



Geometry of Polar Bear Movement

6th, 7th, and 8th grade unit

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Math Core Curriculum:

Gr. 6 – Geometry (CCSS. MATH.CONTENT.6.G.A.1:

Solve real-world and mathematical problems involving area, surface area, and volume)

Gr. 7 – Geometry (CCSS. MATH.CONTENT.7.G.B.6:

Solve real-life and mathematical problems involving angle measure, area, surface area, and volume)

Gr. 8 – Geometry (CCSS. MATH.CONTENT.8.G.B.7:

Understand and apply the Pythagorean Theorem)

Objectives:

To use concepts from geometry such as perimeter, area, and the Pythagorean theorem to explore how polar bears move through their environment.

Students will need to be familiar with the following techniques to solve real life problems:

- Standard operations including addition, subtraction, multiplication, division.
- Movement rates in units of km/hr; ratios and proportional units
- Pythagorean Theorem

Academic Sources Johnson,

A. C., Pongracz, J. D., & Derocher, A. E. (2017). Long-distance movement of a female polar bear from Canada to Russia. Arctic, 121-128.

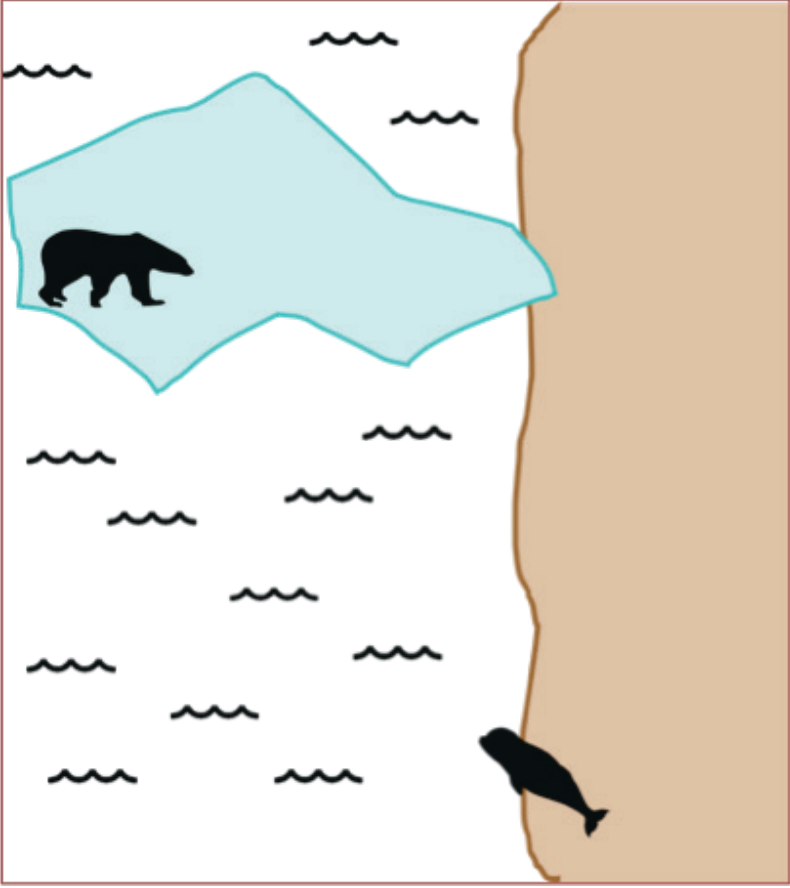
Griffen, B. D. (2018). Modeling the metabolic costs of swimming in polar bears (*Ursus maritimus*). Polar Biology, 41(3), 491-503.

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Before the lesson (optional):

Open this link: <https://polarbearsinternational.org/polar-bears-changing-arctic/polar-bear-facts/habitat/> and read the sections on habitat, especially "Getting Around the Arctic". While reading, write down any vocabulary words you do not understand in the box.

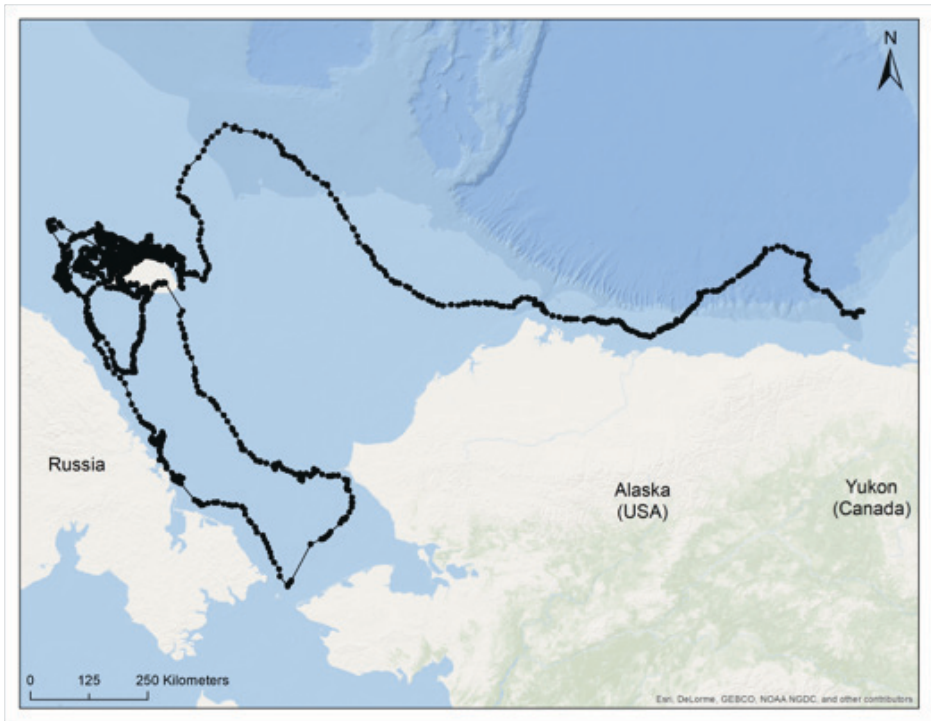
New words:

