IN A SLUMP

Overview:

This lesson uses Google Earth™ to explore the dramatic landscape changes resulting from permafrost thaw. Students read science articles and examine images in Google Earth to compare two retrogressive thaw slumps in the Arctic then complete a worksheet.

Objectives:

The student will:

- compare two retrogressive thaw slumps in the Arctic using either Google Earth or resources provided;
- evaluate the impact of the Selawik Slump on the local ecosystem; and
- consider the impact such an event would have in their community.

Targeted Alaska Grade Level Expectations:

[9] SA1.1 The student demonstrates an understanding of the processes of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, inferring, and communicating.

[10-11] SA1.1 The student demonstrates an understanding of the processes of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, analyzing data, developing models, inferring, and communicating.

[9] SE1.1 The student demonstrates an understanding of how to integrate scientific knowledge and technology to address problems by recognizing that the value of any given technology may be different for different groups of people and at different points in time (e.g., different uses of snow machines in different regions of Alaska).

[10] SE1.1 The student demonstrates an understanding of how to integrate scientific knowledge and technology to address problems by identifying that progress in science and invention is highly interrelated to what else is happening in society.

[9] SD1.2 The student demonstrates an understanding of geochemical cycles by applying knowledge of the water cycle to explain changes in the Earth's surface.

[10] SD1.2 The student demonstrates an understanding of geochemical cycles by describing their interrelationships (i.e., water cycle, carbon cycle, oxygen cycle).

[9-11] SD2.1 The student demonstrates an understanding of the forces that shape Earth by recognizing the dynamic interaction of erosion and deposition including human causes.

Vocabulary:

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

massive ice—a comprehensive term used to describe large masses of ground ice, including wedges, pingo ice, buried ice and large ice lenses

mass wasting—downslope movement of soil or rock under the influence of gravity

retrogression—the process of returning to an earlier state; deteriorating or declining

retrogressive thaw slump—a slope failure resulting from thawing of ice-rich permafrost

thermokarst—topography characterized by an irregular land surface with bogs, pits, and other depressions formed as ice-rich permafrost thaws

wetlands—a low-lying area of land that is saturated with moisture, especially when regarded as the natural habitat of wildlife; marshes, swamps, and bogs are examples of wetlands

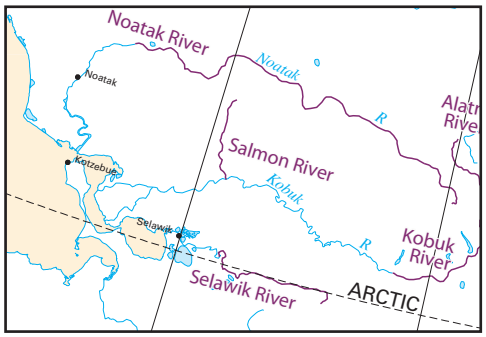
IN A SLUMP

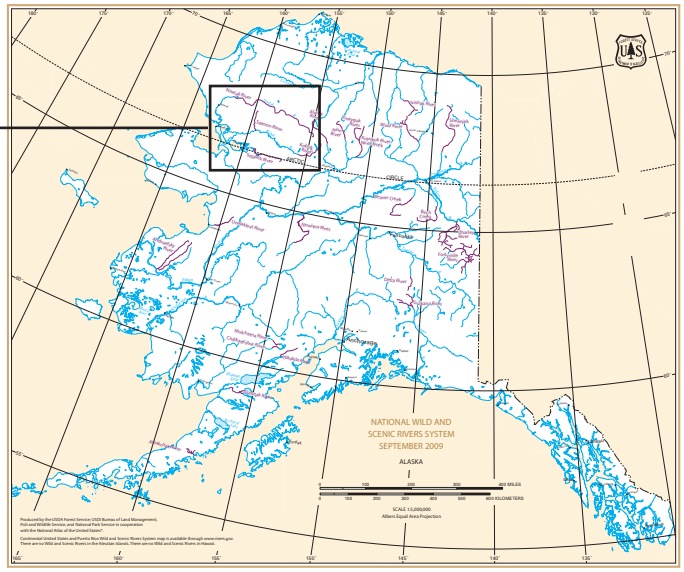
Whole Picture:

The Sheefish is an important subsistence food for many Alaska Native people. Not only is it harvested for human consumption, it is also used for dog food. This lesson highlights a potential threat to the sheefish population in the Selawik River, which is of concern to nearby residents who depend on the fish.

From U.S. Fish and Wildlife Service publication, Assessing Permafrost Thaw Slump Impacts on Sheefish Spawning Habitat in the Selawik River, Alaska:

History: The Selawik River is habitat for a number of whitefish species, including inconnu (sheefish), that support an important subsistence fishery. In the spring of 2004 a large retrogressive thaw slump (slump) occurred above the sheefish spawning area in the upper Selawik River drainage. This event changed the water from a clear to a glacial colored river that was noticed by Selawik National Wildlife Refuge personnel and persons from Selawik. Since 2004 the slump has continued to erode and influence the river with no estimable end in sight. The slump is caused by ice-rich permafrost degradation resulting in slope failure. Researchers indicate that thermokarst rates in the circum-Arctic have increased substantially during a period of particularly rapid warming in the last 25-30 years. The Refuge is in a thermokarst rich and thaw sensitive region of Alaska





and is entirely underlain by discontinuous and continuous permafrost.
Thermokarst features may directly and indirectly impact stream, lake and wetlands ecosystems along with their aquatic inhabitants.

