

IMPACTS OF CLIMATE CHANGE ON CARIBOU

Overview:

In this lesson students examine caribou as a subsistence resource and read and summarize the impact of climate change impacts caribou populations and migration. Students also view and reflect upon a video documenting the knowledge of people from communities throughout the North who traditionally have a close relationship with caribou.

NOTE: This lesson is estimated to take three or more class periods to complete in its entirety.

Objectives:

The student will:

- summarize potential impacts of climate change on caribou populations;
- solve basic math operations (mean, median, mode, range) based on caribou population data; and
- reflect upon the relationship between subsistence communities and natural resources.

Targeted Alaska Performance Measures Tested on the Alaska High School Qualifying Exam (HSQE):

Reading

R4.4 Read and follow multi-step directions to complete complex tasks.

Writing

W4.3 Use the conventions of Standard English independently and consistently including grammar, sentence structure, paragraph structure, punctuation, spelling, and usage.

Math

M2.4.2 Estimate and convert measurements between different systems.

M3.3.2 Apply basic operations efficiently and accurately, using estimation to check the reasonableness of results.

M6.3.2 Interpret and analyze information found in newspapers, magazines, and graphical displays.

M6.3.3 Determine and justify a choice of mean, median, or mode as the best representation of data for a practical situation.

M6.3.4 Make projections based on available data and evaluate whether or not inferences can be made given the parameters of the data.

M10.3.1 Apply mathematical skills and processes to science and humanities.

M10.3.2 Apply mathematical skills and processes to situations with peers and community.

Vocabulary:

circumpolar – surrounding or found in the vicinity of the North or South Poles

ecosystem – a community of living things (plants, animals, fungus and microorganisms) together with their physical environment

habitat – the home or natural environment of a living organism

lichen – an organism that consists of a fungus and an alga living in a symbiotic (mutually supportive) relationship; lichens often live on rocks and tree bark and can thrive in extreme environments; they are an important food source for barren-ground caribou

mean – a number or quantity having a value that is intermediate between other numbers of quantities

median – the middle value in a sequence of numbers (or the average of the two middle numbers when a sequence has an even number of values)

mode – the value that occurs most frequently in a data set

range – the difference between the smallest and largest values in a data set

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Materials:

- Dry erase markers (at least four easily distinguishable colors)
- Tape
- Snowshoe or ski (if available)
- Graph paper (with 1 cm squares, 2 sheets/student, plus about 10-15 extra)
- VIDEO: "Caribou and Climate Change"
- VIDEO: "Caribou Movements"
- VIDEO: "Voices of the Caribou People"
- TEACHER INFORMATION SHEET: "Sink in Snow Data Set"
- STUDENT INFORMATION SHEET: "Caribou and Climate Change"
- STUDENT WORKSHEET: "Impacts of Climate Change on Caribou"
- STUDENT WORKSHEET: "Caribou Math"
- STUDENT REFLECTION SHEET: "Voices of the Caribou People"

Activity Preparation:

1. The day of the lesson, be sure to have a white board available to record lists and data. Have a few different colored markers on hand.
2. Review TEACHER INFORMATION SHEET: "Sink in Snow Data Set."

Activity Procedure:

