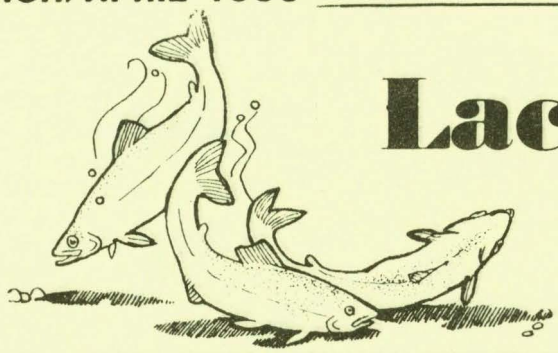
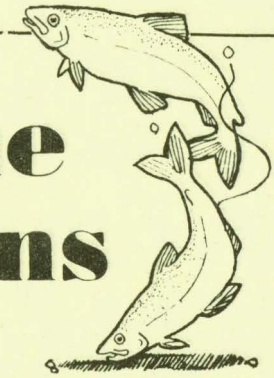
MARCH/APRIL 1983

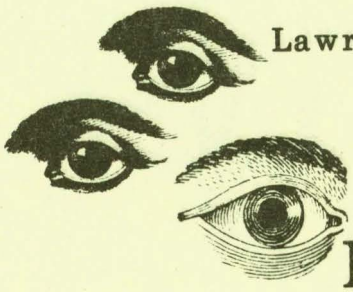


Lacustrine Lessons

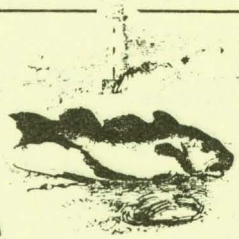


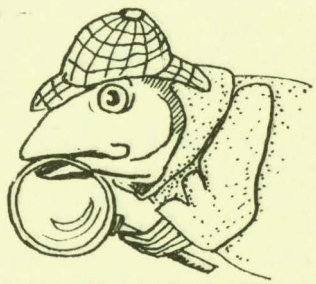
Aquatic Projects for Grades K-12 from the Minnesota Sea Grant Extension Program

"A lake is the landscape's most beautiful and expressive feature.
It is the earth's eye, looking into which the beholder measures the depth of his own nature."
Walden, Henry David Thoreau



Lawrence Lake Trout in The Case of the Mysterious Attacker





The fish in the Knife River area of Lake Superior were angry and confused. Someone in their community was systematically stalking and attacking the larger, more established members of their community. Sometimes the victim died; sometimes he or she was simply scarred and weakened. Nobody in the community appeared to be safe, large fish in nearly every niche had been assaulted. If attacks had been confined to the common suckers the problem may have gone ignored, but whitefish, rainbow trout, and even the superior lake trout had been attacked. Who was this mysterious predator? The community could stand it no longer....the culprit had to be found. So they decided to call in knowledgeable and well traveled Lawrence the Lake Trout.

Lawrence, recently retired from his position with the Sea Grant Extension Program at the University of Minnesota, had the time available to work on the problem. The community delegation met with Lawrence and explained the situation.

Was their request impossible?

Lawrence pondered their request for only a few minutes then agreed to take the case. "I feel it is my duty," pronounced Lawrence, "to solve this problem. The maniac must be identified. Or else the elders in the community will spend their remaining days in fear.

"The first thing to do is to interview those who have survived attacks, but we'll have to act swiftly.

"I'll begin by asking my assistant Salvelinus fontinalis, to interview one of the victims, Catostomus commersoni. In the meantime I'll retire to my study to contemplate this problem."

Although Salvelinus fontinalis normally preferred clear streams and smaller lakes, she was generally well accepted by the Lake Superior community. Her group, brook trout, were old established members of the community and were distantly related to the lake trout. Catostomus commersoni was happy to talk with Salvelinus fontinalis and relieved to hear Lawrence had taken on the case.

"It's just terrible," said Catostomus commersoni, "We're at the mercy of this maniac. You know, we're usually down here at the bottom of the lake where visibility can be very poor. And my eyesight is poor. I didn't even see my attacker. I was minding my own business, feeding on crustaceans and insects along the sandy bottom at the mouth of the Knife River when something smacked me in the side. For a split second I felt scales being scaped off and a dragging sensation on my left side. Some kind of fish had attacked me! Then, as I dashed frantically about, I managed to lose it. I didn't look back. All I wanted was to get out of there, fast! It was pretty dark. I probably wouldn't have seen anything anyway. Sorry I can't give you a better description."