HABITAT CHANGES

In the Selawik River drainage, sheefish are a Refuge trust species that spawn in the river, ~ 45 km down stream of the slump. Sheefish and other whitefish species are major local subsistence resources in the Selawik River. Slump silt substantially affects water clarity and quality during normal summer and fall flow patterns. Fall season cooling decreases silt input. Silt has been found on the substrate in the spawning area during spawning season. It is unknown how persistent the silt is during the late September to early October sheefish spawning season. Unknown quantities of sediment may be depositing in the sheefish spawning area.

Materials:

- TUTORIAL: "UsingGoogle Earth" linked with this lesson.
- VISUAL AID: "Bonnett Plume River Retrogressive Thaw Slump"
- VISUAL AID: "Selawik River Retrogressive Thaw Slump"
- VISUAL AID: "Assessing Permafrost Thaw Slump Impacts on Sheefish Spawning Habitat in the Selawik River, Alaska"

IN A SLUMP

- STUDENT INFORMATION SHEET: "The Selawik Slump Grows Unabated"
- STUDENT INFORMATION SHEET: "Thaw Scars Widespread Across the Northland"
- STUDENT LAB SHEET: "Exploring With Google Earth"
- STUDENT WORKSHEET: "In a Slump"

Activity Preparation:

1. If a school computer system will accommodate accessing Google Earth, it should be used for this lesson. If computers are not already equipped with Google Earth, download it for free at: http://earth.google.com/. To become familiar with Google Earth, see TEACHER INFORMATION SHEET: "Using Google Earth" linked with this lesson.
2. Become familiar with the lesson to be better able to assist students when needed. Bookmark the resources section where students will find KMZ and KML files needed for the lab.
3. If the school computer system will not accommodate accessing Google Earth, an alternative lesson is included.

Activity Procedure:

1. Play a vocabulary game to review and introduce new words. Write the vocabulary words on the board or on a flip chart. Leave off definitions but leave space for later. Read two definitions for each word to the class. Students must vote on the correct definition by holding up one finger or two. The "incorrect" definition can be either extremely silly or so close students really have to listen to pick out the correct one (see box at right). After each vote, put up the correct definition for reference.
2. Hand out STUDENT INFORMATION SHEET: "The Selawik Slump Grows Unabated" and STUDENT INFORMATION SHEET: "Thaw Scars Widespread Across the Northland." Ask students to read each article silently, in small groups or as a class activity. When students are finished reading, ask the following questions to prompt discussion:
    a. What is a retrogressive thaw slump?
    b. What is it about the type of ground that leads to such an impressive feature?
    c. What ecosystem is in danger near Selawik?
    d. Is it possible that other slumps could affect a river's ecosystem in a similar way?
    e. What wildlife might be impacted? How might it impact the human population?

NOTE: Here are some possible second, false definitions, for those whose creativity needs a boost! The real definitions are listed in the vocabulary section.

ecosystem – the computer system used by EcoEnergi, a Norwegian power company and the second largest producer of electricity in Norway

massive ice – Multiple Agent Simulation System in Virtual Environment with Internet Computer Edware is a high-end computer animation and artificial intelligence software package used for generating crowd-related visual effects for film and television

mass wasting – overuse of energy resources in the Commonwealth of Massachusetts, a state in the New England region of the northeastern United States

retrogression – a regression of musical preference that usually leads the listener to an 80's retro station

retrogressive thaw slump – the drooping posture assumed by a dog musher who has been on the trail for 12 hours, when sitting by a toasty fire

thermokarst – an alternative rock band formed in 1994 in Guadalajara, Mexico

wetlands – the lands owned by the Wets, members of the British Conservative Party in Margaret Thatcher's government

3. If students will use Google Earth, hand out STUDENT LAB SHEET: "Exploring With Google Earth." (If not, please go to Alternative Lesson section below.) Ask students to open Google Earth on their computers. (See TUTORIAL: "Using Google Earth.") Under the Layers menu, ask students to make sure the following subheadings are checked:
   - √ Borders and Labels
   - √ Panoramio
   - √ Street View
   - √ Google Earth Community

   Allow students adequate time to work through the lab sheet using Google Earth. Be ready to assist with opening KML and KMZ files using Google Earth.
4. Once students have had time to complete the lab sheet, hand out STUDENT WORKSHEET: "In a Slump" and ask students to complete.
5. Use the worksheet questions to start a class discussion and review. Consider the following:
   a. The Bonnet Plume River slump is decades, if not a century, in the making. The Selawik slump occurred rapidly. What do you think might cause accelerated thaw?
   b. What kind of event might trigger a thaw slump?
   c. There are hundreds of thaw slumps in the Arctic. What is different about the Selawik slump?
   d. Think about your own community. What kind of event could trigger a rapid change in the ecology of the area? How would this affect the community?