1. Review the lesson in its entirety to determine what can be accomplished by students on the first day, the second day, etc., then decide appropriate divisions. In addition, review the section Extension Idea(s) to determine if activities are well suited to continued learning.
2. Work with students to brainstorm a list of subsistence resources used by people in their community. Designate one color marker for each season: winter, spring, summer and fall. Write items on the dry erase board using the color to indicate the season in which they are hunted/gathered. The list might include various species of fish, mammals, birds and plants.
3. Once you have created a comprehensive list, ask students to briefly reflect on and share why/how subsistence resources are important to them. Ask them to list all of the different voices that should be involved in making decisions about Alaska's subsistence resources. These may include: Alaska Native people and other subsistence users, wildlife biologists, Alaska Native Elders, state and local governments, recreational land users (hunting, fishing and wildlife viewing), commercial users (fishing and mining companies) and local business owners. Include the following points in discussion: some subsistence resources such as salmon are also an important part of Alaska's economy; other resources are primarily used as food for Alaskans; and all subsistence resources are important parts of Alaska's ecosystem and natural resource management strategy. Explain this lesson will focus on one subsistence resource that plays an important role in the lives of many Alaskans: caribou.
4. Ask students to imagine they are going out for a walk in winter. What do they do to prepare? (*packing food and water, putting on winter gear, etc.*) What if they will be going off roads and trails? What tools can help them walk across the snow? (*skis and snowshoes*) Remind students that many northern animals (*including caribou, snowshoe hare, lynx and others*) have feet that are adapted for efficiently walking on snow (*like snowshoes and skis*).
5. Pass out two pieces of graph paper to each student. Work with students to calculate their "sinking factor" (weight load on each foot). See TEACHER INFORMATION SHEET: "Sink in Snow Data Set" for detailed directions.

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6. Analyze the “sinking factors” data set created with students. Find mean, median, mode, and range of the data set. Who is better adapted to walk on snow? Whose foot exerts the least pressure measured in pounds per square inch (psi)? If available, calculate the sinking factor of a student on a snowshoe and/or ski. How does it compare? A caribou’s toes spread apart as they walk, increasing the surface area of their footprint, decreasing the psi. The ability to walk on top of the snow, instead of breaking through, conserves energy.
7. Ask students to begin thinking about how populations of living things that are adapted for life in the North might respond to climate change. Instruct students to view the VIDEO: “Caribou and Climate Change” and “Caribou Movements,” and read STUDENT INFORMATION SHEET: “Caribou and Climate Change.” This can be done as a class or independently, depending on what works best for your class.
8. Instruct students to fill out STUDENT WORKSHEET: “Impacts of Climate Change on Caribou” individually or as a class.
9. Pass out STUDENT WORKSHEET: “Caribou Math.” Instruct students to complete individually or in small groups, whatever works best for your class. (NOTE: To provide consistency in student answers, you may choose to review the bar graph together and decide upon the extrapolated values that will be used for the calculations.)
10. Pass out STUDENT REFLECTION SHEET: “Voices of the Caribou People.” Allow time for students to view the VIDEO: “Voices of the Caribou People” (length: approximately 11 minutes) and answer the reflection questions.

Extension Ideas:

1. If caribou are an important part of life in your community, you may want to include a more detailed discussion or writing assignment. Pose a locally relevant question or issue (i.e possible resource development or road construction) that could impact caribou movements or survival in your area. Engage the class in a discussion of the issue or assign students a writing assignment to explore the issue further. Suggested discussion techniques and student worksheets for guided writing assignments can be found under TEACHER RESOURCES on the UNITE US website (uniteusforclimate.org).
2. In many communities moose are a vital subsistence resource. Ask students to research adaptations of moose to the snowy arctic environment. How could climate change impact the moose population? Make a chart similar to the one about caribou.

Answers:

STUDENT WORKSHEET: Impacts of Climate Change on Caribou

1. Answers will vary.
2. Herds are most concentrated in June and July. Students will explain in their own words, but answers should mention the animals are most concentrated just after calving, and most dispersed in the winter months (November-April).

Students’ ideas about why will vary, but may contain all or some of the following reasons: Just after the calves are born, caribou gather in large groups to avoid predators like wolves and bears. They stay together in the mountains and along the coast where wind and cooler temperatures protect them from heat and insects. After insect numbers decline in August, caribou begin to scatter. Rut (mating season) is approaching and males begin to defend territories. Caribou are most widely distributed in the winter months (November-April). During this time they are moving around in smaller groups foraging for lichens and dried plants under the snow.

3. There is a small amount of overlap throughout most of the year. The least overlap occurs during calving and the most occurs during the winter months. Most animals are faithful to their calving grounds. This is how herds are defined.