<p>1. Imagine a polar bear walks around the edge of an ice floe that has five sides, each measuring approximately 1.5 km, hoping that a seal pokes its head up. Draw a diagram. What shape is this ice floe?</p>	
<p>2. What is the total distance the polar bear has travelled while walking all the way around the ice floe?</p>	
<p>3. If the bear is walking at a rate of 5 km/hr, how long does it take for them to walk all the way around this ice floe?</p> <p><i>Bonus:</i> What is the area of this ice floe?</p>	
<p>4. Now imagine there is a polar bear on the far side of an ice floe that has bumped up against the shore and it smells a whale carcass on the shore (see the picture). The polar bear can either walk east for 3km until it hits land and then walk south along the shore for 4km, or it can swim directly to the whale carcass.</p> <p>The polar bear wants to be the first bear to this feast! Without doing any math, what is your guess about whether they should swim or take the long way walking?</p>	

5. Calculate which path would be faster if the path leading to land is 3 km and the whale carcass is 4 km away once land is reached. Assume the bear can walk at a speed of 5 km/hr or swim at a speed of 2 km/hr. The following table might be helpful to organize your calculations.

	Walking Route	Swimming Route
Distance Travelled		
Time Required to Reach Whale		

Polar bears can travel surprisingly long distances. A female polar bear travelled a total of 11,686 km from Canada to Russia. The bear began traveling in spring of 2009 and her recorded journey lasted 798 days, more than 2 years!



6. On average, how far did she travel each day?

7. Do you think you could walk that far in a day?
Could you swim that far in a day?



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Lesson Solutions

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Understand and apply the Pythagorean Theorem)

Learning Objectives:

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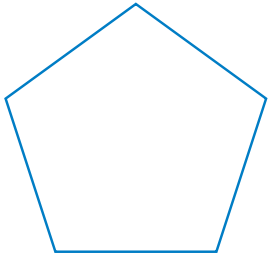
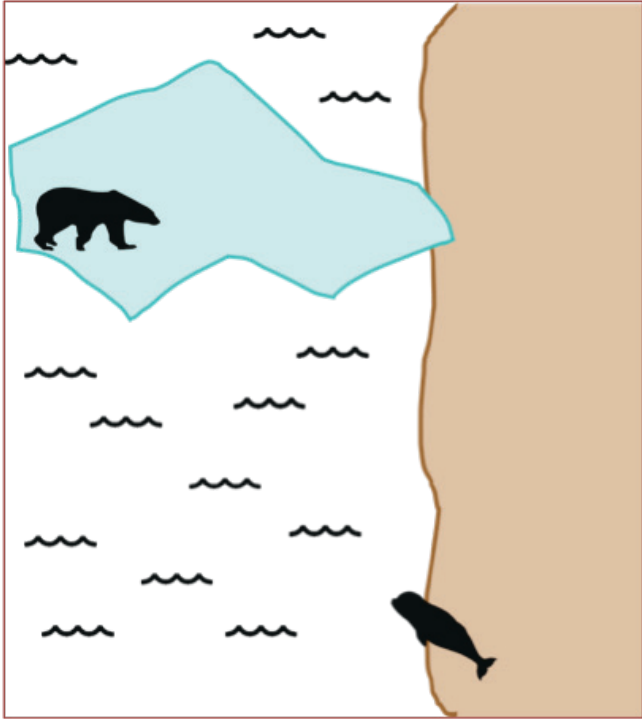
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New words:

