ICE WATER: RIVERS AND PERMAFROST

Overview:

Rivers and streams that run through continuous and discontinuous permafrost areas are affected by changes in permafrost. Changes in water systems impact the surrounding ecology.

Objectives:

The student will:

- label a map of the Yukon River drainage identifying tributaries, communities and permafrost regions;
- use Microsoft Excel to graph salmon survival rate; and
- place the impact of permafrost thaw and salmon survival rates in a cultural context.

Targeted Alaska Grade Level Expectations:

[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:

biochemistry – the scientific study of the chemical composition of living matter and of the chemical processes that go on in living organisms

cohesion – the act or state of sticking together tightly

degrade – to lose its current physical condition

ecosystem – an ecological community made up of plants, animals and microorganisms together with their environment

erosion – the gradual wearing away of land surface materials, especially rocks, sediments, and soils, by the action of water, wind or glacier

foothills – a hilly region at the base of a mountain range

gully – a trench originally worn in earth by running water and through which water often runs after rains

hydrology – a science dealing with the properties, distribution, and circulation of water on and below the Earth's surface and in the atmosphere

ice wedge – a massive, generally wedge-shaped body of ice with its tip pointing downward

landslide – the usually rapid downward movement of a mass of rock, earth, or artificial fill on a slope

melt water – water derived from the melting of ice and snow

runoff – the portion of precipitation on land that ultimately reaches streams often with dissolved or suspended material

sediment – the matter that settles to the bottom of a liquid or material deposited by water, wind, or glaciers

talik – a Russian term that applies to a layer of unfrozen ground below the active layer and above permafrost

thaw slump – slope failure resulting from thawing if ice-rich permafrost

thermal – relating to, or caused by heat

thermo - erosional niche – the space created when ice-bearing permafrost is eroded by the thermal and mechanical action of moving water.

thermokarst – any process of thermal degradation (reduction in the amount of permafrost through thawing) or landscape change due to the thawing of permafrost or massive ground ice

topography – the art or practice of graphic drawing in detail usually on maps or charts of natural and man-made features of a place or region especially in a way to show their relative positions and elevations

tussock – compact tuft especially of grass or sedge; also an area of raised solid ground in a marsh or bog that is bound together by roots of low vegetation

watershed – a region or area bounded peripherally by a divide and draining ultimately to a particular watercourse or body of water

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Whole Picture:

Alaska's Native people have a deep connection to the land. Elders are keenly aware of environmental change because they have an understanding of traditional ecological knowledge – generations of learning and experience with the land and wildlife – and can compare it with the changes that are happening today.

Despite visions of sand and sun associated with the word desert, low annual precipitation coupled with extreme temperatures and poor drainage means most of the Arctic qualifies as desert. Permanently frozen ground underlies the Arctic desert. If the permafrost thaws, the behavior of the surface above changes. Runoff from snowmelt or rain erodes more of the land and carries sediment into rivers and, ultimately, the ocean. More and different sediment in the rivers and oceans may impact both freshwater and marine life. The biogeochemistry of the rivers may change due to the influx of organic matter and minerals brought by permafrost thaw. Terrestrial ecosystems will be affected along with aquatic and sub-aquatic systems. As surface water hydrolological systems transition to groundwater systems due to thawing permafrost, gullies may develop as well as landslides, thermo-erosional niches and slumps. The drying of the active layer will affect vegetation and wildlife and perhaps an increase in wildfires.

In addition to changing local ecosystems, thawing permafrost may have broader impact. Scientists are carefully observing just how permafrost thaw may contribute to global climate. Because frozen ground does not decompose, there are vast amounts of organic carbon frozen in the soil. Thawing allows decomposition to begin and releases stored carbon. Carbon dioxide is a greenhouse gas that traps heat in Earth's atmosphere. Without greenhouse gases the planet would be too cold for life, but with too much, Earth could enter a much warmer climate phase.

Effects of Permafrost Degradation on River Systems and Habitats

From "Impacts of permafrost degradation on arctic river biogeochemistry" by Frey and McClelland.

The biogeochemical changes in river systems brought about by permafrost degradation may have far reaching effects. Changes in water chemistry brought about by an increase in minerals, organic and inorganic material and even increased flow of freshwater into oceans may alter environments. Scientists are studying the biogeochemical effects of degrading permafrost on hydrology systems in the Arctic. Permafrost currently underlies significant portions of the six largest Arctic watersheds (Ob', Yenisey, Lena, Kolyma, Mackenzie and Yukon) in addition to many other smaller streams and rivers entering the Arctic Ocean. As such, profound impacts may occur here with permafrost degradation, including biogeochemical cycling within watersheds and resulting delivery of organic matter, inorganic nutrients, and major ions to the Arctic Ocean. At present, there is considerable uncertainty about how changes in permafrost may impact Arctic rivers and subsequently oceans. Consequences can be highly complex and undoubtedly will exhibit changes specific to particular sites. Factors that affect consequences of permafrost degradation include, type of permafrost thaw (wholesale thawing, draining of thermokarst lakes, erosion of banks) and environmental characteristics of watersheds such as vegetation, soil type and topography. Regardless of the uncertainties in future predictions, however, it is clear that significant impacts on biogeochemical cycling in rivers will transpire with continued warming and permafrost degradation. Scientists emphasize that further collection of data at numerous sites is important to predict changes in river and ocean biogeochemistry.

Materials:

- Clear pitcher
- Ice cubes, enough to fill the pitcher
- Clear plastic cups
- Plastic spoon
- Access to water
- Access to computers equipped with Microsoft Excel software
- Colored pencils (variety of colors)
- VISUAL AID: "Effects of River Erosion"

ICE WATER: RIVERS AND PERMAFROST

- VISUAL AID: "Permafrost Distribution"
- STUDENT INFORMATION SHEET: "Ice Water: Rivers and Permafrost"
- STUDENT WORKSHEET: "In Heart of Alaska: The Yukon River Basin
- STUDENT LAB SHEET: "Survival Rate of Salmon"
- STUDENT WORKSHEET: "Bringing it Home"

Activity Preparation:

Just prior to the start of class, fill a clear pitcher completely full of ice cubes. Add very cold water to fill the pitcher. Add very warm water to a plastic cup.