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4. Students may observe that most animals seem to follow valleys and rivers. Caribou tend to calve in the same area each year, but do not always travel the same route to get there. Migration routes used for many years may suddenly be abandoned in favor of movements to new areas with more food. Caribou seem to have a strong sense of smell and may use it to find and migrate to areas where the vegetation is lush, accessible and plentiful.

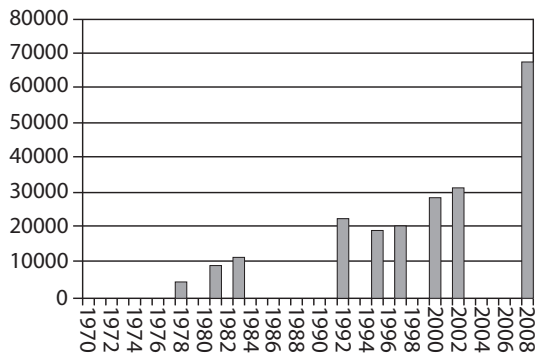
These are the main ideas (see table on following page). Responses will vary slightly.

Observed Change	Impact on Herd Movement	Impact on Body Condition	Impact on Survival and Productivity (# of calves)	Management Implications: What can we do to help?
Warmer, wetter winters cause deeper and heavier snow	caribou have difficulty traveling through deep snow; moving and foraging requires more energy	caribou use more time and energy traveling and foraging; decrease in overall health	cows may not make it to calving grounds resulting in decreased calf survival (poor food and increased predation)	ensure availability and protection of low snow regions (if possible); develop strategies to address climate change; monitor populations and set harvest guidelines
Warmer winters cause cycles of freezing and thawing	caribou have difficulty traveling over ice; abandon areas with severe surface icing	caribou use more time and energy traveling and foraging; decrease in overall health	some caribou may starve in winter; cows may not make it to calving grounds; decreased calf survival (poor food and increased predation)	develop strategies to address climate change; monitor populations and set harvest guidelines
Rivers and lakes break up earlier	open water creates a barrier to travel; caribou may have to go out of their way to find a new route	caribou use more time and energy traveling; decrease in overall health	caribou (especially calves) may drown trying to cross rivers or falling through thin ice	develop strategies to address climate change; monitor populations and set harvest guidelines
Milder winters cause an increase in range and population size of mosquitoes and parasites	move to nontraditional regions seeking areas free of mosquitoes and parasites	increased harassment means less time spent foraging; overall health declines	decreased winter survival due to poor fat reserves	ensure availability and protection of low insect regions (if possible); develop strategies to address climate change; monitor populations and set harvest guidelines

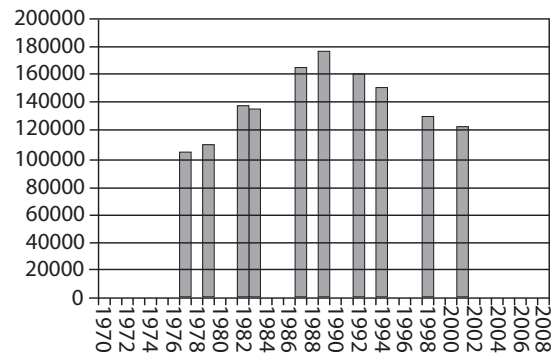
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<p>Snow melts earlier allowing plants and lichens to grow earlier in season</p>	<p>migratory routes and timing have changed to reach areas that are greener and growing earlier in the year</p>	<p>nutrient-rich food increases overall health, especially pregnant and nursing cows and calves</p>	<p>calf survival could increase because of high quality food source (also provides energy for cows to produce milk)</p>	<p>monitor populations and set harvest guidelines</p>
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Central Arctic Herd Population Estimates



Porcupine Caribou Herd Population Estimates



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STUDENT WORKSHEET: Caribou Math

Student answers will vary slightly based on their extrapolations of the bar graph. The values marked on the graphs below are the values used to calculate the answers provided.