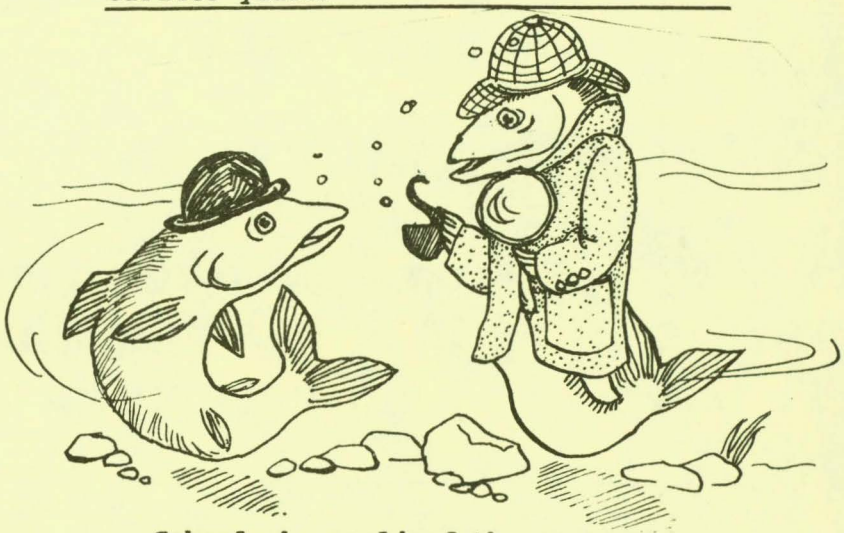
Catostomus commersoni showed Salvelinus fontinalis his scar. It was small and round; about three millimeters in diameter. They couldn't understand why a predator with such a small mouth would attack a fish the size of Catostomus commersoni, who weighed nearly four pounds. It was certainly beyond their understanding. It would take all of Lawrence's skills to crack the case. Salvelinus fontinalis thanked Catostomus commersoni and hurried back to Lawrence to report her findings.

The plot thickens

Lawrence, in the meantime, had been reviewing historical records for similar attacks. The problem had existed for longer than the Knife River community had been aware. In Lake Superior there had been large numbers of such attacks in the 1950s and 1960s. The problem was not a brand new one, but it was unusual.

Large fish frequently prey on smaller fish. It is the nature of the community-- smaller fish have to avoid a larger fish unless the large fish have proven they are not interested in feeding on the smaller ones. But this case was different! The largest fish in nearly every niche had been attacked. This puzzled Lawrence. From his extensive travels he knew there weren't any fish in Lake Superior large enough or fast enough to prey on large lake trout. Acipenser fulvens might be large enough. She'd been reported to grow to over 200 pounds and to be more than eight feet long. But she was part of a group that had been nearly eliminated from Lake Superior and everyone knew she was not equipped to prey on other fish.

Lawrence went over the facts again and again. Suddenly another clue jumped out at him. There were no reports of this type of attack before 1829 and relatively few until 1946. Then in the 1950s there was suddenly an epidemic of similar attacks. The species suffering most was the lake trout, but whitefish and others suffered too. The clue was right there before his eyes. The attacker was a "newcomer" to Lake Superior. It couldn't be a native or there would have been reports of similar attacks in earlier years.



Soberly he realized there was no way to get rid of this menace...life would never be the same.

Quickly Lawrence developed a list of suspects. All of the suspects had been introduced to, or found their way into Lake Superior since 1829. The list was surprisingly long and looked like this (using their real names and common aliases):

1. Onchorhynchus kisutch - coho salmon
2. Onchorhynchus tshawytscha - chinook salmon
3. Onchorhynchus gorbuscha - pink salmon
4. Alosa pseudoharengus - alewife
5. Osmerus mordax - rainbow smelt
6. Petromyzon marinus - sea lamprey
7. Anguilla rostrata - american eel
8. Cyprinus carpio - carp

9. Salmo gairdneri - rainbow trout (steelhead)

10. Salmo trutta - brown trout

11. Salmo salar - atlantic salmon

It was at that point that Salvelinus fontinalis rushed up to Lawrence. "I've talked to Catostomus commersoni," she gasped. "He didn't see his attacker and only got a small round scar out of the ordeal. It has to be a fish with a fairly small mouth. But that doesn't make sense. Small fish don't try and eat larger ones."

"That could be," answered Lawrence. "Either the attacker is large and has a relatively small mouth or the attacker is smaller than its prey. We'll have to call Coregonus artedii and immediately put out an All Points Bulletin (APB). Until this case is solved all fish better beware not only of larger fish but also of smaller fish!"

Salvelinus fontinalis called Coregonus artedii who immediately began carrying the APB to all regions of the lake. Traveling in large schools Coregonus artedii covered the lake from the surface to the depths.

When Salvelinus fontinalis finished with her call Lawrence stated, "Well, I've got a clue too. The records show that the attacker has to be a newcomer to our community. I've created a list of possible suspects, but we'll have to have more clues before we can solve this mystery."

Lawrence and Salvelinus fontinalis finned out to interview other members of the community. When they met at the end of the day they compiled a list of clues.

