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ABSTRACT

Presented in this unit are three activities designed to illustrate the importance of the Great Lakes in transporting cargo. Students first determine the movement of various materials shipped from selected ports. They then compute from map measurements the distances and relative costs of transporting different cargoes via water, rail and truck. Finally, students compare the energy efficiency and environmental implications of these three modes of transport. Included are a list of objectives, an answer key, teaching recommendations, and evaluation items. A student workbook is also provided. (Author/WB)

Ohio Sea Grant

OEAGLS- Oceanic Education Activities for Great Lakes Schools

SHIPPING ON THE GREAT LAKES

by

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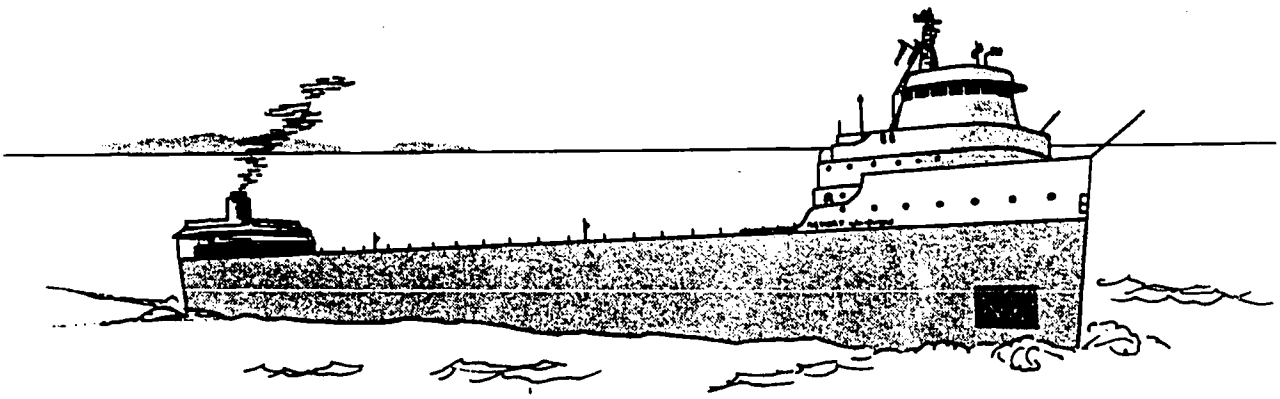
and

Victor J. Mayer, The Ohio State University



Ohio Sea Grant Program
Charles E. Herdendorf, Program Director
Victor J. Mayer, Principal Investigator

OEAGLS INVESTIGATION #21
Completed March, 1980

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Figures are adapted from figure C9-19 of Appendix C9 Commercial Navigation, Great Lakes Basin Framework Study, Great Lakes Basin Commission, 1975.

INVESTIGATION

SHIPPING ON THE GREAT LAKES

Have you ever seen a lake freighter on Lake Erie? Did you wonder where it was coming from? Where it was going? What it was carrying? The Great Lakes are very important routes for the transportation of freight. What advantages do they have over railroads and trucks? This investigation will help you to answer some of these questions.

OBJECTIVES

When you have completed this investigation you will be able to:

1. Name some of the major products transported on the Great Lakes.
2. Identify the cheapest form of transportation.
3. Determine which form of transportation is most energy efficient.
4. Use the scale of a map in determining distances between points.
5. Work more easily with metric units.

ACTIVITY A

WHAT PRODUCTS ARE CARRIED ON THE LAKES?

In this activity you will take a look at some of the major products which are transported across the Lakes. You will locate possible routes for transporting these products. The following is a list of products which are transported in or out of some Lake ports. An I means it is imported into the port and an E that it is exported from that port.

CHICAGO, IL:	grain-E iron ore-I coal-I limestone-I	GREEN BAY, WI:	coal-I fuel oil-I cement-E
DULUTH, MN:	iron ore-E grain-E coal-I	BUFFALO, NY:	grain-I limestone-E coal-E iron ore-I
TOLEDO, OH:	iron ore-I grain-E coal-E	DETROIT, MI:	iron ore-I coal-I limestone-I cement-I

