A lesson from the Native Access to Engineering Programme

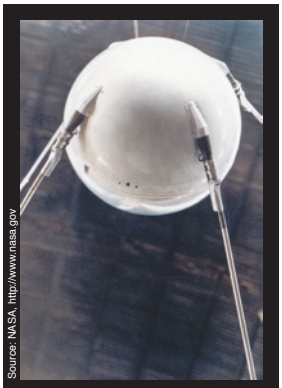
Satellite Tracking of Caribou

Satellite tracking: an application of geomatics in which GPS devices, satellites and ground resources are used to follow, study and observe objects on the Earth.

Satellites

Out on the land on a moonlit night, you look up at the sky. Thinking about the stories your grandfather told, you remember how he said that long ago Coyote released the moon into the sky to orbit around the Earth. Still looking up, you see a small, shiny dot out of the corner of your eye. It could be a star if it wasn't racing across the sky so quickly. Like the moon, this object also orbits the planet, but unlike the moon it was made and put up there by humans.

A satellite is any object which orbits another one. So, the moon is a satellite of the Earth and so is the International Space Station. Satellites can be natural, like the moons of planets, or artificial, like the Anik satellites which deliver television signals across Canada from north to south and east to west.



Source: NASA, http://www.nasa.gov

A model of Sputnik 1, the very first satellite.

Is Earth a satellite for anything?

The very first artificial satellite was called Sputnik. It was launched, by what was then the USSR, on October 4, 1957. It collected information about the electronic density of the ionsophere and sent it back to Earth. More importantly, however, Sputnik proved that artificial satellites would work. In fact, satellites have worked so well that in the year 2000 there were more than 2200 satellites orbiting the Earth. We've even sent some to other planets.

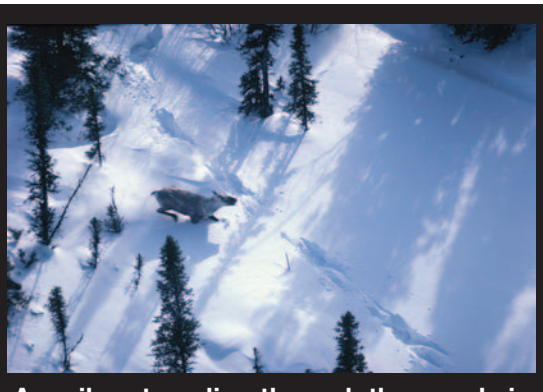
Today, we use satellites to beam communications signals around the world and to study our planet. We even use them to spy on each other. Without Sputnik and the other satellites it inspired, our lives today would be much different.

What might be different in a world without artificial satellites?

Tracking

Tracking, like other traditional skills, is an art and science which has been passed from one generation to the next for thousands of years. While a community's food supply no longer depends on the ability of local hunters to track and kill prey, not so long ago tracking was essential to survival.

Tracking involves identifying and following one or more animals by the signs they leave on the land. Experienced trackers can follow an animal over and through terrain for great distances by seeing things that other people would normally miss. To find their prey, trackers look for obvious signs, like footprints and spoor, but also follow more subtle clues to animal movement, like broken branches and trampled grass.



A caribou traveling through the woods in winter.

Many animals are also hunters and trackers. In fact, in many ways they are better adapted to finding and capturing food than humans. Some have a better sense of smell than we do, others have better senses of sight and/or hearing.

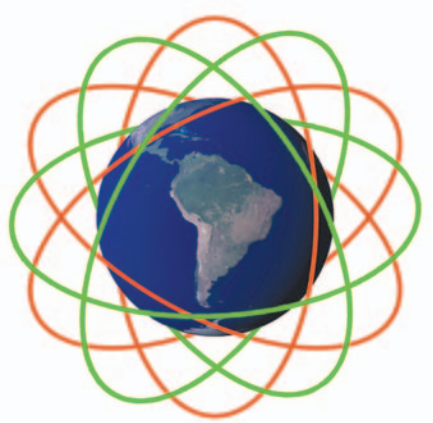
Eagle is a wonderful hunter and tracker.
What advantage does Eagle have over hunters on the ground?