The predator was:

1. 12-25 inches in total length
2. mottled or spotted grey or chocolate in color
3. had a dorsal fin in two distinct parts
4. had a lighter colored stomach than back
5. had a small mouth (about 3mm. in diameter) with very sharp teeth
6. had small round eyes
7. had a body which was long and thin
8. had no scales
9. was a newcomer to Lake Superior

That night Lawrence and Salvelinus fontinalis reviewed the list again and again. "We have a lot of clues," commented Lawrence, "but it could still be any of several suspects. Two key identifying characteristics are missing. No one has commented on the predator's pelvic and pectoral fins or on its gills."

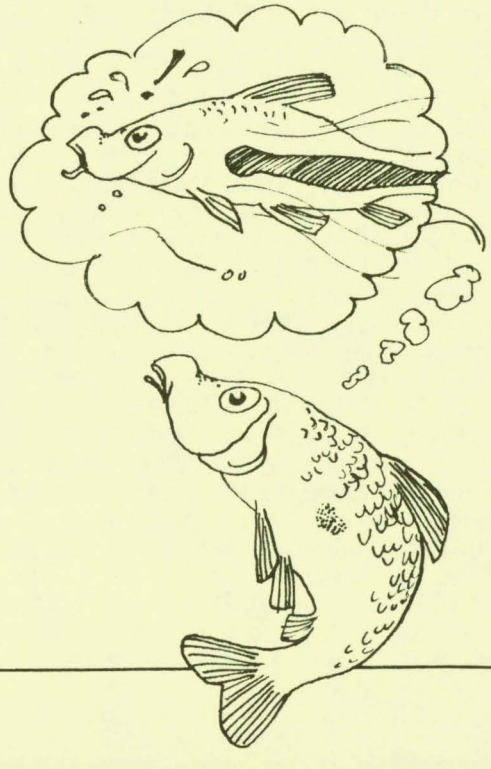
The clue to end all clues

It was at this very moment when Cottus cognatus approached hesitantly. Cottus cognatus was well aware that Lawrence occasionally liked to feed on members of his group, but he, Cottus cognatus, had observed something that he just had to share with the famous Lawrence.

"Lawrence," said Cottus cognatus "you know I'm sensitive about pelvic and pectoral fins because my own are so unusual. Well I caught a glimpse of the fish who attacked Catostomus commensori the other night and I noticed right away that the attacker had no pectoral or pelvic fins! I couldn't believe it."

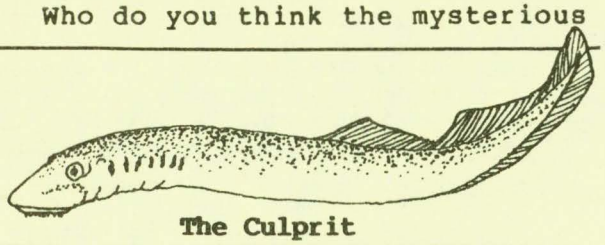
Lawrence beamed, that was it! That was the clincher! Now he knew who the attacker was. Lawrence was so pleased he rewarded Cottus cognatus by promising not to bother the sculpin community for at least two months.

I didn't even see my attacker...I felt scales being scraped off and a dragging sensation on my left side.



After Cottus cognatus left Lawrence unravelled the mystery for Salvelinus fontinalis. As Lawrence described the predator and its behavior he suddenly realized the seriousness of his discovery. His APB would probably have to remain in effect forever. Soberly he realized there was no way to get rid of this menace. Somehow everyone would have to learn to coexist with the newcomer. Slowly he shook his head, life would never be the same.

Who do you think the mysterious



The Culprit

predator was? Discuss how you could identify the culprit. Use a fish identification book or poster to prove your answer is right.

Cast of Characters

The names in the story which are underlined are the scientific names of the fish. The common names of the characters are:

1. Salvelinus namaycush - lake trout
2. Salvelinus fontinalis - brook trout
3. Catostomus commersoni - white sucker
4. Cottus cognatus - slimy sculpin
5. Coregonus artedii - lake herring
6. Acipenser fulvens - lake sturgeon

This is a very "fishy" story. But the story is based on facts.

The sea lamprey had been present in Lake Ontario and the St. Lawrence River since post glacial times, but were unable to enter the other Great Lakes until the Welland Canal was opened in 1829. After 1829, and particularly after the Canal was deepened in 1919, the sea lamprey established themselves slowly in all of the Great Lakes. They reached their peak population in Lake Superior in the 1950s and 1960s. Lamprey's affect on existing fish populations in Lake Superior was dramatic: The number of lake trout was severly reduced and whitefish, suckers, and other fish were affected as well. The native fish in Lake Superior had no defenses against this new predator. Inadvertently, humans had upset the balance of nature. Now they are trying to alter the balance again in favor of the lake trout by destroying the lamprey with chemicals. Their efforts are fairly successful, but it doesn't appear they'll ever elminate the lamprey now that it's been introduced.