CLEVELAND, OH:
iron ore-I
sand, gravel-E
limestone-I

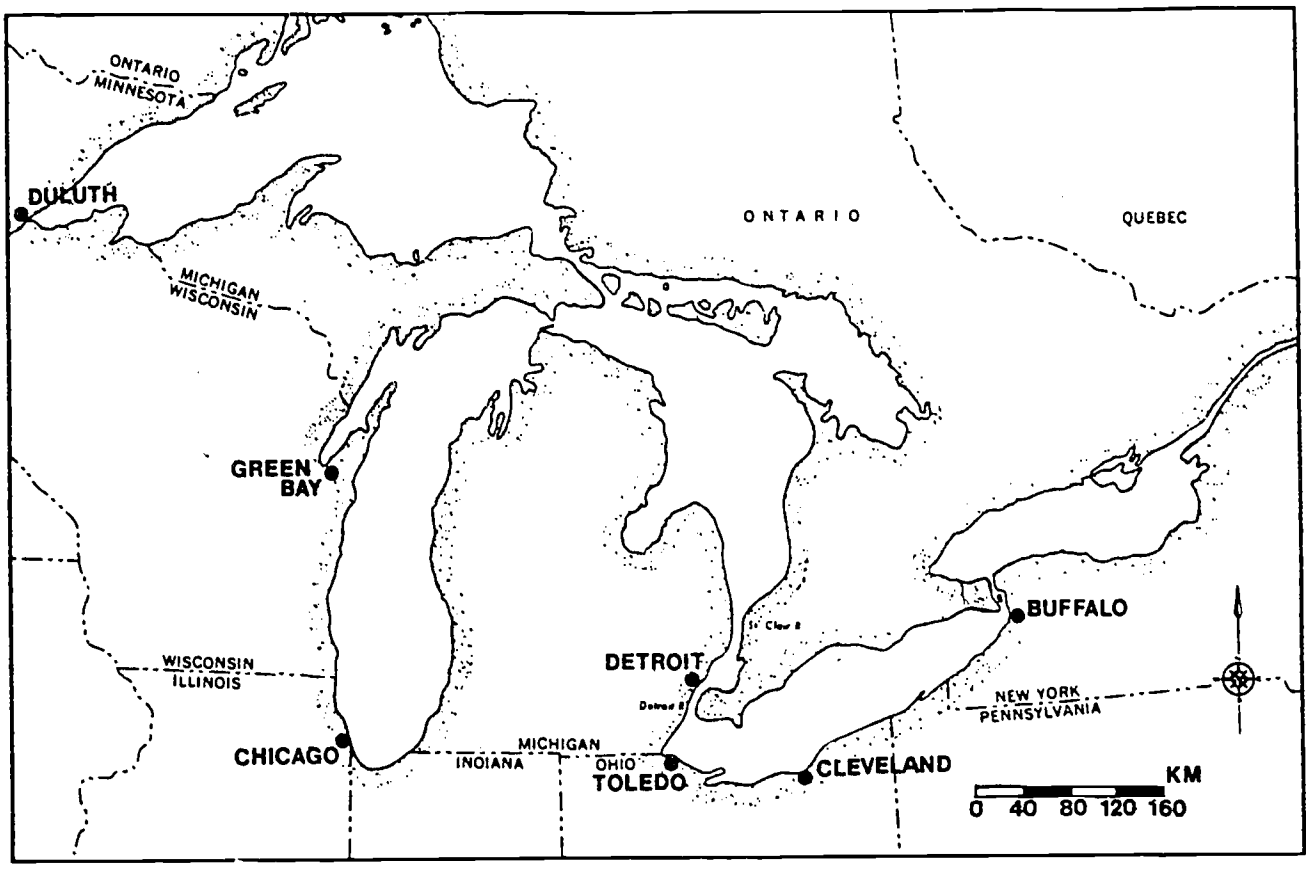
1. Which city exports iron ore?

_____

2. Which cities import iron ore?

_____

3. On Map 1 draw possible routes for the transportation of iron ore using arrows to show the direction in which the ships would move. The product will move from a city of export to a city of import.



Map 1. Transportation of Iron Ore.