Alternative Lesson Procedure:

3. Display VISUAL AID: "Bonnet Plume Retrogressive Thaw Slump." Explain scientists believe permafrost thaw began prior to 1949, though the earliest picture is 1949. (Using the current average melting rate as a guide some say it could have started as early as 1880.) It was likely triggered by a forest fire.
4. Display VISUAL AID: "Selawik River Retrogressive Thaw Slump." Because this thaw slump is in a national wildlife refuge, the area has been well monitored. Scientists know that the slump began in 2004 and have watched its rapid progression.
5. Explain using aerial photography, satellite imagery and other techniques (ground survey, indigenous observation, etc.), scientists have located hundreds of thaw slumps throughout the Arctic. The concern in Selawik is the impact on the ecosystem and how, in turn, it may impact subsistence fishing. Display VISUAL AID: "Assessing Permafrost Thaw Slump Impacts on Sheefish Spawning Habitat in the Selawik River, Alaska" and discuss.
6. Hand out STUDENT WORKSHEET: "In a Slump" and ask students to complete.
7. Use the worksheet questions to start a class discussion and review. Consider the following:
   a. The Bonnet Plume River slump is decades, if not a century, in the making. The Selawik slump occurred rapidly. What do you think might cause accelerated thaw?
   b. What kind of event might trigger a thaw slump?
   c. There are hundreds of thaw slumps in the Arctic. What is different about the Selawik slump?
   d. Think about your own community. What kind of event could trigger a rapid change in the ecology of the area? How would this affect the community?

Ideas for Filming:

Students will complete a short film about permafrost for the final project associated with this UNITE US unit. Each lesson leading to the final project contains ideas about what students might film as they compile clips. Students are not limited to the list and are encouraged to use their imagination and creativity when filming.

IN A SLUMP

Find an interesting picture (or pictures) of the slump and use it in the movie. Narrate, explaining what is occurring and the impact on the ecosystem.

Find out if permafrost thaw has caused a significant ecosystem change in the community. Interview community members to learn more.

Extension Idea:

Learn more about sheefish at the Alaska Department of Fish & Game website Wildlife Notebook Series.

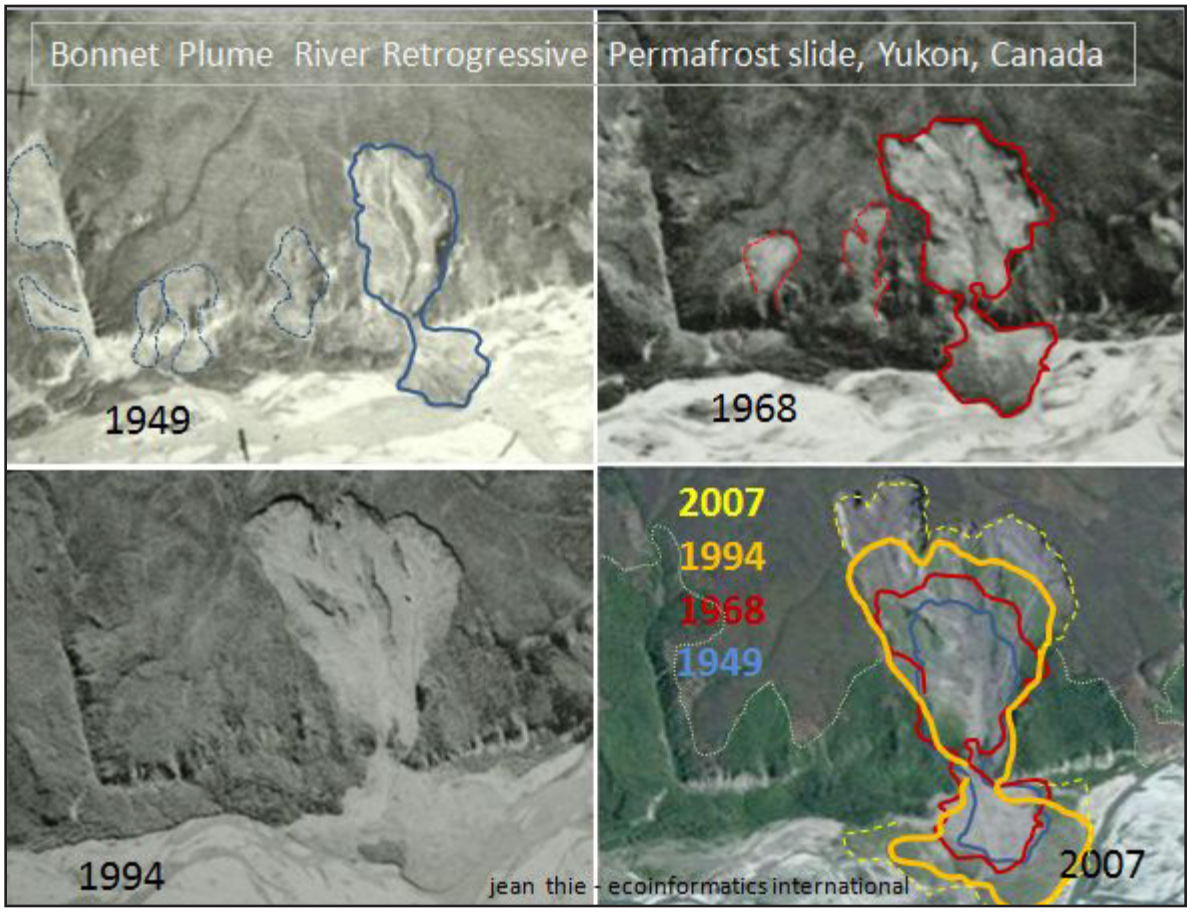
Answers:

STUDENT WORKSHEET: In a Slump

1. 1949
2. 2007
3. 58
4. 2004
5. 2009
6. 5
7. Similar: Both slumps have similar structure (shape) and both occur on a riverbank. They appear to be similar in size. They occurred in a similar landscape (spruce forest, hillside).

   Different: The Bonnet Plume River slump occurred over a longer period of time. The Selawik slump happened in just a few short years. The Selawik slump seems to be having a greater impact on the ecology of the river it is feeding into.
8. When a hill or slope of ice-rich permafrost thaws, the muddy soil begins to flow downward, exposing more permafrost, leading to more thaw.
9. Any three of the following: forest fires, climate change, intense rainfall, meandering rivers, unusually warm temperatures
10. The mud flowing into the river may affect sheefish spawning, and the sheefish population. Sheefish are a staple subsistence food for the people who live in the area.
11. Sheefish return to spawn about seven years from when they hatch. Since the slump occurred in 2004, if it is affecting sheefish spawning it will start to be apparent starting around 2011.
12. Answers will vary.

BONNET PLUME RIVER RETROGRESSIVE THAW SLUMP



SELAWIK RIVER RETROGRESSIVE THAW SLUMP

Photos courtesy of U.S. Fish and Wildlife Service

SELAWIK RIVER RETROGRESSIVE THAW SLUMP

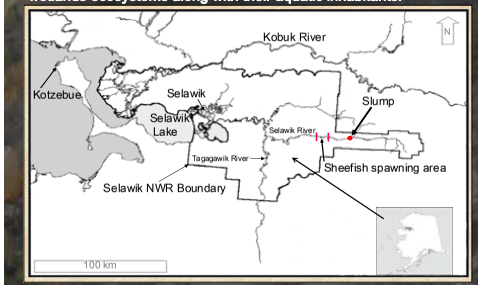
Photos courtesy of U.S. Fish and Wildlife Service

ASSESSING PERMAFROST THAW SLUMP IMPACTS ON SHEEFISH SPAWNING HABITAT IN THE SELAWIK RIVER, ALASKA

Raymond F. Hander[1], Christine L. Moran[2], Benjamin T. Crosby[3]

HISTORY

The Selawik River is habitat for a number of whitefish species, including inconnu (sheefish), that support an important subsistence fishery. In the spring of 2004 a large retrogressive thaw slump (slump) occurred above the sheefish spawning area in the upper Selawik River drainage. This event changed the water from a clear to a glacial colored river that was noticed by Selawik National Wildlife Refuge personnel and persons from Selawik. Since 2004 the slump has continued to erode and influence the river with no estimable end in sight. The slump is caused by ice-rich permafrost degradation resulting in slope failure. Researchers indicate that thermokarst (physical depression of the ground surface) rates in the circum-Arctic have increased substantially during a period of particularly rapid warming in the last 25-30 years. The Refuge is in a thermokarst rich and thaw sensitive region of Alaska and is entirely underlain by discontinuous and continuous permafrost. Thermokarst features may directly and indirectly impact stream, lake, and wetlands ecosystems along with their aquatic inhabitants.



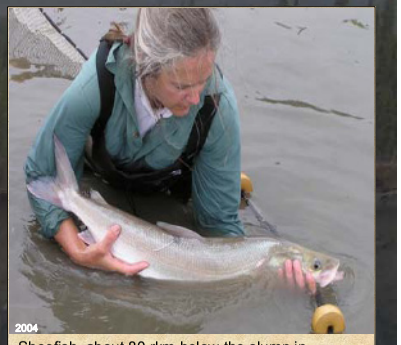
First ground photo in 2005. Slump size scale, see the person?

HABITAT CHANGES

In the Selawik River drainage, sheefish are a Refuge trust species that spawn in the river, ~ 45 km down stream of the slump. Sheefish and other whitefish species are major local subsistence resources in the Selawik River. Slump silt substantially affects water clarity and quality during normal summer and fall flow patterns. Fall season cooling decreases silt input. Silt has been found on the substrate in the spawning area during spawning season. It is unknown how persistent the silt is during the late September to early October sheefish spawning season. Unknown quantities of sediment may be depositing in the sheefish spawning area.