<p>1. Imagine a polar bear walks around the edge of an ice floe that has five sides, each measuring approximately 1.5 km, hoping that a seal pokes its head up. Draw a diagram. What shape is this ice floe?</p>	<p>Solution: This is a regular pentagon. It would be good to discuss with the students whether or not they think there are other ways to draw the ice floe such that each of the 5 sides are 1.5 km in length, i.e., is the solution unique?</p> 
<p>2. What is the total distance the polar bear has travelled while walking all the way around the ice floe?</p>	<p>Solution: $1.5+1.5+1.5+1.5+1.5 = 5 \times 1.5 = 7.5$ km</p>
<p>3. If the bear is walking at a rate of 5 km/hr, how long does it take for them to walk all the way around this ice floe?</p> <p><i>Bonus:</i> What is the area of this ice floe?</p>	<p>Solution: $7.5 \div 5 = 1.5$ hr. This could also be accompanied by a discussion of how the units work for this problem, i.e., [km]/[km/hr] = [hr].</p> <p>Bonus Solution: The formula for the area of a regular pentagon, A, given a side length of x, is $A = \frac{x^2 \sqrt{5}(5+\sqrt{5})}{4}$</p> <p>Here $x = 1.5$ km, so $A = 3.87$ km².</p>
<p>4. Now imagine there is a polar bear on the far side of an ice floe that has bumped up against the shore and it smells a whale carcass on the shore (see the picture). The polar bear can either walk east for 3km until it hits land and then walk south along the shore for 4km, or it can swim directly to the whale carcass.</p> <p>The polar bear wants to be the first bear to this feast! Without doing any math, what is your guess about whether they should swim or take the long way walking?</p>	 <p>Solution: Encourage discussion about variable speeds of travel (e.g., do the students think swimming is faster or slower than walking?)</p>

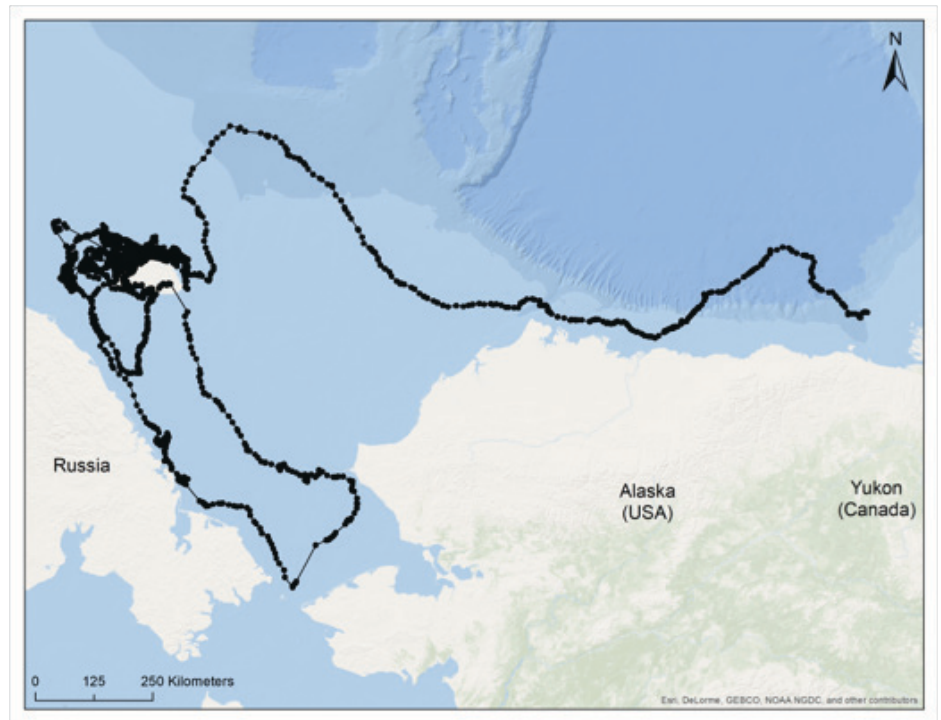
5. Calculate which path would be faster if the path leading to land is 3 km and the whale carcass is 4 km away once land is reached. Assume the bear can walk at a speed of 5 km/hr or swim at a speed of 2 km/hr. The following table might be helpful to organize your calculations.

Solution: To solve this problem, you will need to discuss how the walking route along the ice and then the shore create two sides of a right angle triangle, with the swimming route as the hypotenuse. This can then set up the problem to use the Pythagorean Theorem.

	Walking Route	Swimming Route
Distance Travelled	3 km + 4 km = 7 km	5 km (by Pythagorean Theorem)
Time Required to Reach Whale	7 km ÷ 5 km/hr = 1.4 hr (= 1 hr and 24 min.)	5 km ÷ 2 km/hr = 2.5 hr (= 2 hr and 30 min.)

So it is faster for the bear to walk, even though that requires the bear to travel a longer distance.

Polar bears can travel surprisingly long distances. A female polar bear travelled a total of 11,686 km from Canada to Russia. The bear began traveling in spring of 2009 and her recorded journey lasted 798 days, more than 2 years!



6. On average, how far did she travel each day?

Solution: $11686 \text{ km} \div 798 \text{ days} = 14 \text{ km per day.}$

7. Do you think you could walk that far in a day? Could you swim that far in a day?

Solution: Students may be more comfortable thinking in miles, so it may be helpful to convert 14 km to miles by dividing by 1.609 to get distance of 8.7 mi.