Activity Procedure:

1. Write the word "erosion" on the board. Draw a line away from it, labeling it mechanical. Students are likely familiar with mechanical erosion that occurs due to wind, water, ice (glaciers) and gravity. Review if needed then write the terms under "mechanical." Explain students will learn about another type of erosion called thermal erosion. Draw a line away from the word erosion and label it thermal. Ask students to define thermal and describe the process of thermal erosion. Where might thermal erosion occur? Explain students will focus today on how thermal energy contributes to the erosion that occurs along the banks of rivers and streams that meander through permafrost.
2. Show students a clear pitcher full of ice water. This represents the water that flows in Alaska's rivers and streams, which is usually ice cold water from snow and glacial melt. Pour water into an empty cup, but do not add ice. Using the spoon, remove an ice cube from the pitcher. Show students both the cup and the ice. Ask, "Which is colder? How do you know?" The two may be very close in temperature, but since the water is liquid you know it's warmer.
3. Scoop enough ice cubes into a clear cup to reach the top. Show it to students. Ask a student volunteer to pour warm water over the ice cubes. Ask students to watch what happens. (The ice cubes will melt and shrink.) Explain: The warm water contains kinetic energy; thermal energy always tranfers from the warmer to the cooler, so heat from the water is transferring to the ice, causing it to melt.
4. Hand out STUDENT INFORMATION SHEET: "Ice Water: Rivers and Permafrost." Display VISUAL AID: "Effects of River Erosion," page one. Choose a reading strategy best suited for the class then read through page one of the information sheet. Refer to the visual aid as you proceed. Remind students of the earlier demonstration. The river water is transferring energy to the permafrost causing it to thaw. Once thawed, mechanical erosion carries away the debris and sediment.
5. Display VISUAL AID: "Effects of River Erosion," page two. Ask students to turn to page two of their information sheet. Again, read through the material, referring to the visual aid. NOTE: Student will study the Selawik Slump in greater detail in another UNITE US lesson.
6. Display VISUAL AID: "Effects of River Erosion," page three. Ask students to turn to page three of their information sheet. Again, read through the material, referring to the visual aid. Discuss, using the following questions and prompts as needed:
   a. Describe what you see in this illustration. What is happening to the riverbank?
   b. There is a lot of sediment in the water. Why doesn't it wash away?
   c. What might happen to the salmon eggs on the bottom of the river if they get covered?
   d. What might happen to the plants?
   e. The water is very murky. Do you think the suspended sediment might change where fish like to live?
   f. What other things can you imagine might result from the thawing of permafrost along the bank? (River could get wider, become shallower, eventually change course, etc.)
7. Hand out STUDENT WORKSHEET: "In the Heart of Alaska: The Yukon River Basin." Display VISUAL AID: "Permafrost Distribution." Ask students to complete the worksheet. (Leave visual aid on display for students

as they complete page one of worksheet.) Students may need assistance completing the math problems on page two. The problems are percentage equations.

Question 4 is solved: .001 x 5,000 = 5

Question 5 is solved: 3,000 ÷ .001 = 3,000,000

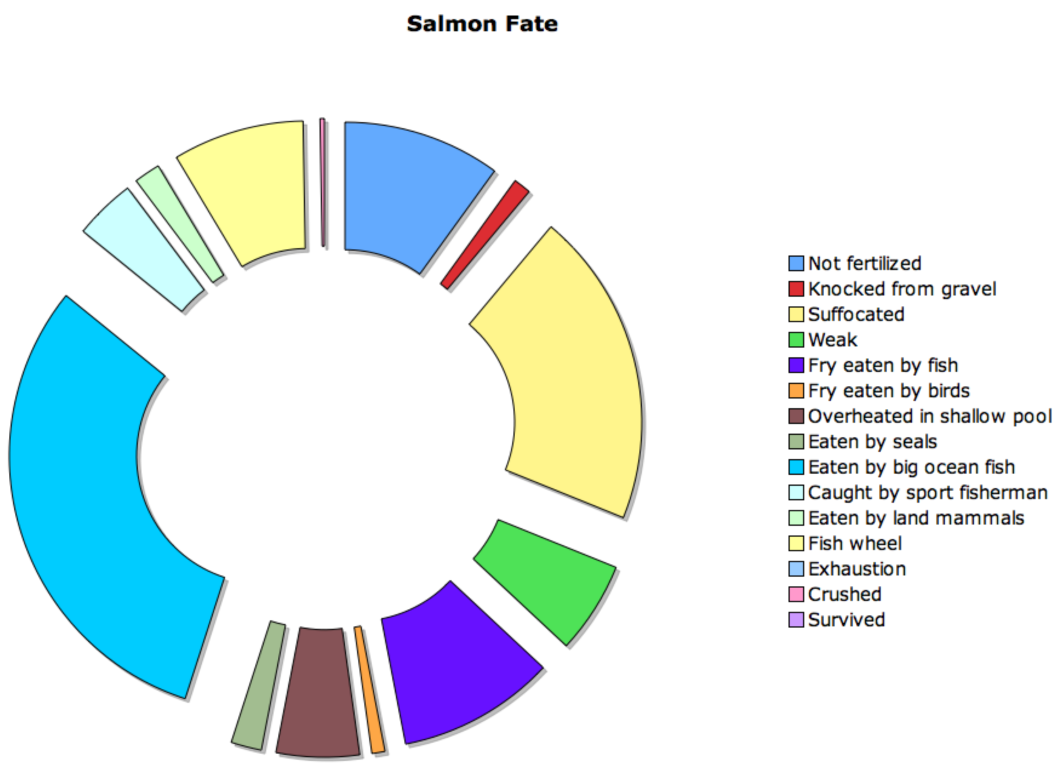
Answers:

STUDENT WORKSHEET: The Heart of Alaska: The Yukon River Basin

1. b. about 33 percent
2. continuous, discontinuous
3. Answers will vary by community
4. .001 x 5,000 = 5
5. 3,000 ÷ .001 = 3,000,000

STUDENT LAB SHEET: The Life of a Salmon Egg

If students follow the directions they should end up with a chart that looks similar to the one shown below.