Erosion progression and deposition build-up from 2004 to 2009

Preliminary analysis of classification of the exposed permafrost and ice on the north wall of the slump



Sheefish, about 80 rkm below the slump in 2004. Note the water turbidity

July 2009, estimates of slump erosion, fan deposition, and flux to the river since 2004

Selawik River and the clear Tagagawik River confluence, about 150 rkm downstream of the slump

Whitefish species, including sheefish, are a staple of local subsistence fisheries

Bathtub ring of deposited silt, 7 rkm below sheefish spawning area, September 2008

CURRENT RESEARCH FOR THE FISH, RIVER, AND SLUMP

- Study and analysis of surrounding landscape for evidence of past events and the prediction of future events.
- Water quality monitoring above and below the slump and in the sheefish spawning area
- Pilot research assessing sheefish egg deposition
- Monitoring the slump for change: aerial photography, ground samples, and measurements.
- Conceptual project of sheefish age assessment to detect potential year class weakness
- Conceptual project of sheefish spawner abundance using DIDSON sonar

INFLUENCE ON FISH AND AQUATIC HABITAT

- What influence will continued silt input have on critical spawning habitat and water quality?
- What level of thermokarst activity can be expected in the future in the Selawik river drainage?
- Will Selawik River sheefish and other fish populations be influenced either directly or indirectly by silt input?

[1] Raymond F. Hander, USFWS, Fairbanks Fish & Wildlife Field Office, 101 12th Ave., Room 110, Fairbanks, AK 99701, (907)456.0402, ray_hander@fws.gov
[2] Christine L. Moran, USFWS, Selawik National Wildlife Refuge, P.O. Box 270, Kotzebue, AK 99752, (907)442-3799, tina_moran@fws.gov
[3] Benjamin T. Crosby, Idaho State University, Dept. of Geosciences, 921 S 8th Ave. – Stop 8072, Pocatello, ID 83209-8072, (208)282-2949, crosby@isu.edu

EHS-106

In a Slump

ASSESSING PERMAFROST THAW SLUMP IMPACTS ON SHEEFISH SPAWNING HABITAT IN THE SELAWIK RIVER, ALASKA

UNITE US VISUAL AID

THE SELAWIK SLUMP GROWS UNABATED

Alaska Science Forum Article #1974, August 26, 2009
by Ned Rozell

This column is provided as a public service by the Geophysical Institute, University of Alaska Fairbanks, incooperation with the UAF research community. Ned Rozell is a science writer at the institute.

About five years ago, Kevin Fox was flying over the Selawik National Wildlife Refuge in northwest Alaska when he noticed the upper portion of the clear-running Selawik River looked cloudy. He traced the plume upstream and noticed what looked like a crater in the boreal forest; through a breach in its side, the crater was leaking a slurry of silt, gravel, and dirt into the river.


The Selawik Slump in summer 2009. Photo by Ben Crosby.

Fox, a pilot with the U.S. Fish and Wildlife Service in Anchorage, had noticed the Selawik Slump, as researchers are now calling the nine-acre permafrost-related scar that has changed the character of the Selawik River. The feature is growing every year, and it may threaten a rich sheefish run used by villagers from Selawik.

Ben Crosby of Idaho State University studies unique landforms, and he began traveling to and studying the Selawik Slump a few years ago, after his father-in-law, Caleb Pungowiyi of Kotzebue, told him about it.

"It's anomalously large," Crosby said by phone from Pocatello. "As far as we know it's the largest in North America."

Permafrost scientists have seen many smaller examples of the Selawik Slump around the north. They call them "retrogressive thaw slumps." These happen when ground that has been frozen for hundreds or thousands of years thaws on a slope, causing it to collapse. This exposes a new wall of frozen material, which then thaws to reveal another one (the back headwall of the slump is now about 80 feet high). In this way the feature eats its way into a hillside. It's as if a giant ice cream scoop removed a swath of forest and tundra.

The slump near Selawik is unusual both for its size and because it may affect the villagers in Selawik, about 175 miles downstream. People in Selawik rely on sheefish as one of their food sources. Sheefish, which can live to be 30-years-old and weigh as much as a plump Yukon River king salmon, scatter their eggs between gravel stones of the river bottom in a preferred stretch of river downstream of the slump. Biologists think the sediment the slump is leaking into the river may fill in those nooks and crannies.

Some generations of sheefish may already be affected, but biologists don't yet know, because those long-lived fish don't return to breed for at least seven years. Because the slump happened around 2004, it will probably be a few more years before biologists can tell that the added sediment might have affected them.

"If we were to see any downturn, it wouldn't be until (about 2014)," said Ray Hander, a biologist with the U.S. Fish and Wildlife Service in Fairbanks who is studying the Selawik River sheefish. When he checked last fall, there was still some gravel showing on the sheefish spawning grounds, about 25 miles downstream of the slump, Hander said.

Like Hubbard Glacier threatening the lifestyles of Yakutat residents who guide for steelhead in the clear Situk River (which would turn cloudy if the glacier blocked Russell Fiord), Selawik Slump is another example of how thawing Alaska ice could change life in a community.

"It's something that's always been there," Hander said about the subsistence relationship between villagers in Selawik and sheefish. "It's not the only fish they seek out, but sheefish are available year-round—jigging under the ice, gill nets, hook and line. They're a food source people depend upon."

The Selawik Slump will endure for decades, scientists think, though its sediment load to the river will wax and wane. And though the feature is unusual in its size, there are thousands more out there in northern Alaska.

"We find them in the landscape where they've occurred in the past; places we see them initiating now are near older scars," Crosby said. "The process has happened for thousands of years. It's just accelerating now."