4. What products could these ships carry on their return trips?

_____

5. Why do you think Green Bay imports coal and fuel oil?

_____

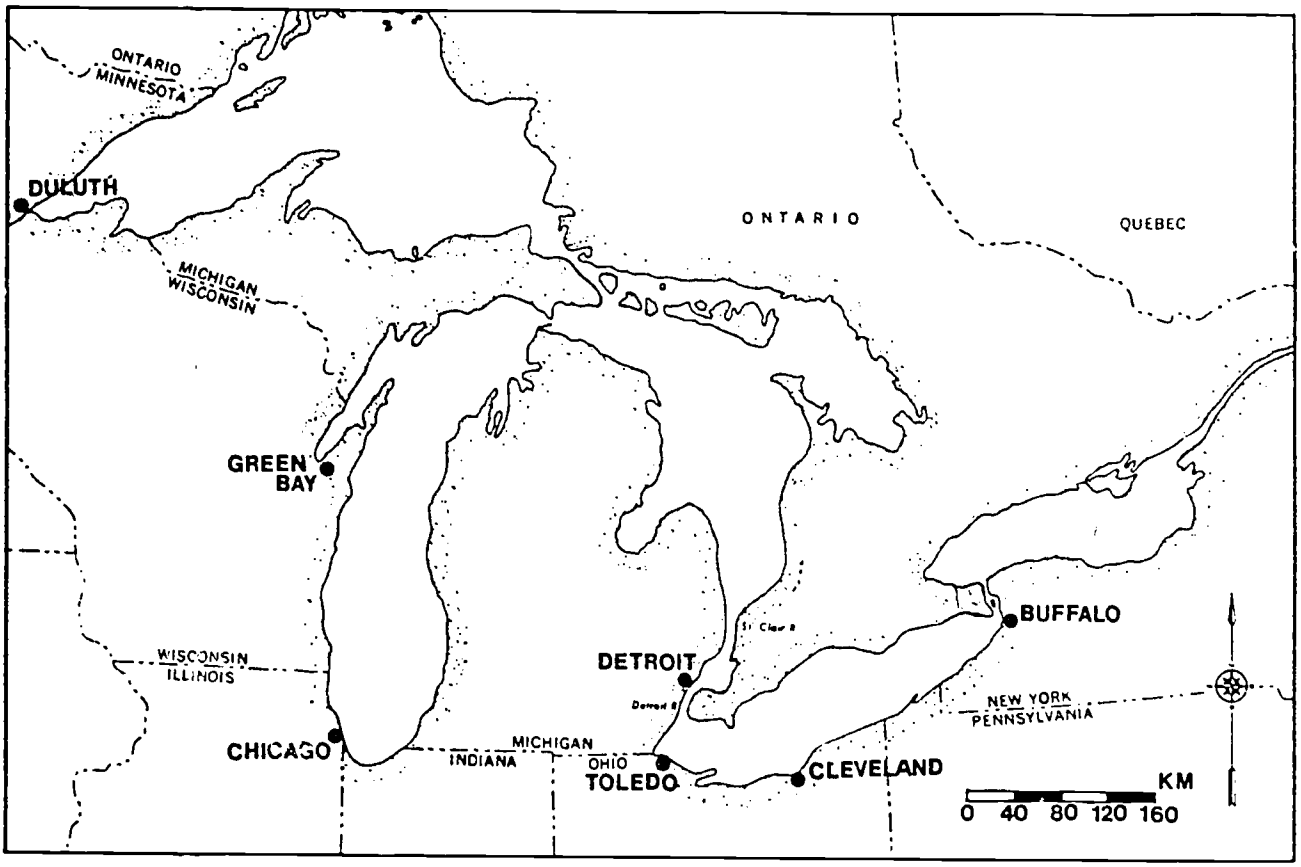
6. What cities export grain?

_____

7. What city imports grain?

_____

8. On Map 2, draw transport routes for grain using arrows to show the direction in which the ships would move.



Map 2. Transportation of Grain.