This story illustrates how to identify fish. Look at the list of witness descriptions. What kinds of information does Lawrence use to identify the attacker? Fish can be identified by a combination of characteristics:

1. Body shape
2. Shape and position of their fins
3. Size and shape of the gills
4. Color
5. Eye shape
6. Mouth (and teeth) shape, size, and location
7. Scale shape and size

Not only do these characteristics help people identify fish they also offer clues about what niche a fish fits in: where it lives, how fast it can swim, how suddenly it can start and stop and turn, and what it eats. For example, the shape of a fish's mouth, its location on the head and the shape of the teeth gives clues to what a fish eats. In the case of the sea lamprey, the round mouth allows the lamprey to attach itself to fish by creating suction. Then its sharp teeth and file-like tongue are used to rasp a hole in the side of the fish so it can suck the fluids from the fish's body.

There are many fascinating organisms that live in Lake Superior, and learning about them can be fun. Writing a creative story is one way to learn. Use your imagination and include facts you have learned by reading about the environment and your own cast of characters.

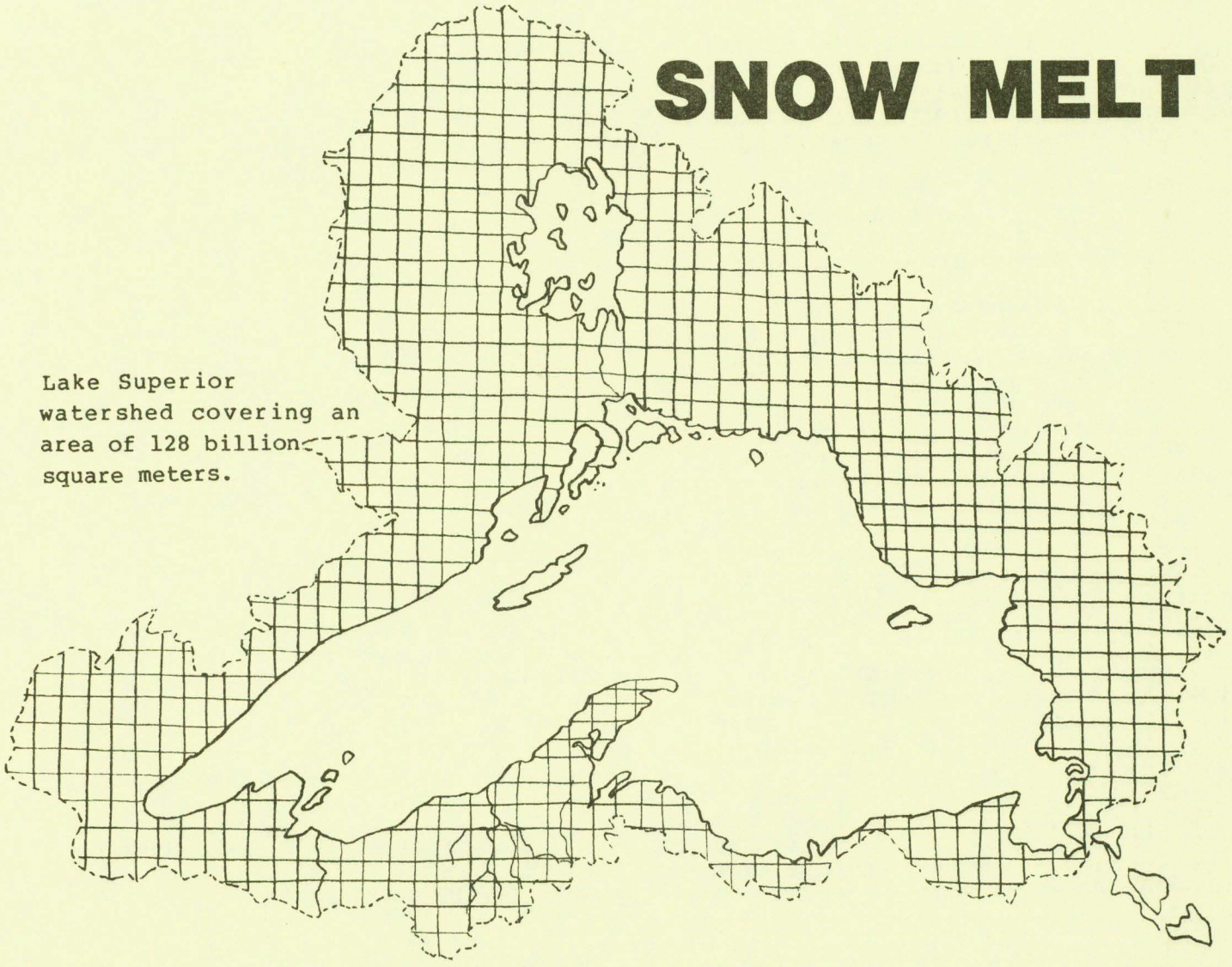
Resources

Downs, W. The Sea Lamprey: Invader of the Great Lakes Wisconsin Sea Grant Institute, 8 pp; available from the Minnesota Sea Grant Extension Program. Free.