STUDENT WORKSHEET: Bringing it Home

Essay answers will vary but should reflect an understanding of the lesson content and include information about permafrost thaw and the potential effects of added sediment in the river.

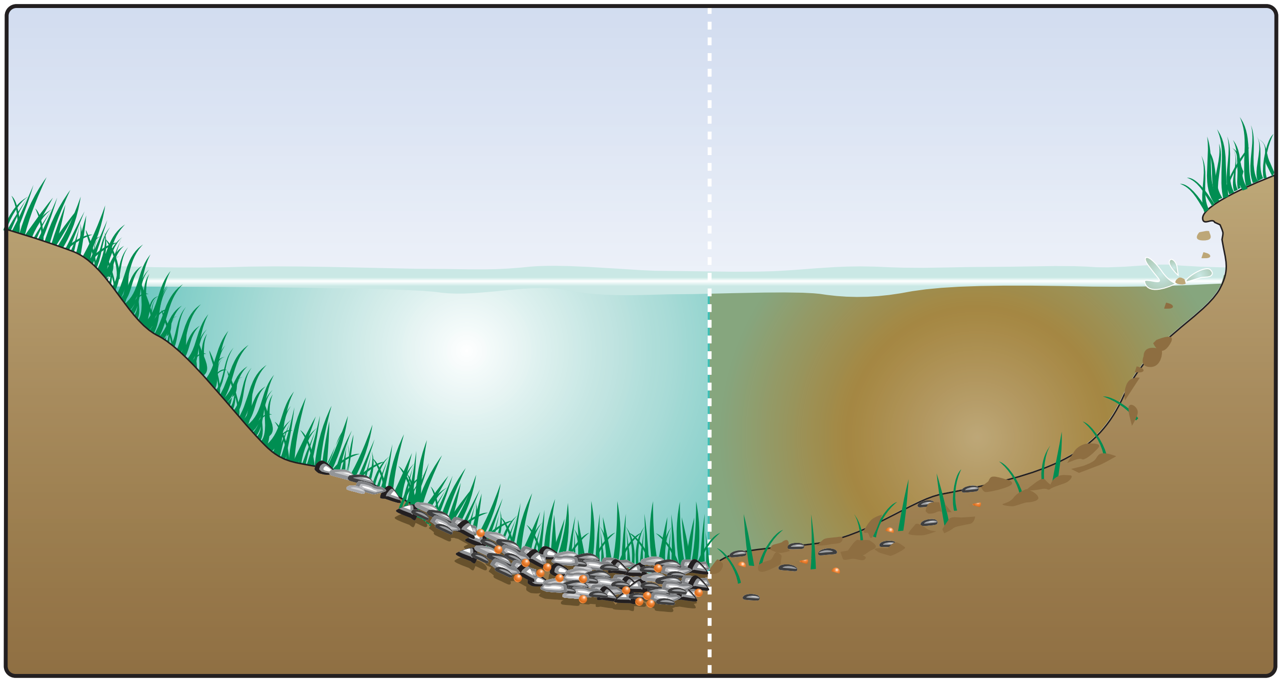
EFFECTS OF RIVER EROSION

A thermo-erosional niche on the Colville River Delta in Alaska. Photo courtesy of Jorgenson and Osterkamp from *Response of Boreal Ecosystems to Varying Modes of Permafrost Degradation*.

The landslides in the photo at left occurred along the Mackenzie River in an area that had been previously burned by a forest fire. The Mackenzie River Drainage is one of five major drainage systems of the Arctic. Photo courtesy of Geological Survey of Canada, Natural Resources Canada.

The photo at right shows the condition of a thaw slump on the Selawik River in 2008. The Selawik River is located in northwestern Alaska. Photo courtesy of the U.S. Fish and Wildlife Service.

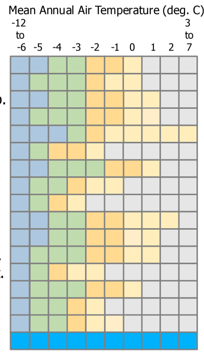
EFFECTS OF RIVER EROSION



Permafrost Characteristics of Alaska

Torre Jorgenson, Kenji Yoshikawa, Mikhail Kanevskiy, and Yuri Shur
University of Alaska Fairbanks, Institute of Northern Engineering, Fairbanks, Alaska, USA
Vladimir Romanovsky, Sergei Marchenko, and Guido Grosse
University of Alaska Fairbanks, Geophysical Institute, Fairbanks, Alaska, USA
Jerry Brown
International Permafrost Association, Woods Hole, Massachusetts, USA
Ben Jones
U.S. Geological Survey, Anchorage, Alaska, USA

