Trends in Sea Ice Data

9th to 12th grade unit

Created by Dr. Jody Reimer and Linda Zhao, University of Utah, Department of Mathematics

Math Core Curriculum:

Grades 9-12 **Interpreting Categorical & Quantitative Data**	**CCSS.MATH.CONTENT.HSS.ID.B.6:** Represent data on two quantitative variables on a scatter plot, and describe how the variables are related.	**CCSS.MATH.CONTENT.HSS.ID.C.7:** Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data.

Learning Objectives:

To understand statistical principles using real world examples and to make inferences with the information that is presented.	Students will gain familiarity with the following ideas: • Estimating and interpreting trend lines • Extrapolation outside of observed values

Additional Materials:

Conservation Concerns: Climate Warming https://polarbearsinternational.org/polar-bears-changing-arctic/conservation-concerns/	**Annual Arctic Sea Ice Minimum 1979-2020 with Area Graph** by NASA Climate Change https://youtu.be/Vphz0HbbQVo	**Sea ice Data Availability:** Sea ice data from the National Snow and Ice Data Center can be obtained on their website: https://nsidc.org/data/g02135#

Trends in Sea Ice Data

Looking for trends in data

We are often interested in how the world is changing over time. Statistics can help us understand what we observe and whether these observations are due to chance or if they represent something real about the world.

Trends in Sea Ice Data

Is it just bad luck or is something suspicious happening?

Imagine that you have one box of candy to share with a friend. Your friend proposes a game with a coin she has in her pocket, to determine how much candy you both get. Every time the coin is "heads", your friend gets to eat a piece of candy. When it's "tails", you get a piece.

You flip the coin 5 times. The results are 4 heads, and 1 tails. It must just not be your day for luck! You flip the coin another 5 times; this time it's 5 heads and no tails. You are starting to get suspicious; is this game rigged?!

1. What kinds of numbers of heads and tails would make you suspicious about your friend's coin being weighted unfairly? How do you know it's not just chance?	
2. What kind of experiment could you do to convince yourself the coin is unfair and not that you are just unlucky?	

Statistics gives us the tools to figure out when things are likely just chance, or when something really is going on!

Changing Sea Ice

Climate change is causing us to observe lots of changes around the world. One change that affects all Arctic animals is a shrinking of the sea ice (see figure below).