Eddy, S. & Underhill, J.C. 1976, Northern Fishes University of Minnesota Press, Minneapolis.

Phillips, G. L., Schmid, W.D. & Underhill, J.C. 1982 Fishes of the Minnesota Region, University of Minnesota Press, Minneapolis.

SNOW MELT



Lake Superior watershed covering an area of 128 billion square meters.

Spring is a time of rushing rivers, snowballs, and floods. The warming days and nights melt the earth's snow cover and send water draining out of the watersheds. Some years, a sudden warming trend continues until the snow cover has completely disappeared in only a few days. The resulting surges of water run rapidly off the land, following water courses and occasionally causing floods where the water flow is restricted.

The following activity will explore the water content of existing snow cover and allow middle school students to estimate how much water could be generated in a given watershed.

Objectives

1. To determine how much water is contained in a volume of spring snow.

2. To determine how much runoff would be generated in the Lake Superior watershed if the existing snow cover suddenly melted.

3. To demonstrate an ability to determine averages and multiply with decimals.

Materials

Plastic garbage bags, shovel, meter stick or meter square, liter measuring container, news print, blackboard

Preparation

1. Discuss with the students the spectacle of spring runoff. What have the students observed in lakes, streams, and rivers? Record guesses on how much water (in m^3 or gallons) could melt from a local watershed or from the Lake Superior watershed.

2. Explain that the class will carry out a brief activity to estimate how much water would be released into a local watershed, or into Lake Superior, given the snow conditions that exist around school.

3. Divide the class into working groups of two or three. Have each group cut one meter square out of newsprint. Explain that they will use the square to identify their sample area.

4. After the students have prepared their newsprint squares, explain the procedure to be followed:

a. Each group should begin by finding an "undisturbed" (having had no obvious tracks or unusual dumpings of snow) area of snow cover.

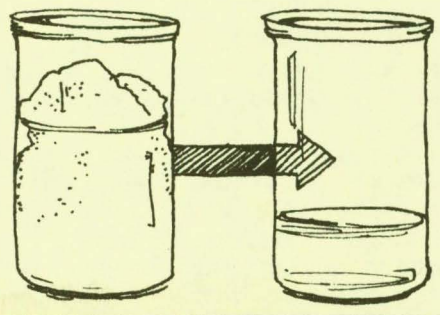
b. Place the newsprint square on the second and draw along the edge with a stick or glove to clearly mark the sample area.

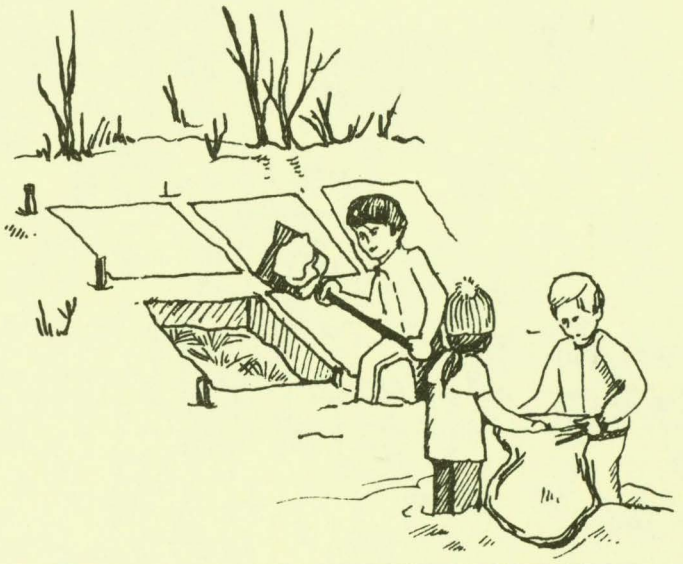
c. Take six to ten readings of depth in the sample area, then determine the average depth of the snow.

d. Carefully shovel all the snow from the sample area into a plastic bag. This excavation of the sample area should leave a square meter of bare ground.

e. Bring the bag of snow back into the classroom, tie the top of the bag, label it, and put it in a warm safe area where the snow can be left to melt.

5. When the students have completed the activity to this point they should reconvene to discuss their observations so far. What was each group's average snow depth? Record the answers on the board and calculate an average of the samples. What accounted for the differences in observations? Was the snow depth under the trees greater or less than that found in open areas? Ask the students to guess how much water is contained in a cubic meter of snow. Demonstrate how big a cubic meter is and record their answers.





6. The following day, when the snow samples have melted, all groups should carefully measure the water in their plastic bags. Record the results on the board. Discuss the possible causes for the differences. Determine an average volume of water from the student results.