Satellite tracking: GPS

Have you ever used a satellite phone?
Have you ever driven in a car that has On-Star?
How do you think these devices work?

Satellites and other technologies have come a long way since Sputnik. The development of lightweight, long lasting computer components, as well as improved imaging, measuring and signaling techniques, have allowed us to build some very complex machines and put them in orbit around our planet.

The global positioning system (GPS) was developed by the US Department of Defence so that it could know precisely where all its people, ships, and vehicles were at any time.



Why would it be important for the armed forces to locate vehicles and people accurately?

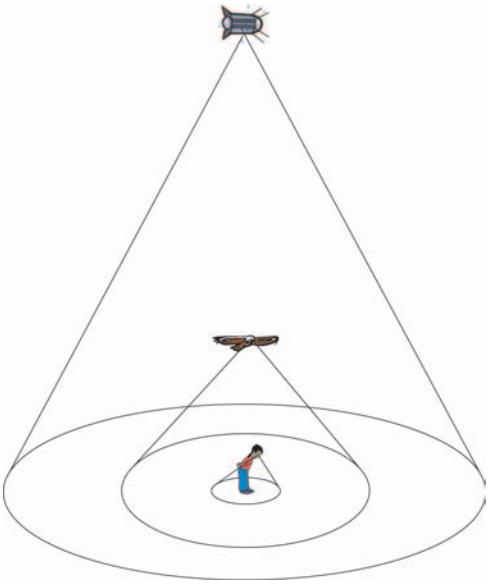
The GPS is a network of (at least) 24 satellites and numerous ground stations which track radio signals from transmitters on the ground, in the air or at sea. The satellites travel in six orbital planes, with (at least) 4 satellites per orbit, each at an altitude of 20,200km.

Because they are in such high orbits, GPS satellites have the same advantage that Eagle does over trackers on the ground: their height lets them see a lot more area. The layout of the GPS network ensures that at any time, any point on the planet falls in the footprint of 4 to 8 satellites. In other words, if you have a GPS radio transmitter/receiver, the GPS satellites can see you at any time in any place no matter where you are on Earth.

Why is it important that you can be seen by more than one satellite at a time?

How it works

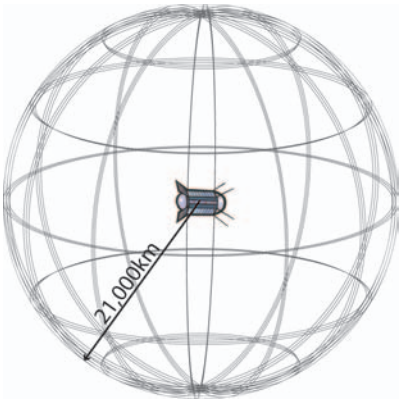
The overlap in satellite footprints is a key component in how GPS works. If you turn on a GPS radio transmitter, its signal is read by 3 of the GPS satellites. Each satellite contains computer chips that tell it how long your signal took to reach it and how fast that signal was traveling. (Radio signals travel at the speed of light or 299,792,458 m/s). By using some pretty simple math, Distance = velocity x time, each satellite can figure out exactly how far it is from your signal.



The higher you are above the Earth, the more you can see on the ground.

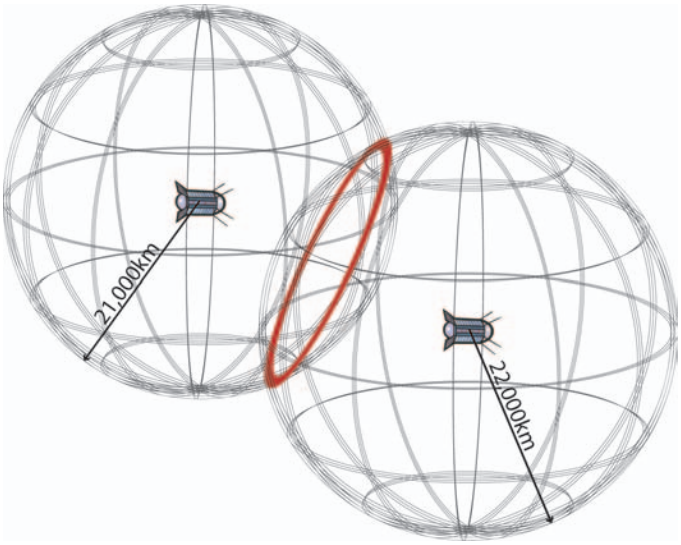
Have you ever heard of triangulation?