9. What products could these ships carry on their return trips?

_____

10. What product does Detroit produce that requires the import of iron ore, limestone and coal?

_____

11. What might be the use of cement, sand and gravel?

_____

12. Why would most of the grain be transported to Buffalo?

_____

ACTIVITY B

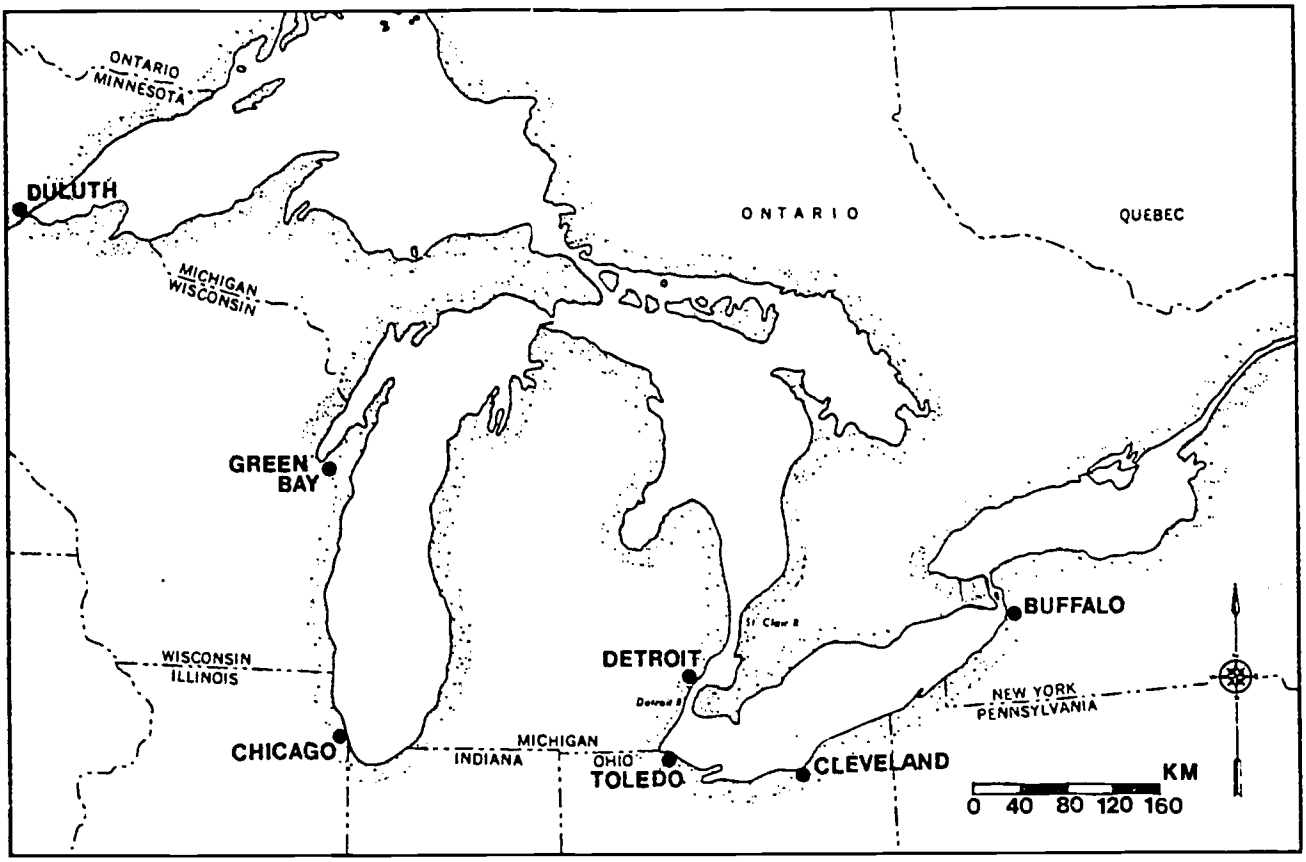
WHAT IS THE MOST ECONOMICAL FORM OF TRANSPORTATION?

Lake shipping is the major form of transportation used for shipping bulk products such as grain and iron ore. Farmers and mining companies charge a very low price for each pound or gram of their product. Therefore, the cost of transportation of bulk products must be very low. If not, the cost of transportation would be a major part of the cost of the final product, such as bread or metal. Manufacturers, on the other hand, must charge a high price per pound or gram for their products because of manufacturing costs. Therefore, the cost of transportation, as long as it is not very very expensive, will not add much to its final price. In this activity you will learn why lake shipping is the best way to transport bulk cargo.

1. On Map 3, draw straight lines from Duluth to Chicago, Chicago to Cleveland, Cleveland to Buffalo. Do not let any of your lines cross any part of a lake.

   These are the general routes followed by railroads and trucks.

2. On the same map, draw the shortest possible route for a ship going from Duluth to Buffalo.



Map 3. Length of Routes Between Major Lake Ports.

3. Determine the length of each route (the land route and the ship route) by laying a string along the route exactly covering the lines you've drawn. Then use the map scale (lower right corner) to convert the string length to kilometers--the distance between Duluth and Buffalo.

   Detach the worksheet from this student booklet. It is the last page. Enter your answers in the table on the worksheet.

4. Suppose your company wanted to transport 600 metric tons of grain from Duluth to Buffalo. Which method of transportation would you use? Why?

   _____

   _____

The following table gives the cost of moving one metric ton of grain 100 km for each transportation method.