Demonstrate how to determine the amount of water contained in one cubic meter of the snow sampled.

$$\frac{\text{avg. vol. water}}{\text{avg. snow depth (in meters)} \times 1m^2} = \frac{?\ \text{(vol. water)}}{1m^3}$$

How does this result compare with the students predictions?

7. Tell the students the land area of the Lake Superior watershed and of your local watershed.

Lake Superior = 128,000,000,000 m^2

Your local watershed contains how many square meters of land?

Ask them to determine how much water would be released in each watershed if sudden, total melt occured and snow cover conditions in the watershed were equal to those found by the students near the school.

(Av. vol. water/square meter x area of watershed = cubic meters of water released from the watershed during a total melt).

8. Discuss the volume of water generated by such a melt. Compare it

to the volume of water of some known lake or pond. (The MPCA has data on some Minnesota lakes. Lake Calhoun in Minneapolis, for example, contains about 18,000,000 cubic meters of water.) What factors might affect how much water would runoff during a melt? (For example: evaporation, percolation into the soil, area covered by houses and roads, etc.).

How does the runoff of the two watersheds compare?

9. Conclude by discussing the possible impact of spring snow melt on the environment. How does it affect the streams and rivers? How might it affect aquatic plants and animals if the snow contains high amounts of acid? (Acid precipitation can occur in the form of snow which would be released in streams as a sudden surge during a melt).

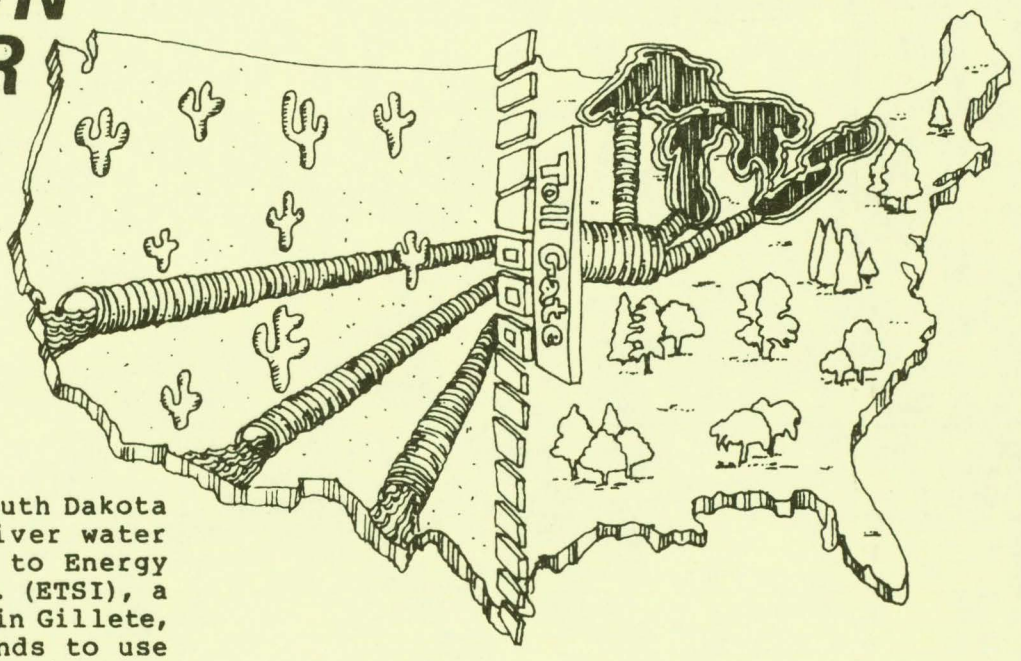
Follow Through

1. Compare the water content of different kinds of snow during several snowfalls.

2. Measure stream velocity during and after the spring thaw.

SOLD DOWN THE RIVER ?