- A. The Porcupine Caribou Herd population grew each year from 1977-1989.
- 1983 and 1992

Although the Porcupine Caribou Herd added more animals (25,000 animals compared to the 10,000 added by the Central Arctic Herd), the Central Arctic Herd appears to have experienced a growth rate (percent change). Since this is an estimate, either herd is an acceptable answer.
- Answers may vary slightly since students are extrapolating; exact numbers are not given.

Porcupine Caribou Herd:	Central Arctic Herd:
1983 population: 135,000	1983 population: 13,000
1992 population: 160,000	1992 population: 23,000
$160,000 - 135,000 = 25,000$	$23,000 - 13,000 = 10,000$
$25,000 \div 135,000 \times 100 = 19\%$ population increase	$10,000 \div 13,000 \times 100 = 77\%$ population increase

The Central Arctic Herd grew at a much greater rate between 1983 and 1992.
- $(5,000 + 9,000 + 13,000 + 22,000 + 18,000 + 20,000 + 27,000 + 31,000 + 67,000) \div 9 = 23,556$

MEAN: 23,556

5,000 9,000 13,000 18,000 20,000 22,000 27,000 31,000 67,000

MEDIAN: 20,000
- No. The mode is the number that appears most frequently in the data set. Since no number repeats, this data set does not have a mode.
- FOR BULLS: $130 \text{ kg} \times 2.2 \text{ lb/kg} = 286 \text{ lb}$

$86 \text{ lbs} \times .04 = 11 \text{ lb}$

4% of a bull caribou's weight is 11 lb. A collar weighing only 4 lb is less than 4% of its body weight and is safe to put on the animal.

FOR COWS: $90 \text{ kg} \times 2.2 \text{ lb/kg} = 198 \text{ lb}$

$198 \text{ lb} \times .04 = 8 \text{ lb}$

4% of a cow caribou's weight is about 8 lb. A collar weighing only 4 lb is less than 4% of its body weight and is safe to put on the animal.
- | | | |
|--|----|--|
| $9,000 \text{ g} \div 1,000 \text{ g/kg} = 9 \text{ kg}$ | OR | $9,000 \text{ g} \div 1,000 \text{ g/kg} = 9 \text{ kg}$ |
| $9 \text{ kg} \times 2.2 \text{ lb/kg} = 20 \text{ lb}$ | | $9 \text{ kg} \div 130 \text{ kg} = 7\%$ |
| $20 \text{ lb} \div 286 \text{ lb} \times 100 = 7\%$ | | |
- What is the total cost of collars?

$125 \times \$1,750 = \$218,750$ total cost of collars

What is the total cost of capturing the caribou?

$125 \times \$500 = \$62,500$ total cost of capturing caribou

What is the total cost of data retrieval?

52 weeks per year \times 1.5 years = 78 weeks total time of project

78 downloads (done once/week) \times \$15/download = \$1,170 total data retrieval cost/animal

$\$1,170 \times 125$ caribou = \$146,250 total cost of data retrieval for 125 animals for 18 months?

What is the total cost of the project?

$\$218,750 + \$62,500 + \$146,250 = \$427,500$ total cost of the project

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STUDENT REFLECTION SHEET: Voices of the Caribou People

Answers will vary for each question, but these are the main ideas provided in the video.

1. Caribou are the livelihood of the communities portrayed in the video. Caribou provide food, clothing and tools, and are the main food source for many families. These communities live amongst the caribou. They share the same landscape. Caribou are a part of celebrations, including dance. Mary Rose Enzoe mentions even the fat is used for grease, and the bones are used for tools (knives, scrapers).
2. Darius talks about the value of the caribou (as a source of food, clothing, and tools) over the long term. He talks about the value of caribou to a culture that has lived and survived with the land, wildlife and water intact for thousands of years. He compares the value of this relationship with the land to the dollar value of extracting a nonrenewable resource such as oil that may only last for a matter of months or years.
3. Steven talks about wildlife management. He talks about the importance of following hunting/ fishing guidelines when you find out animal populations are low. He talks about the importance of communicating with other communities. The last thing he mentions is that we all need to “keep trying,” or keep working together to find solutions that work for people and caribou.
4. Answers will vary.