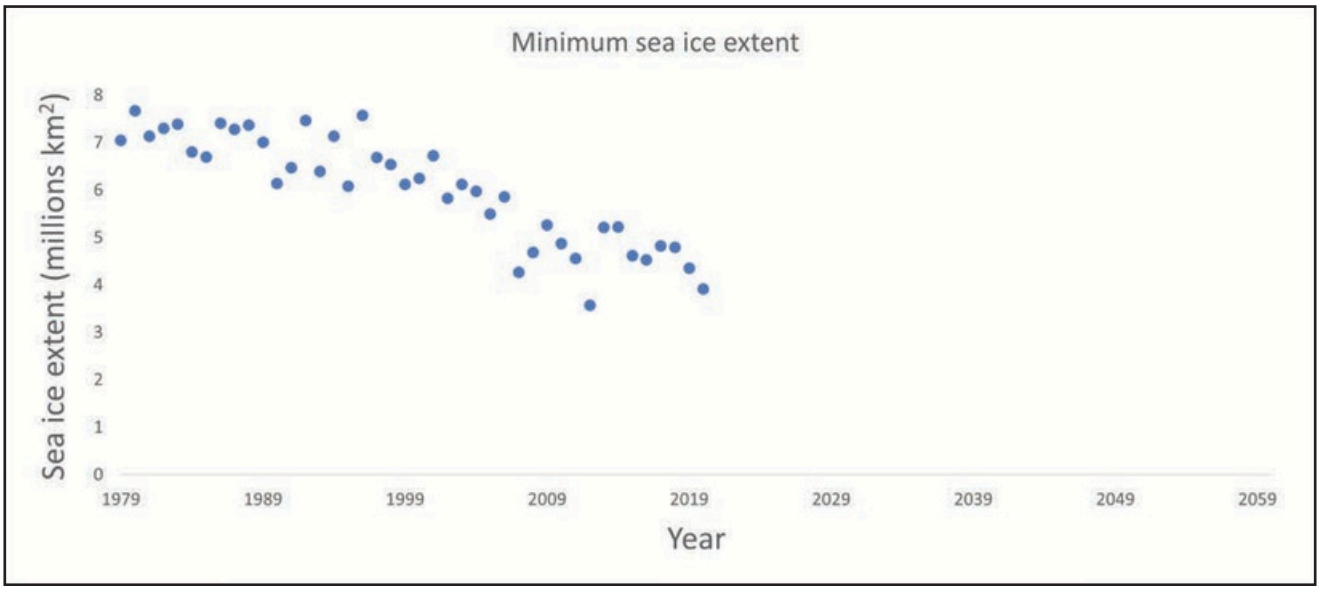

Figure 1: Sea ice extent, as calculated from satellite data since 1979 to 2020.

3. Do you think there is a "best" line we could draw through the data? Using your ruler, draw a straight line on the graph that seems to capture the main trend or pattern in the data.

4. Come up with at least one idea for how to determine which line fits the data "best."	
5. Do you think this pattern is happening by chance, or does the evidence seem strong enough to suggest real changes?	
6. From looking at the line you drew on the graph, when do you think that there will be no ice in September in the summer?	

7. Do you think this guess of when there will be an ice-free summer is realistic or like to happen? What other factors might influence the actual date? **(Bonus):** Using the internet to search, see if you can find the year in which scientists think that we will have an ice-free summer.	
8. Do you think a straight line did a good job capturing the patterns in the data?	
9. How do you think this trend in sea ice will affect polar bears?	

Trends in Sea Ice Data
Lesson Solutions

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1. What kinds of numbers of heads and tails would make you suspicious about your friend's coin being weighted unfairly? How do you know it's not just chance?	Solution: There is no "right" answer, however it may be helpful to discuss concrete numbers (e.g., would 100 heads and no tails be suspicious? What about 1000 heads and 50 tails? Or 600 heads and 400 tails?)
2. What kind of experiment could you do to convince yourself the coin is unfair and not that you are just unlucky?	Solution: Again, there is no right or wrong answer—the goal is to brainstorm and think about how we "know" things using data, and what counts as sufficient evidence.

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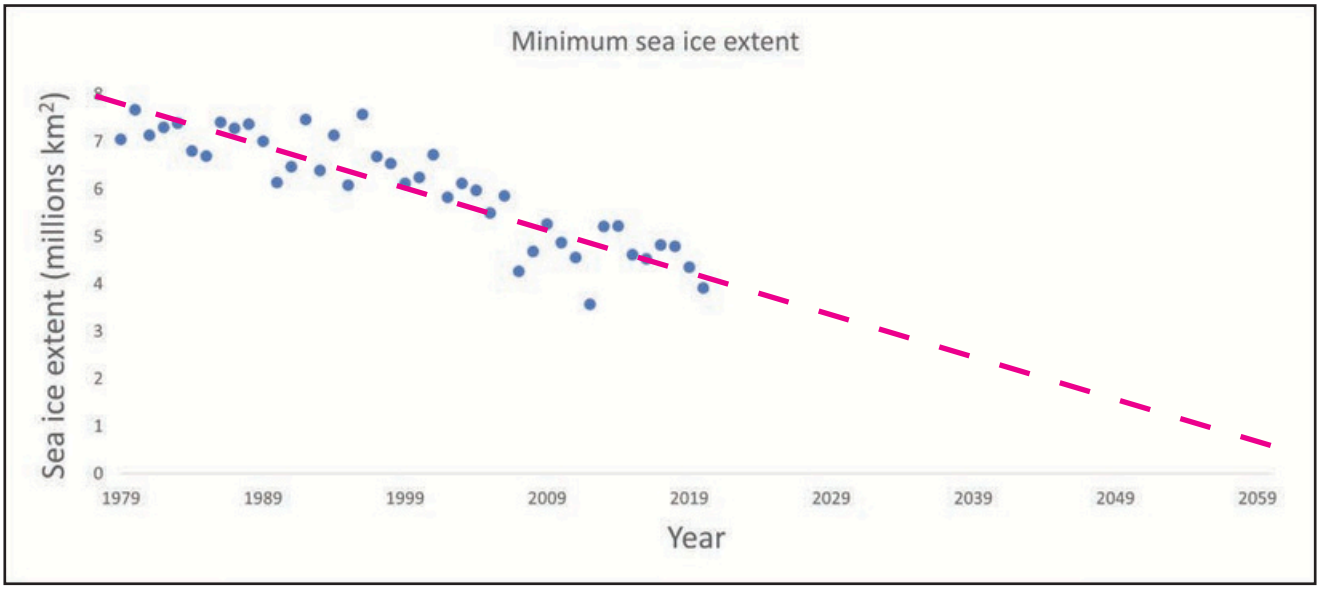