Permafrost Extent by Surficial Deposit



See color legend below

Legend

Permafrost Distribution

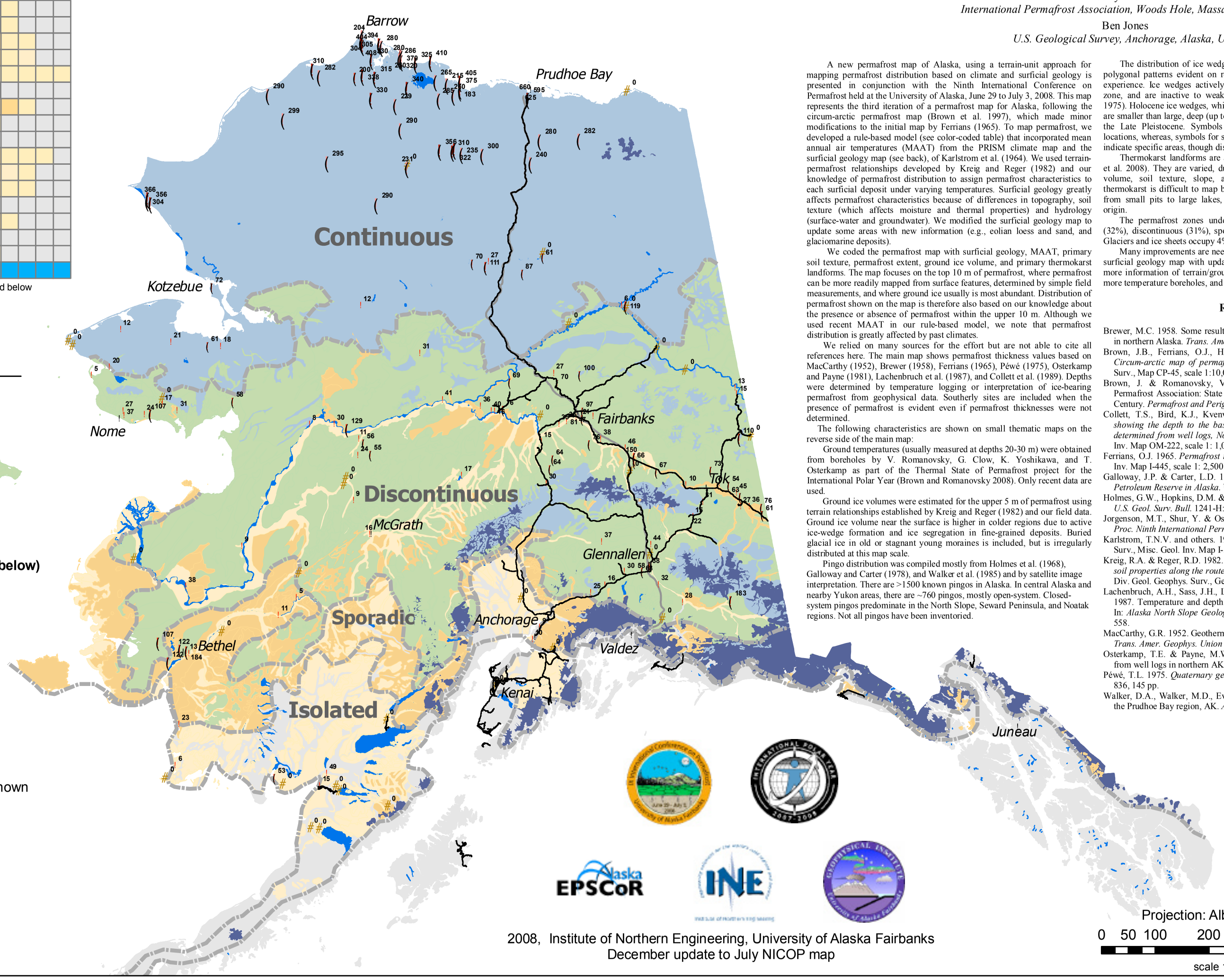
- Glacier
- Continuous (>90%)
- Discontinuous (50-90%)
- Sporadic (10-50%)
- Isolated (>0-10%)
- Absent (0%)
- Large Waterbodies (unfrozen below)
- Permafrost_Zones Generalized

Permafrost Depth (m)

- 5 - 50
- 51 - 100
- 101 - 200
- 201 - 300
- 301 - 500
- 501 - 600
- # Permafrost present but depth unknown

Other Features

- Major Roads
- Trans-Alaska Pipeline



2008, Institute of Northern Engineering, University of Alaska Fairbanks
December update to July NICOP map

A new permafrost map of Alaska, using a terrain-unit approach for mapping permafrost distribution based on climate and surficial geology is presented in conjunction with the Ninth International Conference on Permafrost held at the University of Alaska, June 29 to July 3, 2008. This map represents the third iteration of a permafrost map for Alaska, following the circum-arctic permafrost map (Brown et al. 1997), which made minor modifications to the initial map by Ferrians (1965). To map permafrost, we developed a rule-based model (see color-coded table) that incorporated mean annual air temperatures (MAAT) from the PRISM climate map and the surficial geology map (see back), of Karlstrom et al. (1964). We used terrain-permafrost relationships developed by Kreig and Reger (1982) and our knowledge of permafrost distribution to assign permafrost characteristics to each surficial deposit under varying temperatures. Surficial geology greatly affects permafrost characteristics because of differences in topography, soil texture (which affects moisture and thermal properties) and hydrology (surface-water and groundwater). We modified the surficial geology map to update some areas with new information (e.g., eolian loess and sand, and glaciomarine deposits).

We coded the permafrost map with surficial geology, MAAT, primary soil texture, permafrost extent, ground ice volume, and primary thermokarst landforms. The map focuses on the top 10 m of permafrost, where permafrost can be more readily mapped from surface features, determined by simple field measurements, and where ground ice usually is most abundant. Distribution of permafrost shown on the map is therefore also based on our knowledge about the presence or absence of permafrost within the upper 10 m. Although we used recent MAAT in our rule-based model, we note that permafrost distribution is greatly affected by past climates.

We relied on many sources for the effort but are not able to cite all references here. The main map shows permafrost thickness values based on MacCarthy (1952), Brewer (1958), Ferrians (1965), Péwé (1975), Osterkamp and Payne (1981), Lachenbruch et al. (1987), and Collett et al. (1989). Depths were determined by temperature logging or interpretation of ice-bearing permafrost from geophysical data. Southerly sites are included when the presence of permafrost is evident even if permafrost thicknesses were not determined.

The following characteristics are shown on small thematic maps on the reverse side of the main map:

Ground temperatures (usually measured at depths 20-30 m) were obtained from boreholes by V. Romanovsky, G. Clow, K. Yoshikawa, and T. Osterkamp as part of the Thermal State of Permafrost project for the International Polar Year (Brown and Romanovsky 2008). Only recent data are used.

Ground ice volumes were estimated for the upper 5 m of permafrost using terrain relationships established by Kreig and Reger (1982) and our field data. Ground ice volume near the surface is higher in colder regions due to active ice-wedge formation and ice segregation in fine-grained deposits. Buried glacial ice in old or stagnant young moraines is included, but is irregularly distributed at this map scale.

Pingo distribution was compiled mostly from Holmes et al. (1968), Galloway and Carter (1978), and Walker et al. (1985) and by satellite image interpretation. There are >1500 known pingos in Alaska. In central Alaska and nearby Yukon areas, there are ~760 pingos, mostly open-system. Closed-system pingos predominate in the North Slope, Seward Peninsula, and Noatak regions. Not all pingos have been inventoried.