Illustration Courtesy
Freshwater Foundation

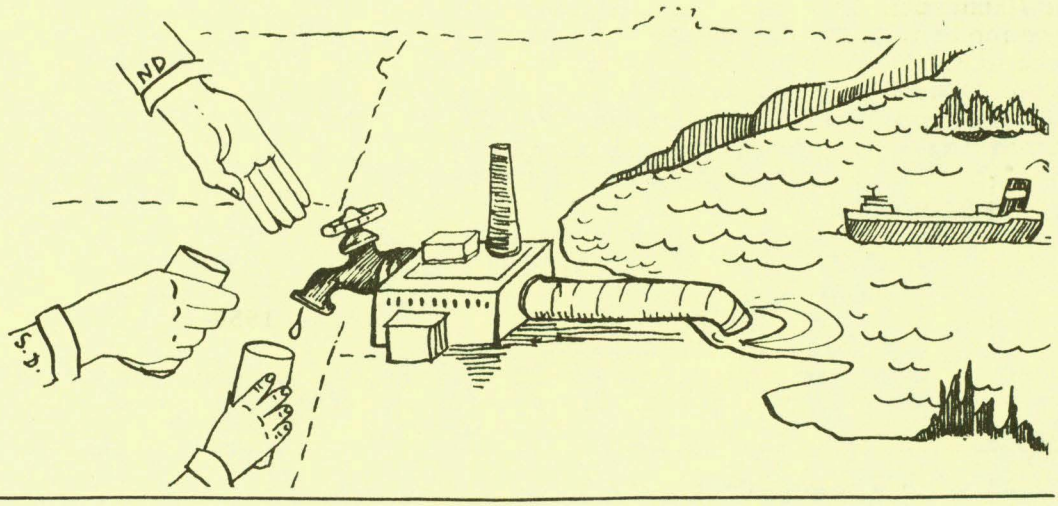


In 1981 the state of South Dakota agreed to sell Missouri River water from the Oabe Reservior to Energy Transportation System, Inc. (ETSI), a private coal slurry company in Gillete, Wyoming. The company intends to use the water in a coal slurry pipeline which will connect Gillete with Arkansas, Oklahoma, and Louisiana. ETSI believes the pipeline is a sound investment: Slurry pipelines' variable costs amount to 30% of their initial operating costs, whereas variable costs of railroads (the other primary means of moving coal) are about 85%.

If the sale is successfully defended by South Dakota in court, and assuming that ETSI doesn't change its mind, South Dakota will benefit financially from the transaction. The state may receive up to $34 million during the ten years that ETSI has to develop the pipeline. After the pipeline is functional, ETSI has contracted to buy 50,000 acre feet (6.165×10^7 cubic meters) per year for 50 years. This quantity equals about 0.27% of the annual discharge of the Oabe Reservior. South Dakota will receive $9 million per year, indexed upwards at 1/2 of the Fixed Weighted Price Index for the Gross National Product. At the base price of $9 million, ETSI is paying $180 per acre foot (14.6 cents per cubic meter).

South Dakota's decision to sell some of its water resources comes at a time when many water-poor states are investigating new sources for fresh water. Water rich states like Minnesota appear to have difficulty deciding whether to be concerned or excited about outstate demands for their water.

South Dakota has set the precedent, the political, social, economic, and environmental consequences remain to be seen.

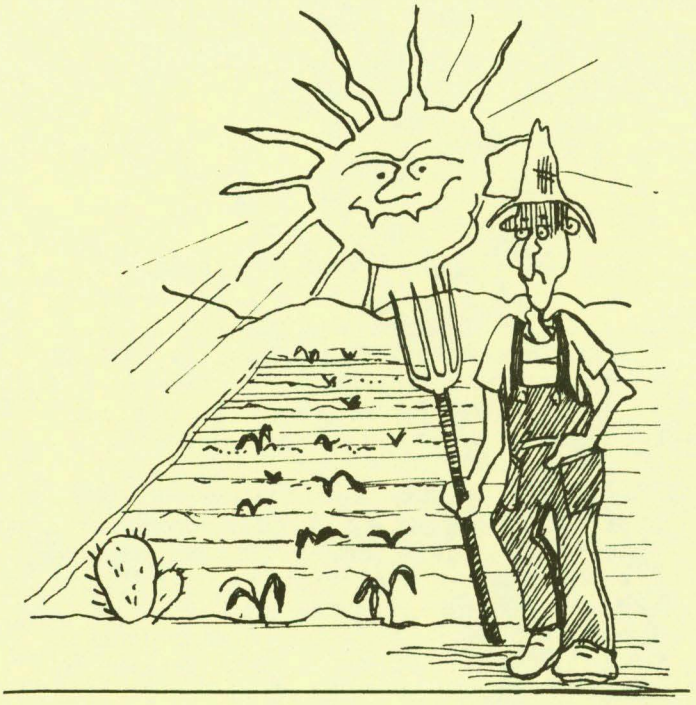


Objectives

1. To demonstrate an ability to manipulate formulas.

2. To demonstrate an ability to work with exponentials.

3. To determine and discuss some of the impacts of a hypothetical sale of water from Lake Superior.



Ninety-five percent of the fresh surface water in North America is contained in the Great Lakes. Yet the fastest growing areas of the United States are in the freshwater-poor West, South, and Southwest. Withdrawal of freshwater from the ground southeast of Phoenix has caused the land to sink an average of seven feet. The San Joaquin Valley in California has sunk 30 feet because of a depleted aquifer. And the Ogalla Aquifer, which supplies ground water to much of the High Plains, is being drawn down 10 to 14 times faster than it is being replenished.

Statistics like these lead many people to believe that there will be a demand for Great Lakes water in the near future.

South Dakota recently decided to sell 50,000 acre feet of water per year for 50 years to a private company.

The following activity will allow students to use their mathematical skills to determine the effects of water diversion on Lake Superior.