METHOD	COST
RAILROAD	$1.00
HIGHWAY	$2.12
WATER	$0.09

5. Determine the total cost of transporting your grain by each method of transportation. Use the following formula:

$$\text{COST} \times \text{METRIC TONS} \times \frac{\text{DISTANCE (km)}}{100} = \text{TOTAL COST}$$

   Enter your answers on the worksheet.

6. Which is the cheapest method of transporting cargo from Duluth to Buffalo?

   _____

7. Did you pick the cheapest method in number 4 above?

   _____

8. Why would you want to use this method to transport bulk cargo such as grain and iron ore rather than manufactured goods such as cars?

   _____

   _____

   _____

9. Determine the distance from Chicago to Toledo for the three transportation methods.

   Enter your answers on the worksheet.

10. Determine the cost of transporting 600 metric tons of grain by each of the three transportation methods.

    Enter your answers on the worksheet.

11. What is the cheapest method of transporting cargo from Chicago to Toledo?

    _____

12. Is this the same as from Duluth to Buffalo?

    _____

13. How many times more costly is the next to cheapest method than the cheapest method of transportation between Duluth and Buffalo? To determine this, divide the total cost of the cheapest method into the total cost of the next cheapest method.

    _____

14. Now do the same for the Chicago to Toledo route.

    _____

15. Would companies be more likely to ship grain by rail between Duluth and Buffalo or between Chicago and Toledo? Why?

    _____

    _____

    _____

    _____

ACTIVITY C

WHICH TRANSPORTATION METHOD USES THE LEAST ENERGY?

Our country is now facing a real crisis in its energy supply. We must become much more efficient in our uses of energy if we are to keep our high standard of living. Much of our energy is consumed by transporting materials around our country. Are we using the most energy efficient methods?

The table below gives the number of metric tons of a material each method can transport a distance of one kilometer while using one liter of fuel.

TRANSPORTATION METHOD	FUEL EFFICIENCY
RAILROAD	52 MT/L/KM
HIGHWAY (TRUCK)	15 MT/L/KM
WATER (FREIGHTER)	129 MT/L/KM

In this activity you will calculate the total amount of fuel required to transport the 600 metric tons of grain from Duluth to Buffalo. To do this, you will divide the 600 MT by the amount of fuel required by the transportation method (fuel efficiency). You then multiply this by the total distance transported to find the total number of liters of fuel.

$$\frac{600\ \text{MT}}{\text{FUEL EFFICIENCY}} \times \text{DISTANCE} = \text{TOTAL AMOUNT OF FUEL}$$

1. Using the distances you calculated in Activity B (see Worksheet), determine the amount of fuel required to transport 600 metric tons of grain from Duluth to Buffalo for each transportation method.

   Enter your answers in the Fuel column of the worksheet.

2. Which is the most energy efficient?

   _____

3. Determine the amount of fuel required for each method in the trip from Chicago to Toledo. Enter your answers in the fuel column of the worksheet.

4. Which is the most energy efficient method for this trip?

   _____

5. Does this agree with the cheapest transportation method for this trip? See question 11, Activity B.

   _____

6. As energy becomes more scarce, which transportation methods will become more popular between Duluth and Buffalo? Why?

_____

_____

Between Chicago and Toledo? Why?

_____

_____

Each of the three methods of transportation affect the environment in different ways. Ships, for example, use the surface of the water whereas highways must be constructed to carry trucks.

7. Get together with one or two fellow students. Together identify as many ways as you can that each of the methods of transportation affect the environment. List them below:

RAILROAD:

TRUCKS:

LAKE FREIGHTER:

8. Which method do you think has the greatest effect on the environment? Why?

_____

_____

_____

_____

REVIEW QUESTIONS

1. What are some products which are transported across the Great Lakes?

2. What appears to be the cheapest method of transportation?

3. Which is the most energy-efficient method of transportation?

4. Which of the methods of transportation has the least impact on the environment?

5. What do you think will happen with the use of lake freighters in the future? Railroads? Trucks? Explain your reasons.

TRANSPORTATION METHOD	Duluth-Buffalo			Chicago-Toledo		
	Distance	Cost	Fuel (1)	Distance	Cost	Fuel (1)
Railroad						
Highway						
Water (Lake Freighter)						

WORKSHEET FOR ACTIVITY B AND C.