The distribution of ice wedges was determined from the literature, from polygonal patterns evident on remote sensing imagery, and from our field experience. Ice wedges actively form mainly in the continuous permafrost zone, and are inactive to weakly active in the discontinuous zone (Péwé 1975). Holocene ice wedges, which are limited to the top 3-5 m of permafrost, are smaller than large, deep (up to 35 m) syngenetic ice wedges formed during the Late Pleistocene. Symbols for abundant ice wedges denote general locations, whereas, symbols for sparse Holocene and Late Pleistocene wedges indicate specific areas, though distribution remains poorly known.

Thermokarst landforms are abundant in all permafrost zones (Jorgenson et al. 2008). They are varied, due to differences in temperature, ground ice volume, soil texture, slope, and hydrologic conditions. Abundance of thermokarst is difficult to map because of the wide range in size of features from small pits to large lakes, and similar landforms may have different origin.

The permafrost zones underlie 80% of Alaska, including continuous (32%), discontinuous (31%), sporadic (8%), and isolated (10%) permafrost. Glaciers and ice sheets occupy 4% of the area.

Many improvements are needed for a better permafrost map, including: a surficial geology map with updated information and better spatial accuracy; more information of terrain/ground ice/temperature/permafrost relationships, more temperature boreholes, and improved spatial models.

References

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ICE WATER: RIVERS AND PERMAFROST

Ice Water: Rivers and Permafrost

Alaska's rivers are cold. That's not really news to anyone. After all, they're fed by melting snow and icy glaciers. Many of them wind through Arctic lands underlain with frozen ground, right through the fragile Arctic ecosystem. So what happens if the permafrost begins to thaw? Things begin to change.

Erosion

Mechanical erosion: the process of weathering.

Wind and water carry sediment from its source and deposit it somewhere else. Rain, snowmelt, glacial melt, rivers and streams all contribute; so does gravity. The down-slope creep of soil and other material is under the force of gravity.

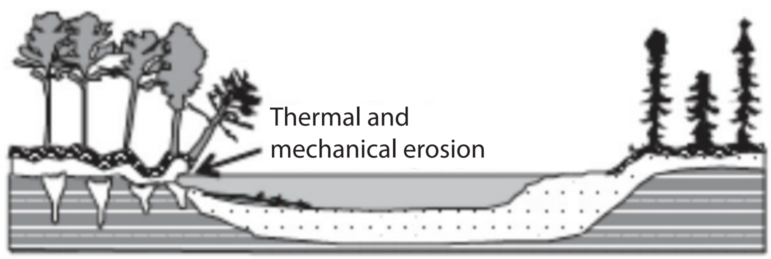
Thermal erosion: erosion caused by heat.

Even though river water is cold, it's still warmer than permafrost. When the water hits the frozen bank, it causes it to thaw. After that, mechanical erosion takes over.

Erosion and Permafrost

Most large rivers don't have permafrost under them, even in the continuous permafrost zone, but permafrost is prevalent along the banks in the continuous zone and occurs in the discontinuous zone as well. Warming temperatures can cause permafrost to thaw, which can lead to increased erosion. Thermo-erosional niches, landslides and thaw slumps can result when a frozen riverbank begins to thaw.

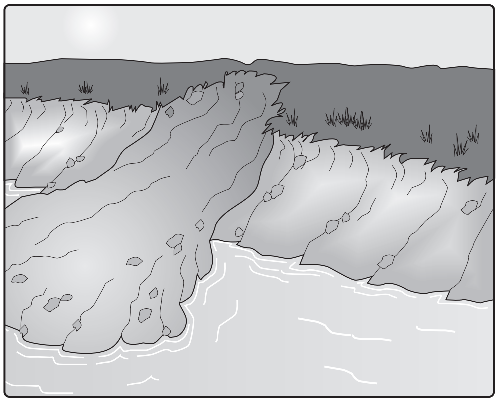
Thermo-erosional Niche



Thermo-erosional Niche

A thermo-erosional niche is formed when the river undercuts thawed portions of the bank and the upper parts, which may be still frozen, causing the bank to collapse and melt. This leads to mass movement of the bank down slope.

A thero-erosional niche on the Colville River Delta on Alaska's North Slope. Photo courtesy of Jorgenson and Osterkamp from *Response of Boreal Ecosystems to Varying Modes of Permafrost Degradation*.



Landslides

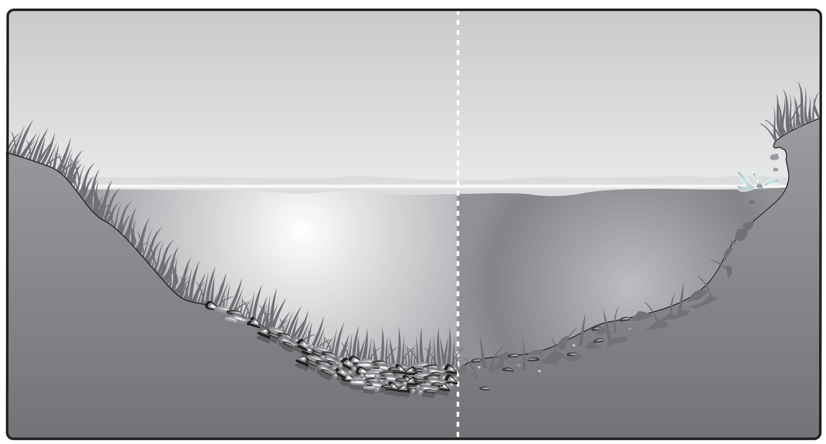
Landslides can occur when a slope of frozen land meets conditions that cause it to thaw.

Extreme summer temperatures, drought (which kills vegetation), forest fires, erosion of topsoil, and changing climate are among the catalysts. As permafrost thaws, the wet soil loses cohesion and easily slides downhill. When this occurs along a riverbank, the debris is deposited into the river. In one study of the Mackenzie River in Canada researchers counted over 2,000 landslides along the river route.