THAW SCARS WIDESPREAD ACROSS THE NORTHLAND

Alaska Science Forum Article #1979, September 30, 2009
by Ned Rozell

This column is provided as a public service by the Geophysical Institute, University of Alaska Fairbanks, incooperation with the UAF research community. Ned Rozell is a science writer at the institute.

A retrogressive thaw slump on the Bonnet Plume River in northern Yukon Territory. The top of the feature is about a half-mile wide and the mudflow extends more than a mile. Photo by Doug Davidge.

One month ago, I wrote about a dramatic landscape feature in western Alaska called the Selawik Slump. The slump, caused by thawing permafrost, looks like a bomb crater leaking mud from the boreal forest into a clear northern river. There are dozens of them in northern Alaska, though none as big as the one on the Selawik River.

There are also many of these beacons of change in the Yukon Territory, according to Doug Davidge of Whitehorse, who read the Selawik column in the Yukon News. A few years ago Davidge was flying over the Peel River country east of Eagle Plains for work when he saw a gaping wound on a hillside. Scientists once described these features as "tundra mudflows." They now call them retrogressive thaw slumps.

"We flew over some very dramatic looking retrogressive thaws, and we could pick out other ones as we flew along," he said.

Davidge snapped a photo of the largest thaw slump he and the pilot noticed, near a drainage called Bonnet Plume. Though not as large, it looks similar to the feature that is now clouding the Selawik River. Retrogressive thaw slumps form when warm air eats at permafrost that contains large bodies of ice. The features often develop when a river cuts into a frozen bank on an outside bend.

As ice and frozen soil thaw back into a bank or hillside, more and more of the ground collapses in on itself, leaving a crater of churned soil backed by a steep, frozen headwall. That wall retreats over time, mud flows downhill and often into rivers, and the slump grows.

Though it's not part of Davidge's job for Environment Canada, the giant scar on the landscape intrigued him enough to send him to Google Earth on his own time to search for more of the characteristic scoops missing from hillsides along the remote Peel River drainage. He found a lot of them.

"I don't have the total count in front of me," he said from his office in Whitehorse. "I keep adding them to the list, but it's probably in the range of 200 or so . . . There are many other huge ones out there."

Yukon Geological Survey Geologist Panya Lipovsky has studied the retrogressive thaw slumps for a few years in central and southern Yukon. One of the more interesting ones she's encountered is 60 miles north of the town of Ross River on the South MacMillan River; it's known as the Surprise Rapids Slide.

"That's the biggest one I'm aware of," she said, also from her office in Whitehorse. "It's about (2,300 feet) wide and has traveled up to about (one-and-one-half miles from the hillside to the river). It may have been triggered by a forest fire in the 1870s and still hasn't stabilized in more than 100 years. The headwall keeps melting back."

Some of the slumps she has observed are recent and some date back more than a century. They may be related to forest fires, intense rainfall, meandering rivers, and/or warming air temperatures, she said. One of the more active periods for the Surprise Rapids Slide happened in the 1940s, when the central Yukon had record high early summer temperatures, according to Brent Ward of Simon Fraser University.

Lipovsky knows of slumps that are eating into hillsides at the rate of 30 feet per year. Some have altered the flow of rivers and have clouded them up with their runoff, but she hasn't heard of any troubling people in the Yukon, as the Selawik Slump might be affecting the people of Selawik should cloudy water damage sheefish spawning grounds.

There aren't many scientists who are studying these eye-catching northern expressions of permafrost lost, but thaw slumps may draw more attention as they continue to express themselves on the less-frozen northern landscape.

"We've only just started keeping an inventory of these things in the last couple years," Lipovsky said.

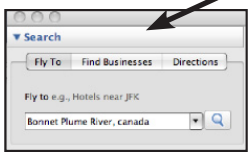
NAME: _____

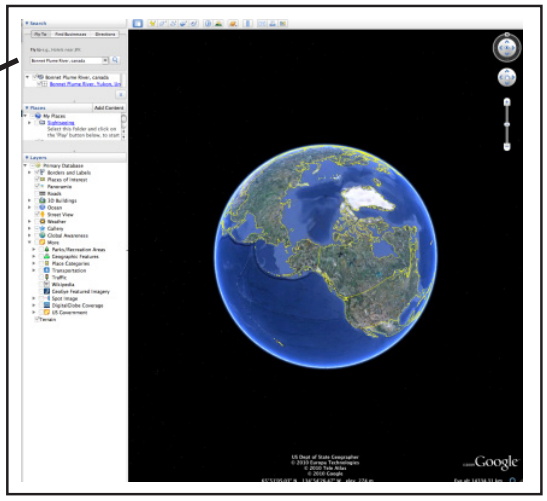
EXPLORING WITH GOOGLE EARTH

1. Let's take a look at retrogressive thaw slumps using Google Earth! First you'll need to open Google Earth. Double click on the icon:

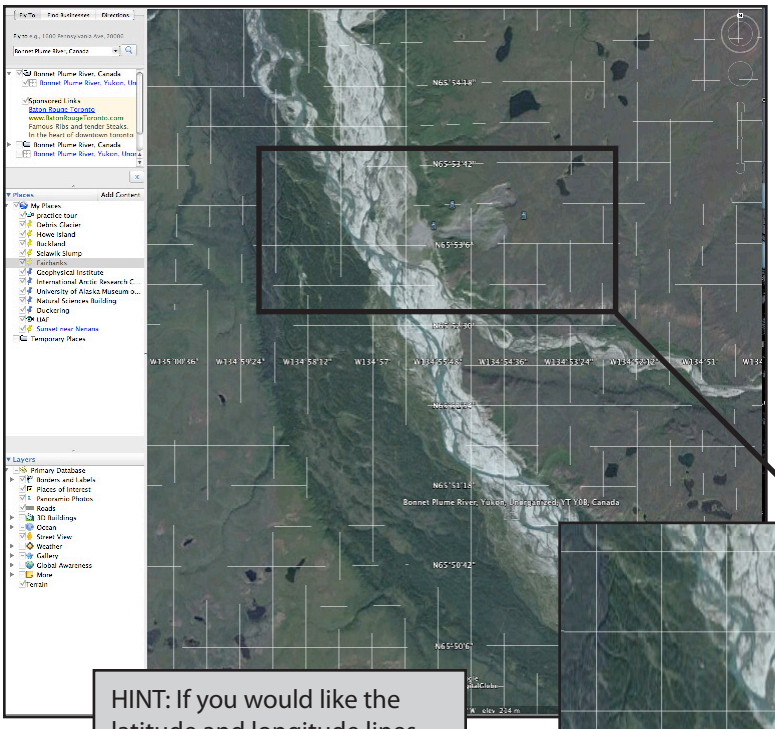
2. Now, let's look at Bonnet Plume River slump in Canada. In the Fly To box, type "Bonnet Plume River, Canada." Click on the magnifying glass to search and **Fly To** the Bonnet Plume River.

> HINT: If you don't find the river by typing in the name, type the following coordinates into the search box:
>
> 65.865781, -134.928144
>
> Click on the magnifying glass to **Fly To** the Bonnet Plume River.

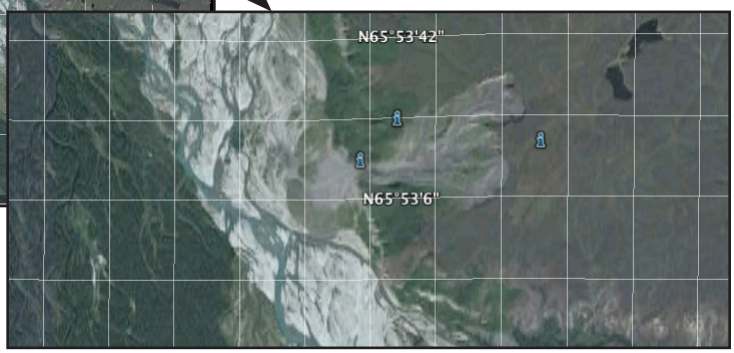




3. To see the slump, you'll have to move up the river a little way. It is easier to find the slump if you zoom out just a bit.



> HINT: If you would like the latitude and longitude lines to show, go to the toolbar and select "View," then choose "Grid." Voila!



> HINT: View from all angles by changing direction. Drag the (N) control around the circle.
>
> Use the controls to move up and down as well as zoom in and out.

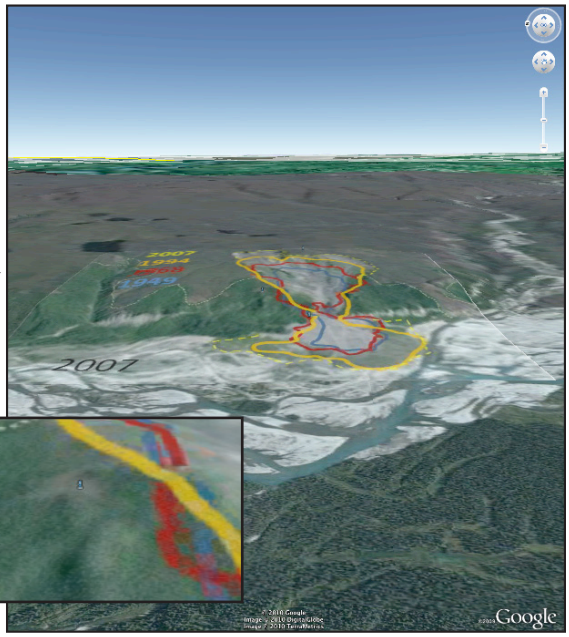
NAME: _____

EXPLORING WITH GOOGLE EARTH

1. Once you see where it is, you can zoom in and explore from all angles by moving the (N) around the controller. (See HINTS.)

2. Now let's have some fun.
   Leave Google Earth open, but go to the UNITE US website at www.uniteusforclimate.org. Click the tab for "In Class Resources" and scroll down to "Maps and KMZ/KML Files." Click this tab and choose the "Bonnet Plume River Thaw Slump" KMZ file. When you click on it, it will ask what program you want to use to open it. Choose Google Earth.