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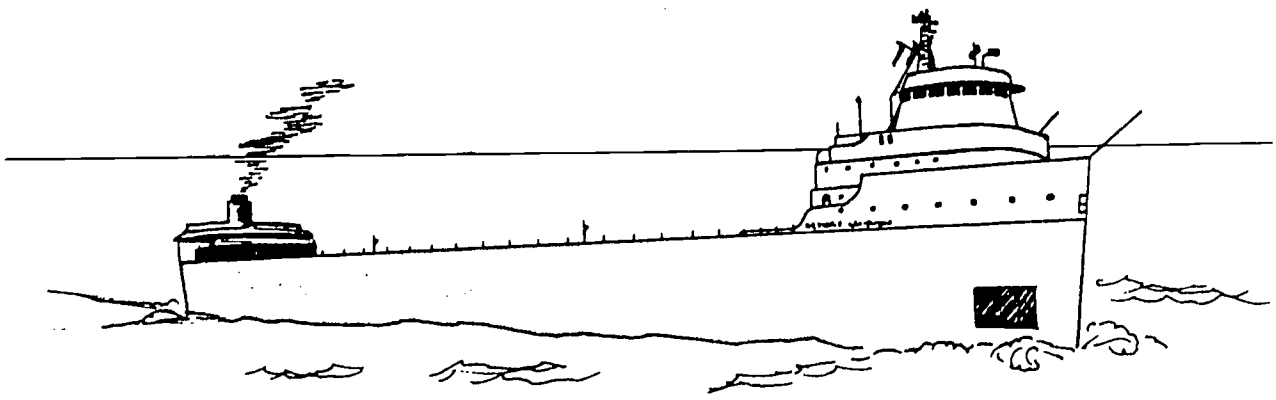

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TEACHER GUIDE

OEAGLS INVESTIGATION #21
Completed March, 1980

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Figures are adapted from figure C9-19 of Appendix C9 Commercial Navigation, Great Lakes Basin Framework Study, Great Lakes Basin Comission, 1975.

INVESTIGATION

SHIPPING ON THE GREAT LAKES

OVERVIEW

With the increasing cost of energy and with the diminishing supply of fossil fuels that we will soon experience, it is becoming more and more important that students understand how products are transported from place to place and what implications the methods of transport have for energy use and for the cost of the product to the consumer. Students see trucks on the highway every day, but few ever see lake freighters. It is important that they realize the importance of the lakes in transporting cargo. That is the major goal of this investigation.

In Activity A, students determine the direction of movement of various materials shipped from selected ports on the Great Lakes. In Activity B they determine the distances different materials must be transported via water, rail and truck, and the relative costs. Then, in Activity C they study the energy efficiency and environmental implications of the three different methods of transport. The investigation provides practice in conversion of map distances using scales and the computational skills of multiplication and division.

PREREQUISITE STUDENT BACKGROUND

Students should be able to multiply and divide and be able to use decimals. They should also be able to read maps, understand the use of scale, and be somewhat familiar with metric units.

OBJECTIVES

When students have completed this investigation they should be able to:

1. Name some of the major products transported on the Great Lakes.
2. Identify the cheapest form of transportation.
3. Determine which form of transportation is most energy efficient.
4. Use the scale of a map in determining distances between points.
5. Work more easily with metric units.

MATERIALS

The only materials necessary are a pencil, paper, and string to use in measuring distances between points. It is advisable to have calculators available for the computations.

SUGGESTED APPROACH

The investigation is designed to be used in an individualized mode. It could even be assigned as homework. There should be an opportunity, however, to conduct a class discussion when students have completed the investigation. The review questions at the end of the Student Guide can be used to start such a discussion. You might also want to have a discussion before assigning the investigation, focused on student knowledge of shipping on the Great Lakes. You might ask them what they know about the types of products that are shipped via the lakes--what products are brought to Ohio and are shipped from Ohio. You might also ask them which of the three modes of transportation, water, rail and road are most efficient. Such a discussion will serve to orient them toward the investigation and create interest in working on the investigation.

ACTIVITY A

WHAT PRODUCTS ARE CARRIED ON THE LAKES?

Keywords: import, export, freight, transportation

PROCEDURE

1. Duluth is the one city that exports iron ore. It is located near the Mesabi Iron Range, the major iron ore producing region in the country.