Student Worksheet

Formulas & Definitions*

1. $V_D = (P \times A_D)\ (0.482)$
2. $V_E = (A_L)\ (0.51 \text{ meters})$
3. $V_L = A_L \times P$
4. $V_O = V_D + V_L - V_E$

1976	= 0.525 m/yr*
1967	= 0.544 m/yr*
1950	= 1.018 m/yr*
1972	= 1.006 m/yr*

Where:

P = annual average precipitation over the lake basin in meters per year

A_D = land surface area in the lake basin (12.77×10^{10} square meters for the Lake Superior basin)

A_L = water surface area of the lake in the Lake Superior basin (8.21×10^{10} sqaure meters)

V_D = volume of precipitation in cubic meters entering the lake from the land

V_E = volume of water in cubic meters which evaporates annually from Lake Superior

V_L = volume of precipitation in cubic meters which falls directly on the lake surface

V_O = the volume of water in cubic meters which is discharged from Lake Superior through the St. Mary's river and Sault Ste. Marie locks

Problems

1. What percent of the total Lake Superior drainage basin (land and water surface $V_L + V_D$) is covered with water?

2. Calculate V_O for the following annual precipitation rates:

average annual precipitation m/yr	= 0.762 m/yr
1982	= 0.869 m/yr*

3. Graph the results from problem two. The V_O should be on the y axis and the annual precipitation should be on the x axis. At what precipitation level would there be no discharge (assuming the lake is a steady state system)?

4. If Minnesota sold 1.8495×10^8 m^3 (150,000 acre feet) of water from Lake Superior each year, it would be selling an amount closely proportional to that sold by South Dakota from the Missouri River. What percent of the annual average discharge does this amount to? What percent is it of the exceptional years noted in problem 2?

5. South Dakota is selling its water for $180/acre foot (14.6 cents per cubic meter) after several initial fees have been paid (fees which may total $34 million). What would be the annual income for Minnesota if it sold $1.8495 \times 10^8 m^3$ per year?

6. If Lake Superior is considered to be in a steady state, with input equaling output, and $1.8495 \times 10^8 m^3$ was suddenly withdrawn, what would be the resulting drop in water level?

7. If the environmentalists, politicans, and industry agreed to a sale of Lake Superior, and 0.27% of the annual discharge was considered an acceptable amount to withdraw, would you favor 0.27% of the average annual precipitation or 0.27% of the maximum or minimum recorded precipitation? Why? How do the three volumes compare?

*The definition and formulas used in this exercise have been derived from the Lake Superior drainage basin. The formulas and symbols are not necesarily transferable to any other system. A working assumption is that the lake is a steady state system.

Preparation

1. Individual copies of the student worksheet should be reproduced for distribution.

2. Students must be able to work with exponents in order to deal with the large numbers involved.

Procedure

1. Introduce the topic of diversion and sale of water resources by describing the South Dakota, ETSI project. Point out that Minnesota policies regarding such water sales are somewhat nebulous and could be altered by congressional action.

2. Introduce the worksheet as an activity which will give the students an opportunity to explore the significance of a water sale from Lake Superior if it were patterned after South Dakota's precedent.

3. After the students have completed the worksheet discuss their results. From a mathematical (volumetric consideration) perspective would such a proposed water sale appear to have a significant impact on Lake Superior? Does the income derived from such a sale appear to be acceptable? (A 1981 University of Minnesota study determined that irrigation water for corn on class one and two soils increased the production by a value of 13.4 cents per cubic meter. On the other hand Northern Great Plains irrigators pay for Bureau of Reclamation water, on the average, only 2/10 of a cent per cubic meter).

4. Point out that the formulas used in the activity use average figures and are specific to the Lake Superior basin. What refinements could be made to the formulas to create a model which would be appropriate for any of the Great Lakes?

5. Conclude by pointing out that this activity has only superficially explored the impact of water diversion on the Lake Superior water cycle. It has not explored the potential environmental impacts or addressed the value judgements involved in permitting such a sale.

Follow Through

1. Create an environmental impact statement (see the Lacustrine Lessons Nov. - Dec. 1981) statement relating to the sale of water from Lake Superior.

2. Conduct a debate on the pros and cons of such a sale of Lake Superior water.

3. Invite a hydraulic engineer to discuss the factors to consider when trying to model a large natural watershed system.

Lacustrine Lessons is published five times during the school year as an educational service of the Minnesota Sea Grant Extension Program, University of Minnesota, Duluth. Sea Grant is a state and federal program concerned with the understanding and wise use of our freshwater and saltwater seas.

"Lacustrine Lessons" is sent free of charge to anyone requesting this service. It is published with funds provided by the Office of Sea Grant, National Oceanic and Atmospheric Administration, U.S. Dept. of Commerce, and the University of Minnesota through Continuing Education and Extension and the Agricultural Extension Service.

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"lacustrine/lə-'kəs-trən/adj.(prob. from French or Italian 'lacustre,' from Latin 'lacus' lake): of, relating to, or growing in lakes." *Webster's New Collegiate Dictionary*

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Duluth, MN 55812

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