   Soon you should see this view. →



   This is an image overlay that shows the progression of the slump from 1949 to 2007.

   You can zoom in and out and rotate the image.

   When you zoom in, notice the ℹ icon in the foreground to the left. Click on it to bring up information about the Bonnet Plume River slump.

3. Now let's look at a thaw slump in Alaska. Go to the folder linked "Maps and KMZ/KML Files" in the curricula description. Click this tab and choose the KML file: "Selawik Slump." When you click on it, it will ask what program you want to use to open it. Choose Google Earth.

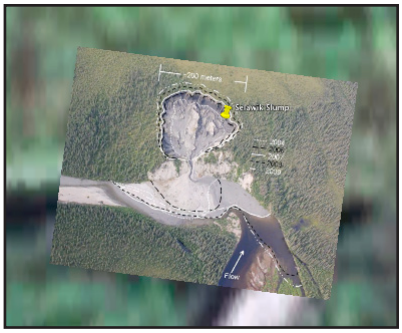
   You will notice right away that the image resolution is much lower in this area. The more you zoom in, the blurrier it gets.

   Thankfully, we have an overlay and images of the area, courtesy of the U.S. Fish and Wildlife Service.

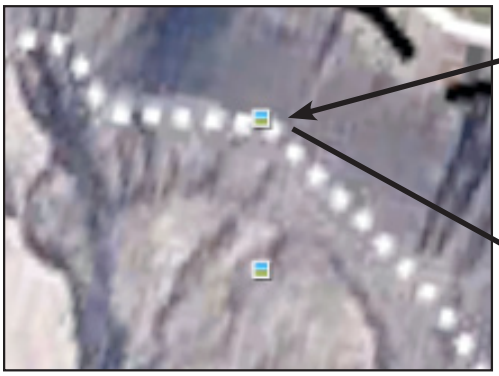
NAME: _____

EXPLORING WITH GOOGLE EARTH

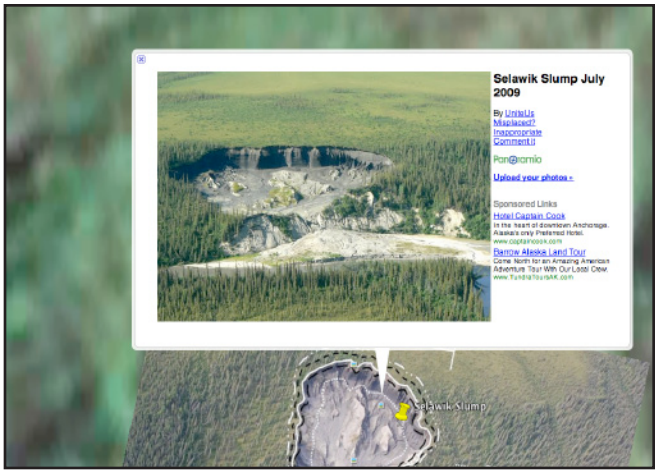
1. Return to the "Maps and KMZ/KML Files" folder and find the file titled "Selawik Slump Overlay." Choose to open with Google Earth. You should see this:



2. Use the control panel and the hand icon to explore – zoom closer, zoom out, rotate, etc.



When you zoom in, you'll notice picture icons. Click on the icons and view pictures of the slump taken different years.



HINT: If you can't see the picture icons, make sure you remembered to check (√) Panoramio Pictures under the Layers heading on the left-side menu of Google Earth.

3. Notice the icon to the left.

Click on the icon and view additional information about the Selawik Slump.

View the picture from all angles by changing direction. Drag the (N) control around the circle.

4. If you have time, visit additional retrogressive thaw slump sites in Google Earth. Find the KMZ file titled "Additional Permafrost Features." Some icons will lead you to areas with low resolution, others to areas with high resolution.

NAME: _____

IN A SLUMP

Directions: Use STUDENT INFORMATION SHEETS: "The Selawik Slump Grows Unabated," and "Thaw Scars Widespread Across the Northland" along with Google Earth. If Google Earth is unavailable, use VISUAL AIDS: "Bonnett Plume River Retrogressive Thaw Slump," "Selawik River Retrogressive Thaw Slump," and "Assessing Permafrost Thaw Slump Impacts on Sheefish Spawning Habitat in the Selawik River." Refer to vocabulary words. Complete the following questions.

1. What is the first year marked on the Bonnet Plume River progression? _____
2. What is the last year marked? _____
3. How many years between? _____
4. What is the first year marked on the Selawik Slump progression? _____
5. What is the last year marked? _____
6. How many years between? _____
7. Compare the erosion progression of the Bonnet Plume River slump with that of the Selawik Slump. What is similar about the two? What is different?

   _____

   _____

8. What is a thaw slump?

   _____

   _____

9. Name three things scientist think may trigger a thaw slump.

   _____

   _____

   _____

10. Thinking just of the Selawik Slump, what is the primary concern of scientists and local residents?

    _____

    _____

11. When will it be known if the Selawik Slump will significantly alter the sheefish population?

    _____

Critical Thinking:

12. Think about your own community and the ecosystem around it. If a similar event were to occur nearby, how would it affect the lifestyle of those who live there?

    _____

    _____

    _____