When each satellite knows how far away it is from your signal, it is easy for computers to trilaterate your exact position. Trilateration sounds difficult, but is actually quite a simple idea.



Satellite 1 picks up your signal and calculates that you are 21,000 km away. It sends a signal to the ground station that you are somewhere on a sphere with a radius of 21,000 km centred on satellite 1.

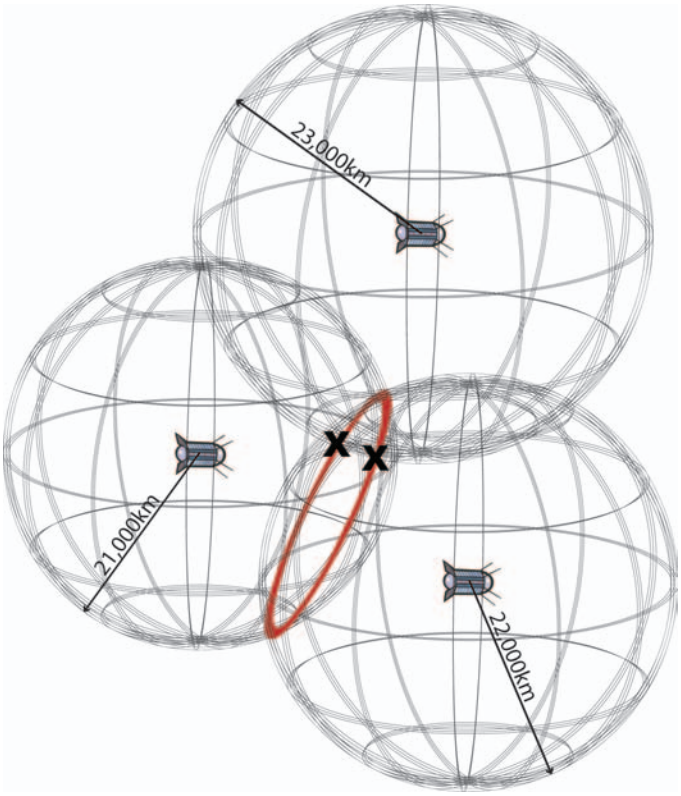
Satellite 2 also picks up your signal and calculates that you are 22,000 km away. It sends a signal to the same ground station that you are somewhere on a sphere with a radius of 22,000 km centred on satellite 2.



The computer at the ground station knows that if both satellite 1 and 2 can read your signal, sphere 1 and sphere 2 must intersect.

What shape is described by the intersection of two spheres?

The ground station now knows that you are somewhere on the circle described by the intersection of sphere 1 and sphere 2.



When the 3rd satellite picks up your signal, a computer calculates that you are located at one of the 2 spots marked "X." Often only one of those spots makes sense.

Finally (or almost), satellite 3 picks up your signal and calculates that you are 23,000 km away. It sends a signal to the same ground station that you are somewhere on a sphere with a radius of 23,000 km centred on satellite 3. The computer at the ground station knows that if satellite 1, 2 and 3 can read your signal, sphere 1, sphere 2 and sphere 3 must intersect. There are only 2 very precise points where this can happen and the computer calculates both of these points.

How does the computer know which of the points is your location?

Most of the time, only one of the locations will actually fall on Earth. In cases where both points make sense, the ground station looks at a fourth measurement related to signal time and decides which point is the right one.

Satellite tracking and animals

Why track animals by satellite?

As human populations and activities expand into just about any part of the planet, we are taking up land (and water and air) which used to be the realm of our animal brothers and sisters. Human use of animal habitat has lead to changes in animal behaviour, endangerment of species and, in some cases, extinction.

Do you know of any local animal species which are threatened, protected or endangered?