The “sinking factor” (or weight load on foot) is a way to look at an animal’s adaptation to snowy environments. It measures the pressure exerted by an animal’s foot on the snow and, therefore, can estimate the potential that the animal will sink into the snow. Sinking into the snow requires more energy to walk and feed than walking on top of the snow. Animals that are well adapted to snowy environments often have feet with a large surface area to reduce the potential for sinking into the snow. Other factors that may affect the “sinking factor” include the hardness of the snow and the way the animal is moving (walking, running, bounding, etc.).

Pass out two pieces of graph paper per student. Students should trace their shoe/boot onto the graph paper. Students with larger feet will need a piece of tape to attach two pieces of graph paper together to create a piece large enough for their entire foot. Instruct students to find the area of their “track” (in square centimeters) by counting the squares contained in the outline. This will require some estimation since shoes/boots do not have straight edges. Students should count only the squares that are more than half included inside the outline, and ignore the squares that are less than half included.

To calculate psi (pounds per square inch):

1. Convert the area of the outline from square centimeters (cm^2) to square inches (in^2). Round answer to the nearest tenth.

$$1 \text{ inch} = 2.54 \text{ cm and so } 1 \text{ in}^2 = 6.45 \text{ cm}^2$$

2. Divide student’s estimated weight (in pounds) by the area (in square inches). Again, round answer to the nearest tenth.

EXAMPLE: The area of a boot is calculated at 209 cm^2 for an individual weighing 140 pounds

$$209 \text{ cm}^2 \div 6.45 \text{ cm}^2 / \text{in}^2 = 32.4 \text{ in}^2$$

$$140 \text{ lb} \div 32.4 \text{ in}^2 = 4.3 \text{ lb/in}^2 \text{ or } 4.3 \text{ psi}$$

This is a measurement of the force or pressure exerted by an individual’s foot onto the snow. Once students have finished calculating their psi, ask them to come up and write the value on white board. After all values are reported, review how to find the mean, median, mode and range of a data set.

Caribou are migratory mammals of the North. They have a circumpolar distribution. This means they are found throughout the Northern Hemisphere, in the tundra and northern forests of North America, Russia, and Scandinavia. Their world-wide population is estimated at five million. Alaska's 900,000 caribou are separated into 32 different herds. Caribou herds are identified by where females give birth to their calves. These herds may mix on their wintering grounds. The largest herd is the Western Arctic Herd whose population was estimated at 401,000 animals in July 2009.

Migration is a seasonal movement from one region or habitat to another. Some species of birds, insects, fish, and mammals all migrate. Caribou migrate to different regions of the north that provide the resources they need to survive at different times of year. Some individuals may travel more than 3,000 miles each year and their movements can be hard to predict. Most herds are drawn to a particular calving area where they return each spring, but the path they take to get there can vary based on food availability, snow levels, weather conditions and human activity.

How might global climate change affect migrating caribou herds?

Caribou are adapted for life in the North. Their large hoofs spread widely when they walk, allowing them to travel in snow, swim across rivers and walk on tundra. Caribou forage on the ground.

Warmer temperatures can create conditions that make it more difficult for caribou to travel and find food.