Thaw Slumps

One of the most dramatic changes that can occur when permafrost thaws is the development of a retrogressive thaw slump. A thaw slump occurs when sloped ground—frozen for hundreds, maybe thousands, of years—thaws, causing it to collapse. This exposes a new wall of frozen material, which then thaws to reveal another one. In this way the feature eats its way into a hillside. It's as if someone took a giant ice cream scoop to landscape. The muddy debris then heads downhill, often into streams and rivers.

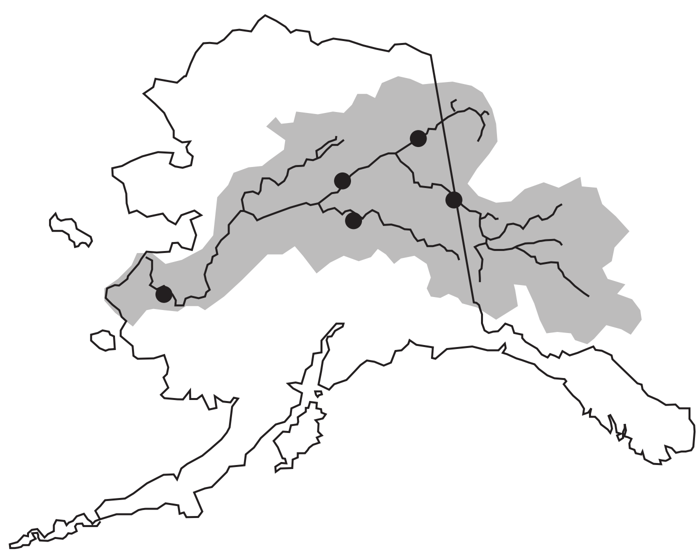
Why is This Important?



Thermo-erosional niches, landslides and thaw slumps can all deposit sediment into rivers. That sediment can change the river, impacting the ecosystem.

- Small sediment could fill the spaces between the gravel on the river bottom where fertilized fish eggs settle to over-winter.
- The influx of debris and sediment could change a river's biochemistry, adding minerals, organic and inorganic material, which could affect the habitat of all that rely on it, including fish, animals, insects and plants.
- Most of Alaska's rivers and streams ultimately empty into the ocean. Changes in river chemistry could mean changes in ocean chemistry.

The illustration to the right shows the Yukon River drainage area. The Yukon River and all its tributaries empty into the Bering Sea. The Yukon River drainage is underlain with continuous and discontinuous permafrost.



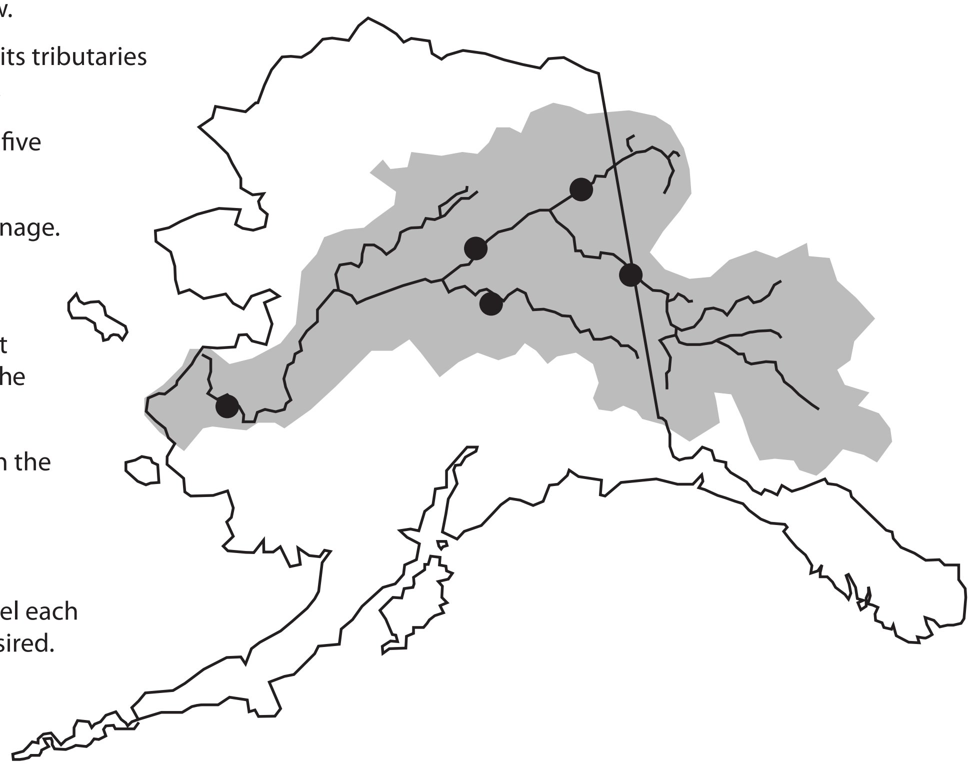
NAME: ______________________________

THE HEART OF ALASKA: THE YUKON RIVER BASIN

PART 1

Directions: The Alaska map below highlights the Yukon River drainage. Use classroom reference material, the Internet, and other resources to find answers, then place the following information on the map. When finished complete the questions that follow.

- Trace the Yukon River and its tributaries with a blue colored pencil.
- Label the Yukon River and five tributaries.
- Label the Yukon River Drainage.
- Label at least three communities in the Yukon River drainage. Use a red dot to mark the location. Write the name.
- Label the ocean into which the Yukon River drains.
- Sketch the approximate boundaries of the state's permafrost zones then label each region. Lightly shade if desired.