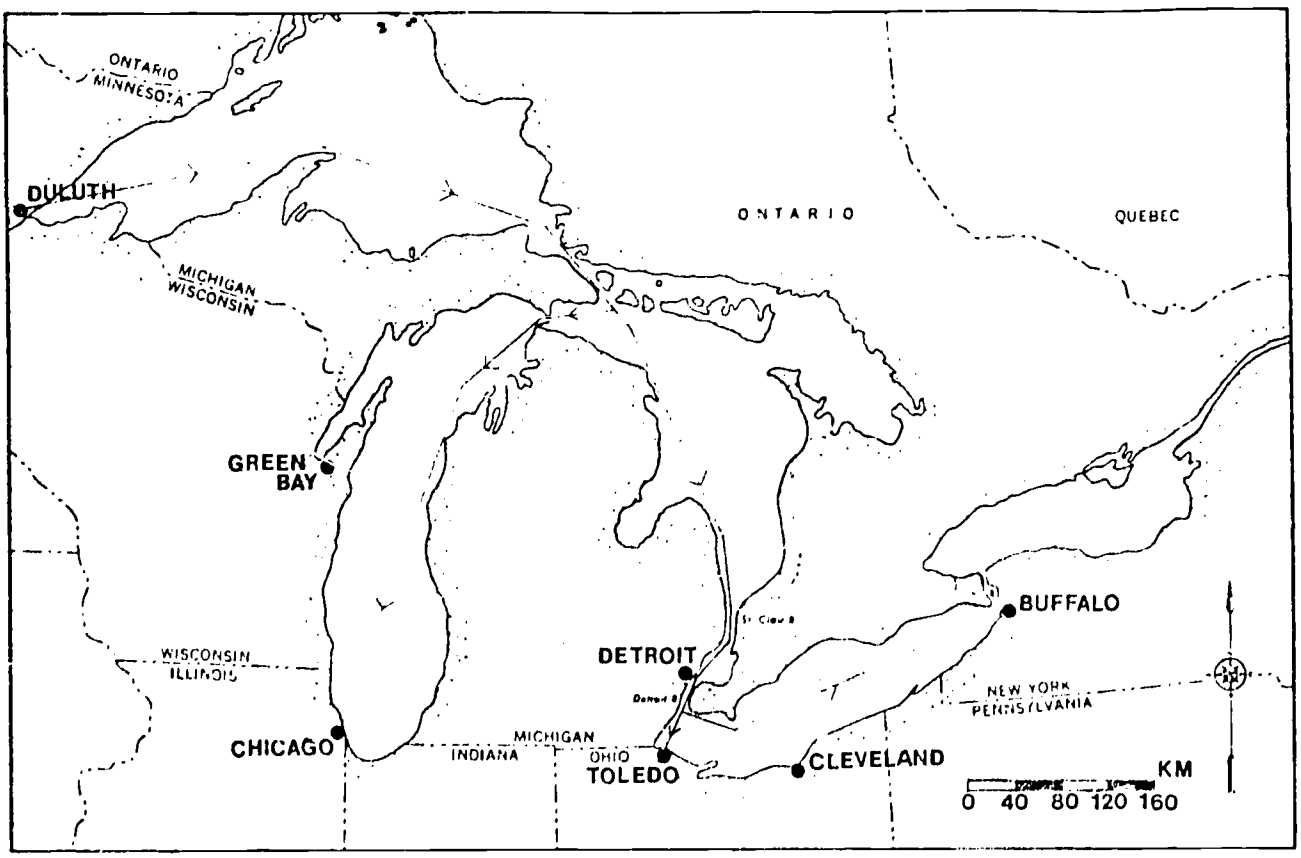

Figure TG-1. Shipping Routes for Coal on the Great Lakes.

2. Five cities import iron ore; Chicago, Toledo, Buffalo, Detroit and Cleveland.

3. See Figure TG-1.

4. According to the information students are given, the only thing that Duluth imports is coal; therefore, only Toledo and Buffalo would have anything to send back on the ships to Duluth. This, however, is probably not completely true. There may be other types of bulk cargo that Duluth is in need of, that other ports can ship, but regardless, many of the ore carriers return empty to Duluth.

5. Green Bay probably imports coal and fuel oil because it does not have a local source of those energy supplies. Both are used for generation of electricity and for industrial power sources.