Figure 1: Sea ice extent, as calculated from satellite data since 1979 to 2020.

3. Do you think there is a "best" line we could draw through the data? Using your ruler, draw a straight line on the graph that seems to capture the main trend or pattern in the data.	Solution: A possible "best fit" line is drawn using red dashes. The idea is to just provide something that looks somewhat reasonable.
4. Come up with at least one idea for how to determine which line fits the data "best."	Solution: This is another brainstorming question; there are many ways in which scientists decide which line fits "best" (e.g., maximum likelihood, minimizing the sum of squares). If students are stumped, you could suggest a line with really poor fit to the data, ask why they think it is a poor fit. One key idea to cover here is the idea of somehow minimizing how far away the line is from each of the points.
5. Do you think this pattern is happening by chance, or does the evidence seem strong enough to suggest real changes?	Solution: This is an opinion question. Most students will likely see this evidence as quite strong; you could propose other made-up data that is more or less compelling, to help develop student intuition.

6. From looking at the line you drew on the graph, when do you think that there will be no ice in September in the summer?	Solution: Look at the x intercept; for the red line above, the line intersects the x axis at approximation year 2060.
7. Do you think this guess of when there will be an ice-free summer is realistic or like to happen? What other factors might influence the actual date? **(Bonus):** Using the internet to search, see if you can find the year in which scientists think that we will have an ice-free summer.	Solution: Many factors might influence when there is actually an ice free summer. Scientists often talk about feedback loops and tipping points. One of these is related to sea ice albedo – water reflects less sunlight than ice, so as less and less ice is present, the air gets warmer faster and faster, causing an increase in the rate of sea ice decline. Other factors that may influence the rate of sea ice loss include the amount of emissions due to human activity, which could either slow down this rate or speed it up. Bonus Solution: There is no one scientific consensus on this; depending on assumptions made about the emissions scenario and the model used, possible estimates could include, for example the years 2035, 2048, or 2086. [See Guarino, M. V., Sime, L. C., Schröeder, D., Malmierca-Vallet, I., Rosenblum, E., Ringer, M., ... & Sellar, A. (2020). Sea-ice-free Arctic during the Last Interglacial supports fast future loss. Nature Climate Change, 10(10), 928-932.] In general, model averages suggest sometime in the middle of our current century.
8. Do you think a straight line did a good job capturing the patterns in the data?	Solution: students may answer yes or no; an alternate could be a line with a slight curve, or many curves. What about a line that goes through each of the points, like a connect-the-dots picture; do they think that is a useful line to look at? Why or why not? In general, we try to find patterns in data – if you draw a line connecting every dot, you cannot see the bigger pattern, which makes it difficult to understand why or how things are changing.
9. How do you think this trend in sea ice will affect polar bears?	Solution: polar bears need sea ice as a platform for hunting, travel, for finding mates, and even for giving birth in some areas. If the sea ice is melting earlier and forming later in the fall, this shortens the amount of time polar bears can hunt on the ice. Additionally, as sea ice melts, the whole Arctic ecosystem will experience shifts, from the phytoplankton and algae at the bottom of the food web, through the zooplankton, fish, and marine mammals, which ultimately affects the available food for polar bears. If students are interested in helping mitigate the loss of sea ice for polar bears (and for humans!), see the "We have the power to protect polar bears" pamphlet here: https://surl.li/xlrcrz.