These days the needs of animals and the needs of people are often in conflict so, wildlife management boards, environmental agencies, regional governments and Aboriginal communities are tracking animals to study and protect them. They are working together and using geomatics technologies to discover more about habitat use, home range size, mortality and survivorship, as well as migration and migration routes. The information gathered is then used to make decisions about land use, conservation measures etc.

Polar bears, muskoxen, elephants, camels, turtles, sharks, whales, sea lions, wolves, swans and eagles have all been followed using satellite tracking; but the first animals to be tracked this way were caribou.

Source: NOAA, http://www.noaa.gov

Satellite tracking has been and is being used to track species which are threatend or endangered by human activity, like this loggerhead turtle.

Caribou

What are caribou called in your language?

In Latin they are known as, *Rangifer tarandus,* in Inuttitut *tuktu*, in Dene *etthén*, and in Mi'qmaw *xalibou*: a word which means shovel and refers to the shape of the animals' hooves. The English word *caribou* was probably derived from the Mi'qmaw.

A woodland caribou who is beginning to moult.

Caribou are the oldest member of the deer family. There are 4 types of caribou in North America, each defined, in part, by its range: Grant's Caribou in Alaska and the Yukon; Peary caribou in the far north, usually on Arctic islands; Woodland caribou, in southern Canada and northern parts of the US; and Barren-ground caribou in northern Canada and Alaska.

What kind of caribou, if any, are found where you live?

Both woodland and barren-ground caribou are being tracked by satellite. They are tracked with the ARGOS system, a joint project of the Centre National d'Etudes Spatiales (NNES) in France with the National Aeronautics and Space Administration (NASA) and National Oceanic and Atmospheric Administration (NOAA) in the United States.

Barren-ground caribou

With approximately 1.2 million animals, barren-ground caribou are by far the most abundant species of caribou in North America. Some herds are estimated in the hundreds of thousands. Barren-ground caribou live most of their lives on the tundra between the coast of Alaska in the west and Baffin Island in the east. They migrate seasonally, from north to south and back again, in patterns that are well-known to the peoples of the north.


Source: NOAA, http://www.noaa.gov

Barren-ground caribou.

Barren-ground caribou herds have wide (and sometimes overlapping) winter ranges, but return to the same calving grounds each summer. They are usually named for these areas in which they have their young. There are 8 major herds which account for more than 90% of all the animals. In order from Alaska to Hudson Bay, they are the Porcupine herd, Cape Bathurst herd, Bluenose West herd, Bluenose East herd, Bathurst herd, Ahiak herd, Beverly herd, and Qamanirjuaq herd. The remaining barren-ground caribou live in smaller herds that spend the entire year on the tundra. Half of these animals are found on Baffin Island.

Why track barren-ground caribou?


Source: J. Barta

Meat drying in a smoke house.

What reasons can you think of for wanting to track an animal?

When entire communities depended on the caribou as a major food source, changes in the animal population or the inability to find the animals during fall migration could mean extreme hardship or even starvation. Animal movements were carefully watched during the spring and summer, and information was shared between families. This information combined with intimate knowledge of the normal variation in caribou range and behaviour would help hunters find enough food for the long winter months.

Even today barren-ground caribou are considered a keystone species in the north: changes in their populations have deep and lasting impacts on other species and ecosystem processes. While changes in their range and behaviour no longer lead to starvation, they have serious economic and social impacts.

Barren ground caribou live in a fragile environment. Both natural and human-induced changes in the north may impact their health and their numbers. Wild fires can severely damage food sources causing a change in migrations routes, or forcing more than one herd to share territory. Resource exploration and mining activities can have similar effects. Some scientists think that stressful changes in the environment can cause changes not only in a herd's range and access to food but also in its rate of reproduction, resulting in a drop in population. The Porcupine caribou herd, for instance, underwent quite a rapid drop in population from 1989 when it had about 178,000 animals, to 1998 when it had about 129,000 animals.

What percentage change occurred in the Porcupine Caribou herd between 1989 and 1998?

Satellite tracking is being used to learn more about the caribou herds' habitat and habits. It is also being used to track changes in behaviour related to things such as industrial activities and climate change. Ultimately, the purpose of tracking is not so much to manage the caribou, as to manage human activity and behaviour so that it does not negatively impact the herds.