- 1. Warmer Arctic temperatures produce snow that is deeper and heavier (wetter) than normal.**
Caribou feed on tundra plants, mushrooms and lichens. Deep, heavy snow makes it more difficult for them to reach their food. Deep snow also requires more energy to walk through and slows them down. If snow is deep throughout their range, traveling will require a lot more energy and cows may not make it all the way to their calving grounds in the spring. Traditional calving grounds provide nutrient-rich food and safety from predators (wolves and bears). Calves that are born away from the traditional calving grounds may not survive.
- 2. Warmer Arctic temperatures create cycles of freezing and thawing or freezing rain.**
If the ground is iced over from repeated freezing and thawing (or from freezing rain), caribou often can't break through the ice to access the food underneath. This can result in winter starvation.
- 3. Warmer Arctic temperatures could cause rivers and lakes to break up earlier.**
This is a problem for caribou and people. Open rivers and lakes can create a barrier to travel. There is also the increased possibility of losing calves that are too small and weak to survive water crossings. The "Tuktu and Nogak Project" is a research project that collected observations from Inuit Elders on the Bathurst Caribou Herd (in northern Canada). The Elders observed the caribou shifted their migration routes to avoid rivers full of rushing water and chunks of ice. They also noted more caribou were drowning as they fell through thin ice.
- 4. Warmer Arctic temperatures could increase populations of mosquitoes and parasites by allowing them to survive farther north and higher up the mountains (where they couldn't survive before.)**
Caribou go out of their way to seek windy and mountainous areas to avoid mosquitoes and other insects. If caribou spend more time and energy trying to avoid mosquitoes, they will spend less time eating and putting on weight for winter. This will decrease survival rates.
- 5. Warmer Arctic temperatures could cause snow to melt earlier in the spring, allowing plants and lichens to start growing earlier in the year.**
Elders in some Canadian provinces noticed caribou have changed their migration to reach areas that are greener and growing earlier in the year. Scientists in Alaska have looked at satellite images of the calving grounds of the Porcupine Caribou Herd that were taken between 1983 and 1996. These images clearly showed that vegetation appeared earlier in the spring as years passed. The availability of nutrient-rich food earlier in the year could cause increased survival rates, especially of calves. The new growth in the plants also provides the energy cows need to produce milk.

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Directions: Read the student information sheet and watch the VIDEO: "Caribou Movements." Answer the following questions and fill in the chart on page two.

1. Describe your observations about the movement of the caribou herds.

2. When are the herds most concentrated? When are they most widely distributed? Why? What do you think is the benefit of large and small groups at different times of the year? (Hint: Think about safety from predators and the availability of food.)

3. Do the herds ever mix? If so, when?

4. Can you tell what defines their migratory pathways?

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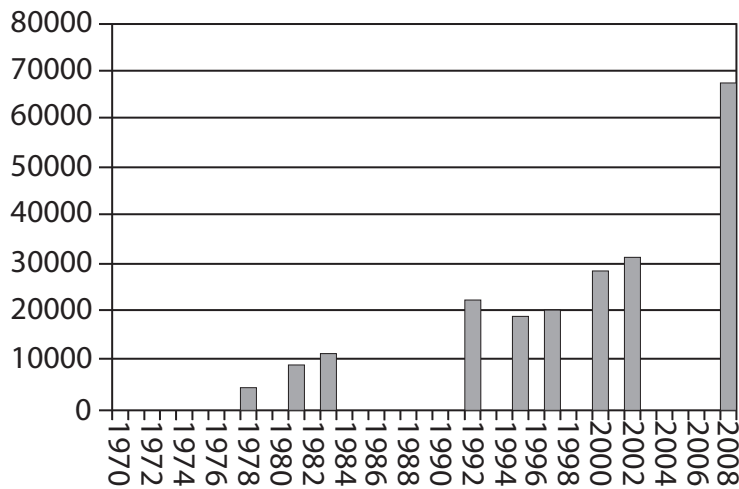
IMPACTS OF CLIMATE CHANGE ON CARIBOU

Observed Change	Impact on Herd Movement	Impact on Body Condition	Impact on Survival and Productivity (# of calves)	Management Implications: What can we do to help?
<p>Warmer, wetter winters cause deeper and heavier snow</p>				
<p>Warmer winters cause cycles of freezing and thawing</p>				
<p>Rivers and lakes break up earlier</p>				
<p>Milder winters cause an increase in range and population size of mosquitoes and parasites</p>				
<p>Snow melts earlier allowing plants and lichens to grow earlier in season</p>				