1. The Yukon River drainage covers ______________________________ percent of Alaska?

   A. about 50 percent
   B. about 33 percent
   C. about 10 percent
   D. about 80 percent

2. What type(s) of permafrost underlay the Yukon River Basin? Circle all that apply.

   continuous   discontinuous   sporadic   isolated

3. What is the name of your community? ______________________________

   Is it located in the Yukon River drainage? ____________________

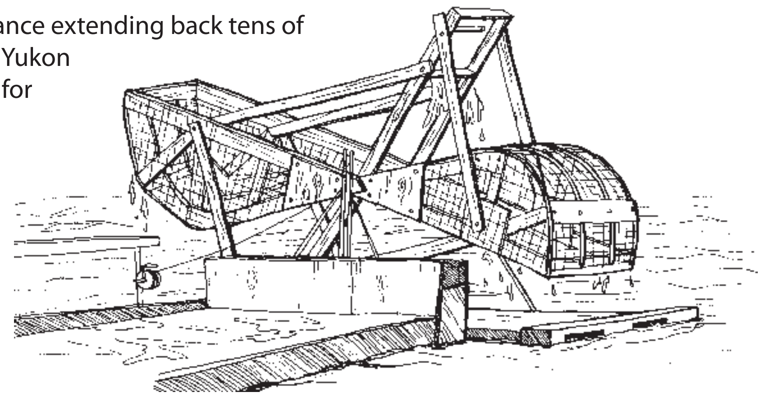
NAME: ___________________________

THE HEART OF ALASKA: THE YUKON RIVER BASIN

PART 2

Directions: Read the following background information, then complete the questions that follow.

Background: People and the Yukon

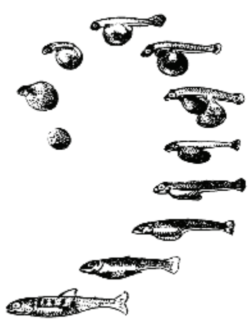


The Yukon River has cultural and historical significance extending back tens of thousands of years. Anthropologists speculate the Yukon Valley may have been the main immigration route for North America's first people.

The Yukon River has the longest salmon migration of any river in the world. Alaska's Indigenous people have depended on the river's salmon harvest for more than 10,000 years. Still today people set up fish camps with fish wheels and nets each summer and enjoy the bounty of the river, which is not only an important source of subsistence food but a cultural cornerstone.

Salmon and the Yukon

Changes in the biochemistry of the river could have a significant impact on the river's salmon population, which would impact the subsistence lifestyle of those who depend on the salmon run. Scientists are concerned that sediment from permafrost thaw could smother salmon eggs deposited in the gravel at the river bottom.



The female salmon uses her tail fin to create a shallow depression in the gravel at the bottom of the river. In it she lays up to 5,000 eggs, which are then fertilized by the male. The female covers the eggs with gravel and moves to another area to lay more eggs. She may do this up to seven times.

4. Under normal circumstances, only about .001 percent of the eggs laid in a gravel bed will reach maturity at sea and return to spawning grounds to start the cycle again. Of 5,000 eggs, how many will survive?

   Answer: ___________________

5. Remember, only about .001 percent of eggs reach maturity. If one fish camp catches then dries or freezes 3,000 salmon to provide 12 families with fish for the winter, how many salmon eggs had to be deposited to provide the 3,000 fish?

   Answer: ___________________

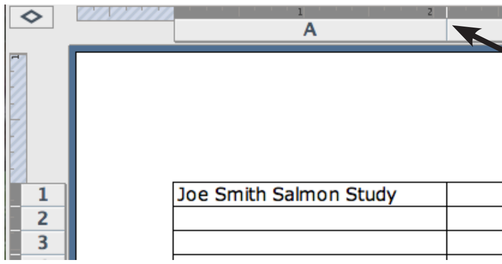
NAME: ______________________________

SURVIVAL RATE OF SALMON

Directions: Using the hypothetical data provided, use Microsoft Excel to create a spreadsheet that describes the fate of one bed of 5,000 salmon eggs. Follow the steps carefully.

STEP 1: Open a new Microsoft Excel file. Save it as <Your Name> Salmon Study.

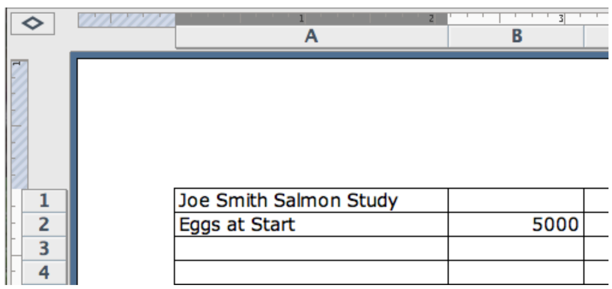
STEP 2: Use the file name as the spreadsheet title. Type it in column A, row 1.



	A
1	Joe Smith Salmon Study
2	
3	

Hint: You can make the column wider by sliding the boundary line to the right.

STEP 3: In row 2, under column A (cell A2), type **Eggs at Start**. In column B (cell B2), type **5,000**.



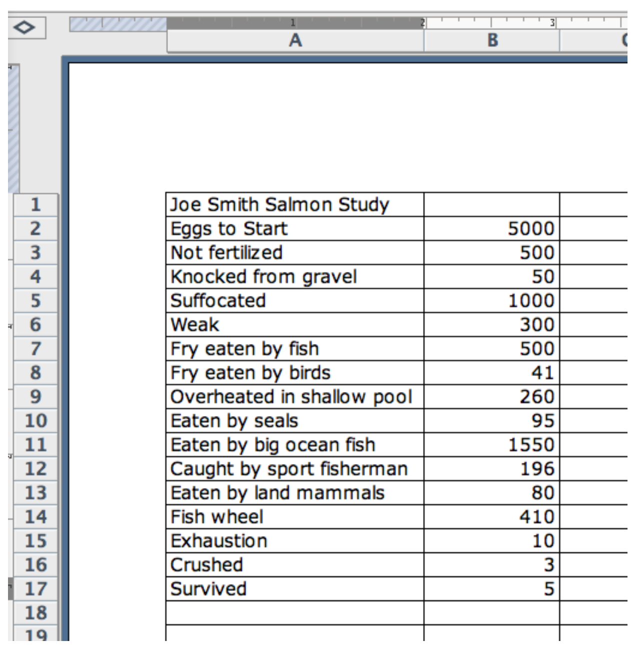
	A	B
1	Joe Smith Salmon Study	
2	Eggs at Start	5000
3		
4		

Hint: Don't forget to click "Save" often!

STEP 4: Fill in the remaining data from the information below. Abbreviate phrases when needed. The description goes in column A, the number in column B.