Could tracking help hunters?

Collars and collaring

In order to track an animal it has to be tagged or collared with a device which contains a GPS transmitter. Caribou are tracked using satellite radio collars.

Have you heard of any other types of animal tracking devices?

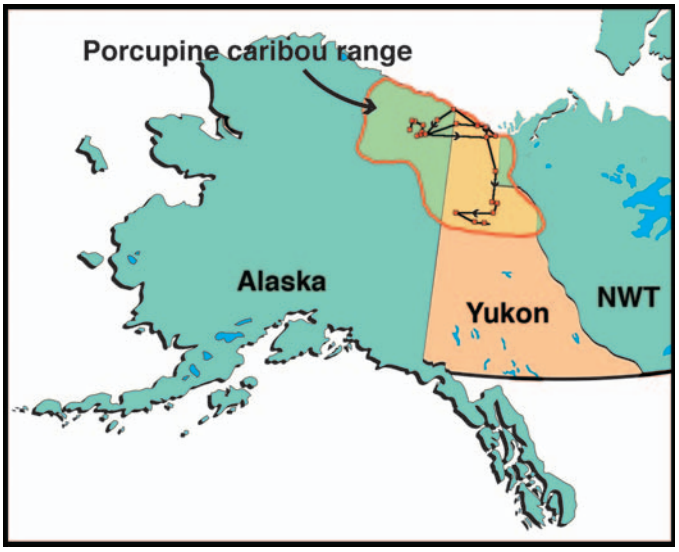
Caribou are usually captured for collaring in one of two ways.

They can be caught by a team in a boat while crossing a body of water. In this method, a cow is roped over the antlers and gently maneuvered to shallow water. There, one person holds the caribou, while the other attaches the collar to its neck. Within 2-3 minutes the animal is back swimming.

The quickest way to collar a caribou is to capture one while it is crossing a body of water. This group of caribou is crossing the Yukon River.
Source: Yukon Archives #7040
Claude and Mary Tidd fonds

In areas without large bodies of water, or when water is frozen, caribou are captured with helicopters and net guns. In this method, a cow is identified from the helicopter. A net gun is used to shoot a net over the antlers and front legs of the animal. A team on the ground then immobilize the caribou by tying its legs together and/or hooding the animal to calm it. The collar is attached around the neck, while other measurements or blood samples are quickly taken. The animal is released within 7 minutes.

Which collaring method do you think is better? Why do you think most animals collared are cows?



Satellite tracking of the Porcupine caribou herd has defined its full range, and allowed for tracking of individual animals. The map above shows the migration of a cow called Blixen from Jan 1-Dec 31, 2000.

Only a tiny percentage of any herd has to be collared in order to gain information about the overall herd. In the Porcupine Caribou herd for instance, 15-20 animals are being tracked at any time. The herd's overall size was estimated in 1998 as having approximately 129,000 animals. A herd that big, often moves in a number of smaller groups, spread over a fairly wide area. While tracking of an individual caribou provides a lot of information about movement and behaviour of that animal, it also provides information about the location of these smaller groups, and allows scientists to easily find them in the field for observation.

What percentage of animals in the Porcupine Caribou herd is being tracked?

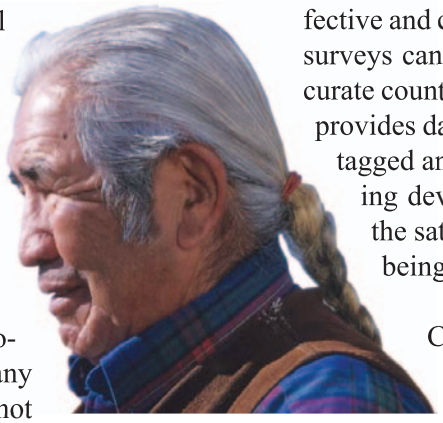
Where the first satellite collars used were close to 2kg, the newest collars weigh about 900g. Collars are attached around the caribous' necks loosely, but tight enough so that they can't get caught on branches or other objects. The new collars turn on once every 8 days for one hour, they can pinpoint an animal's location to within 10m. Older collars were on for 5-7 hours every 4 days and were only accurate to about 1000m.

