning and methods of proof

Communication

- Organize and consolidate their mathematical thinking through communication
- Communicate their mathematical thinking coherently and clearly to peers, teachers, and others
- Analyze and evaluate the mathematical thinking and strategies of others;

Connections

- Recognize and use connections among mathematical ideas
- Understand how mathematical ideas interconnect and build on one another to produce a coherent whole
- Recognize and apply mathematics in contexts outside of mathematics

Representation

- Create and use representations to organize, record, and communicate mathematical ideas
- Select, apply, and translate among mathematical representations to solve problems
- Use representations to model and interpret physical, social, and mathematical phenomena