Out of 5,000 eggs, 500 did not get fertilized so they died. A riverboat dropped anchor, knocking 50 eggs free of the gravel. Sediment eroding from the riverbank washed over the gravel and suffocated 1,000. Upon hatching, 300 alevins were too weak to survive. Larger fish in the river ate 500 young fry. Birds snatched 41 fry from the river. After becoming trapped in a shallow pool, 260 smolts died from becoming overheated. During the years spent growing in the ocean 1,550 of the salmon were eaten by bigger fish, 95 were gobbled up by seals, and 196 were caught by sport fishermen. Once they headed back up the river, bears, otters and other land mammals ate 80 salmon. A fish wheel harvested 410. Before reaching the spawning ground, 10 died from exhaustion and 3 were crushed against rocks trying to jump a waterfall. Of the original 5,000, only 5 made it all the way.

Your spreadsheet should look similar to the one at right.



	A	B
1	Joe Smith Salmon Study	
2	Eggs to Start	5000
3	Not fertilized	500
4	Knocked from gravel	50
5	Suffocated	1000
6	Weak	300
7	Fry eaten by fish	500
8	Fry eaten by birds	41
9	Overheated in shallow pool	260
10	Eaten by seals	95
11	Eaten by big ocean fish	1550
12	Caught by sport fisherman	196
13	Eaten by land mammals	80
14	Fish wheel	410
15	Exhaustion	10
16	Crushed	3
17	Survived	5
18		
19		

NAME: ______________________________

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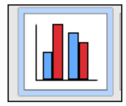
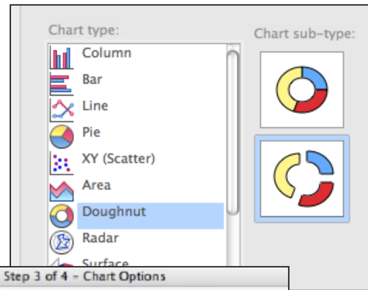
Eaten by land mammals	80
Fish wheel	410
Exhaustion	10
Crushed	3
Survived	5

STEP 5: Now make a graph from the data. Highlight the rows that break down the fate of the eggs. Exclude the row that says **Eggs to Start**, and start at row 3.

STEP 6: Click on the Chart Wizard function located on the toolbar. It looks like this:

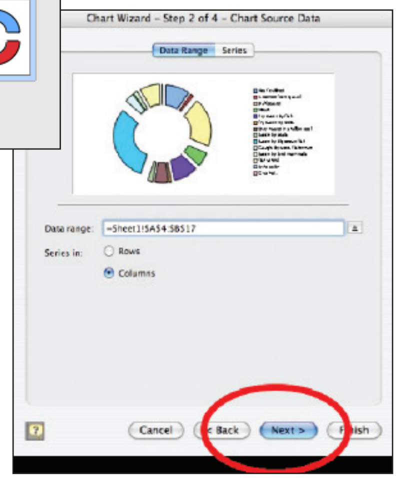


STEP 7: Select **Doughnut** chart, then choose the option that shows the doughnut broken out in sections.

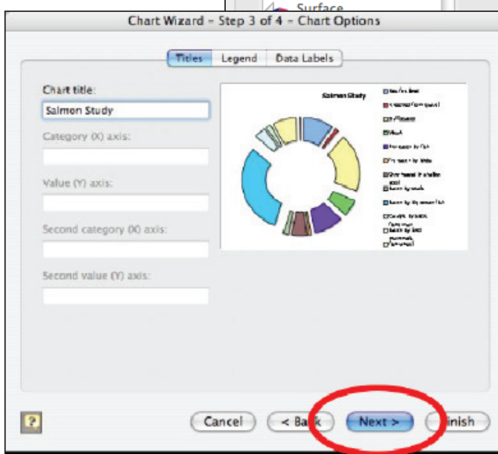


STEP 8: Click **Next >**.

STEP 9: Click **Next >** again when asked about data range.

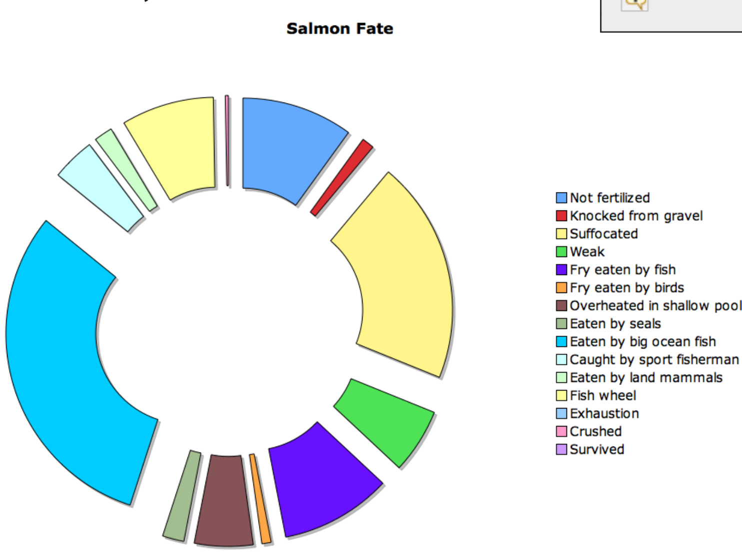


STEP 10: Give your chart a title. You can use the same title as in row 1, or use a shorter version. Click **Next >** again.



STEP 11: Choose to keep your chart within the current page of your spreadsheet. Make sure to click **As new sheet:** then click **Finish**.

Another tab will open that shows a visual breakdown of a possible salmon life scenario. Be sure to save your file!



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BRINGING IT HOME

Directions: Based on the information you have learned from the worksheet, The Heart of Alaska: The Yukon River Basin and the lab sheet: Survival Rate of Salmon, address the scenario:

Scenario

Your community is located near a river in the Yukon River basin. The people in your community depend on salmon and other fish in the river for subsistence. On a recent motorboat trip up the river you noticed several small landslides and the beginnings of what could be a thaw slump. You are concerned and wish to share what you know with community leaders. What would you tell them? Include what you know about permafrost thaw, the sediment it could add to the river and the survival rate of salmon.