How much more accurate are the new collars?

In addition, new collars are designed to drop off after a specified period of time, about 3 years. Older collars did not fall off by themselves, and animals had to be recaptured in order to have them removed. As far as scientists and wildlife management boards can tell, while the satellite collars cause some matting of fur around a caribou's neck, the collaring and collars have no impact on overall behaviour or quality of life. In some communities, however, the Elders are not so sure.

Elders concerns

In many communities, Elders have some serious concerns about both the methods of capturing caribou and the use of satellite collars. For thousands and thousands of years, the life of people and caribou in the north have been intimately linked. Because the animal was (and is) so important to community life, it was greatly respected especially when hunted for food.



Elders today still teach that it is important to respect the caribou at all times. When an animal is killed, people must use as much of it as they can; any remains must be treated appropriately and disposed of properly. Many Elders say that living caribou should not be harassed in any way, and some teach that the animals should not be handled at all unless they are being hunted. Disrespecting the caribou, they say, leads to changes in the animals' behaviour and may cause them to abandon the people entirely.

Can you see why Elder's might be worried about satellite radio collars?

While there are other ways to track caribou, none are as effective and cost efficient as satellite radio tracking. Air photo surveys can miss large groups of animals and lead to inaccurate counts; they are also very expensive. Ear tagging only provides data about where and when an animal is originally tagged and where it eventually dies. Other types of tracking devices need to be placed on the animals just like the satellite radio collars with the added draw backs of being more expensive and less easy to track.

Communities who need information about local caribou herds, then, sometimes have to make difficult decisions about balancing their respect for the wisdom of their Elders with their need for current understanding of the animals and their behaviour. In some places, communities have decided not to track the caribou.

What decision would you make regarding tracking caribou with satellite radio collars?

What's been learned

In communities which have decided to track caribou, local hunters, Elders, scientists and wildlife management boards are working together in order to develop a broad base of knowledge about the caribou.

The small percentage of animals (usually a small fraction of 1%) within herds that are collared provide lots of information. For instance, observations made possible by the collars have shown that:

- calving grounds for each herd are very predictable and quite small whereas winter ranges vary widely and cover huge tracts of land;
- herds can share territory during the winter but have distinct calving grounds.