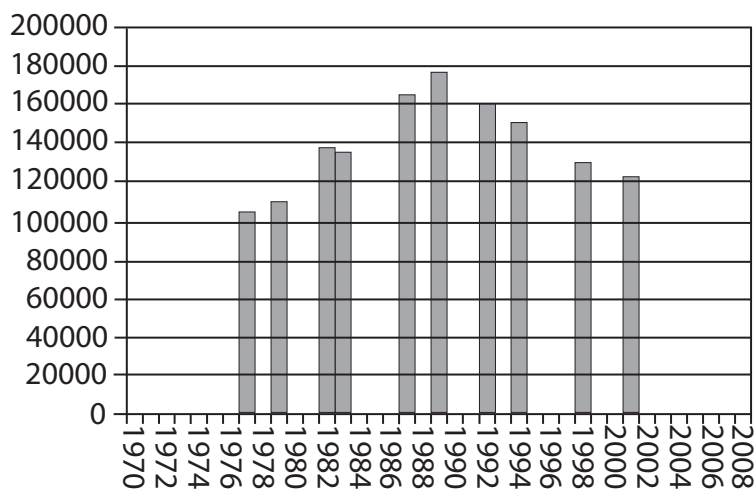
NAME: _____
CARIBOU MATH

Directions: Use the information in the bar graphs below to answer questions 1-5. Use math calculations to determine the correct answer for questions 6-8. Round up to the nearest whole number and write your answers in the space provided. Don't forget to show your work! Remember that mean is an average, median is the middle value in a sequence of numbers (or the average of the two middle numbers when a sequence has an even number of values) and mode is the value that occurs most frequently in a data set.

Central Arctic Herd Population Estimates



Porcupine Caribou Herd Population Estimates



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CARIBOU MATH

- Which of the following statements is NOT true. Circle it.
 - The Porcupine Caribou Herd population grew each year from 1977-1989.
 - The Porcupine Caribou Herd is larger than the Central Arctic Herd.
 - The Central Arctic Herd grew by more than 100% between 2002 and 2008.
 - The Central Arctic Herd included 20,000 animals in 1997.
- Find the two years for which there is population data for both the Central Arctic Herd and the Porcupine Caribou Herd. Write them here. Which herd appears to have experienced a greater growth rate (percent change) during this time?
- Calculate the growth rate (percent change) for each herd during this time. Was your initial interpretation (guess) correct? Show your work.
- Calculate the mean and median population size of the Central Arctic Herd for the years depicted. Show your work.
- Find the mode for this data set. Show your work.
- The general rule for a collar put on an animal is that it should weight less than 4% of the animal's body weight. An average bull caribou weighs 130 kg. An average cow weighs 90 kg. Use math calculations to determine if a 4 lb collar is safe for both males and females. Show your work.

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CARIBOU MATH

7. A bull caribou's antlers can weigh up to 9,000 g. What percentage of his body weight do his antlers represent? Show your work.

8. You are a biologist studying caribou in Alaska. You would like to put satellite collars on 125 caribou. Each collar costs \$1,750. The approximate cost of capturing each caribou is \$500 (to cover travel, equipment, fuel and salaries.) You will also need to pay for data retrieval (the fee paid to the satellite company for providing you with the animal's locations.) The data retrieval cost is \$15/animal for each download. The collars are programmed to transmit a signal one day a week. The collars should transmit for 18 months.

What is the total cost of collars? Show your work.

What is the total cost of capturing the caribou? Show your work.

What is the total cost of data retrieval? Show your work.

What is the total cost of the project? Show your work.

NAME: _____
VOICES OF THE CARIBOU PEOPLE

Directions: Watch the VIDEO: "Voices of the Caribou People," Answer the following questions.

1. In what ways are caribou an important part of life in the communities portrayed in the video? Why do you think they identify themselves as "caribou people?"

2. Darius Elias from Old Crow, Yukon states, "What's on top of the ground, there, is much more valuable than what's underneath." What do you think he means by this? Do you agree or disagree?

3. Steven Frost from Old Crow, Yukon states that, "We all have to do our part. We want those kids that aren't even born yet to have what we have." What do you think he means by this? What can you do?

4. Describe your community's relationship with caribou. If caribou is not a part of life in your community, is there another natural resource that plays an important role in your life and culture?