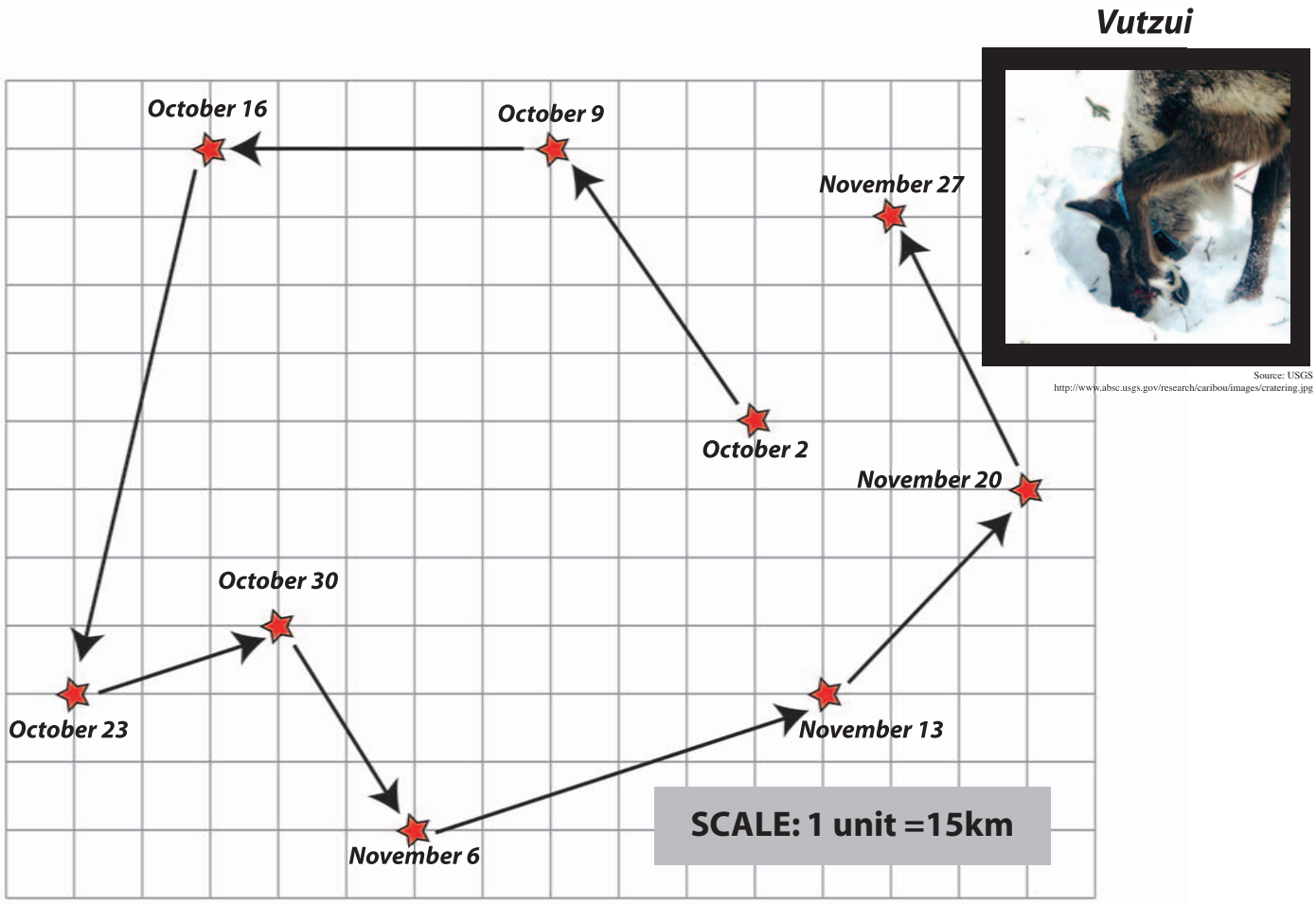
The collars also allow for observations of calving rates and overall population.

A number of herds have been followed since the mid to late 1990s and will continue to be observed into the future. The long-term data collection will show natural variations in behaviour and range which will be used to make informed decisions about local projects and growth which will benefit communities while ensuring the heath and well-being of the caribou herds.

Sources:

All about GPS
http://www.trimble.com/gps/index.html
Animal Tracking in the Virtual Age
http://animal.discovery.com/fansites/wildkingdom/elephant/science/science.html
ARGOS
http://www.argosinc.com/
Beverly and Qamanirjuaq Management Board
http://www.arctic-caribou.com/faq.html
Environment Canada
http://www.speciesatrisk.gc.ca/search/speciesDetails_e.cfm?SpeciesID=638
Hinterland Who's Who – Caribou
http://www.hww.ca/hww2.asp?id=85
Native living skills, Manatake American Indian Council
http://www.manataka.org/page245.html
Porcupine Caribou Satellite Collar Project
http://www.taiga.net/satellite/
Satellites
http://collections.ic.gc.ca/satellites/english/index.html
Sputnik and The Dawn of the Space Age
http://www.hq.nasa.gov/office/pao/History/sputnik/

Connecting to Math



Vutzui, a cow in the Porcupine caribou herd, was collared during the summer. Her movements are being tracked by the ARGOS satellite system. The map above shows Vutzui's location at one week intervals from October 2 through November 27. As a wildlife biologist in the community of Old Crow, you are watching Vutzui's movements closely. In a few weeks, you will be making a presentation to children at the local school and community Elders. You have to figure out the following information in order to prepare your presentation.

a) How much distance did Vutzui travel from October 2 to November 27?
b) In which week did she travel the most distance? The least distance?
c) How far is Vutzui traveling each week on average?
d) What was Vutzui's total displacement from October 2 to November 27?
e) The maps shows Vutzui's path in between known locations as a straight line. Is this an accurate way to show how she traveled?

ISSN 1494-4944