6. Grain is exported by Chicago, Duluth and Toledo.

7. Buffalo imports grain.

8. See Figure TG-2.

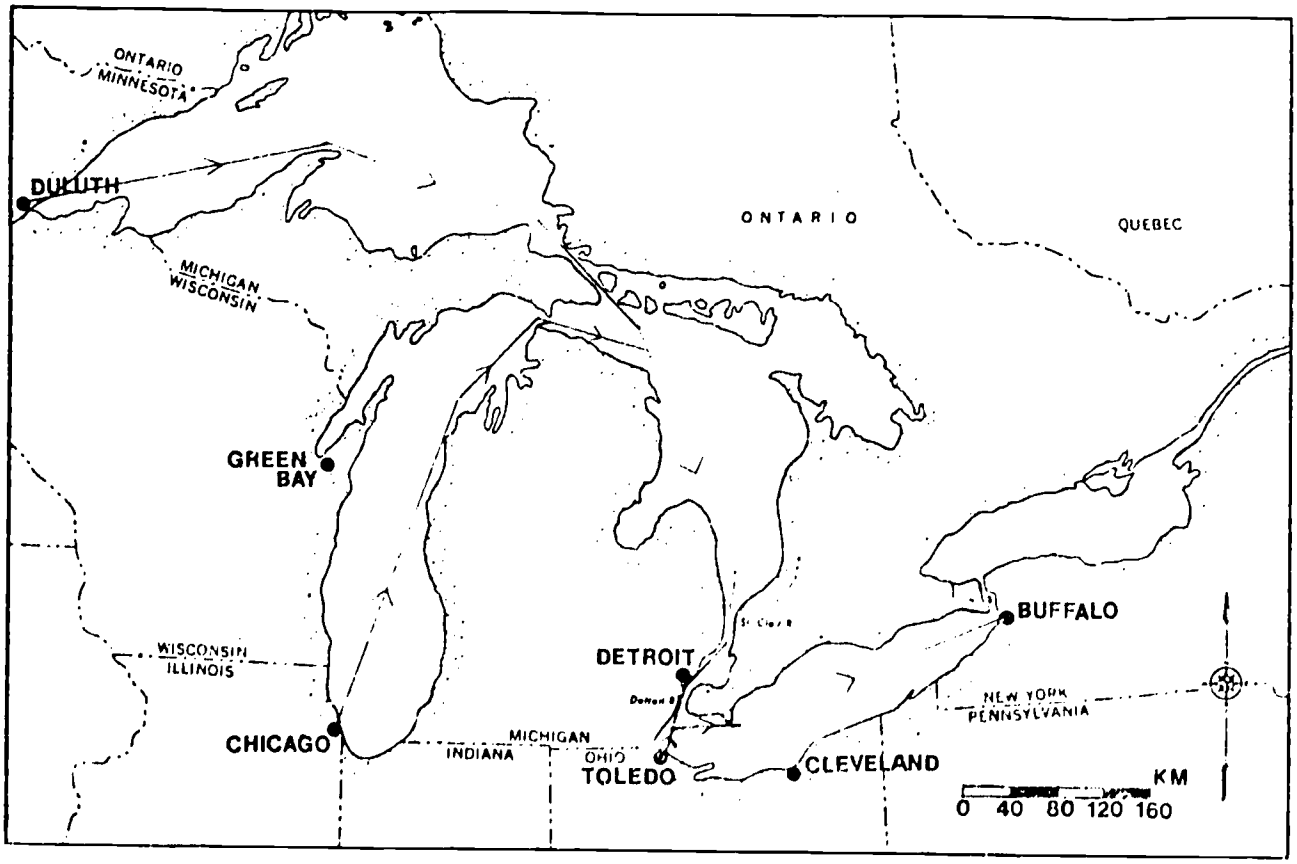

Figure TG-2. Shipping Routes for Grain on the Great Lakes.

9. Ships returning to Duluth could take coal from Buffalo; those returning to Chicago could carry limestone. According to the information provided, Toledo doesn't import any of the things that Buffalo exports. Again there may be other bulk cargos that the ships could carry, however, many of them probably return to their ports empty.

10. Detroit produces steel required in automobiles. All three products are necessary in the production of steel.

11. Cement, sand and gravel are used in construction of buildings and highways, both for concrete and in what is called road metal, loose material used under the highway to promote drainage.

12. Buffalo is one of the largest railroad centers in the United States. Grain is unloaded here for rail transport to be distributed throughout the East.

ACTIVITY B — WHAT IS THE MOST ECONOMICAL FORM OF TRANSPORTATION?

PROCEDURE

Keywords: bulk products, manufactured goods, metric ton

1. See Figure TG-3.

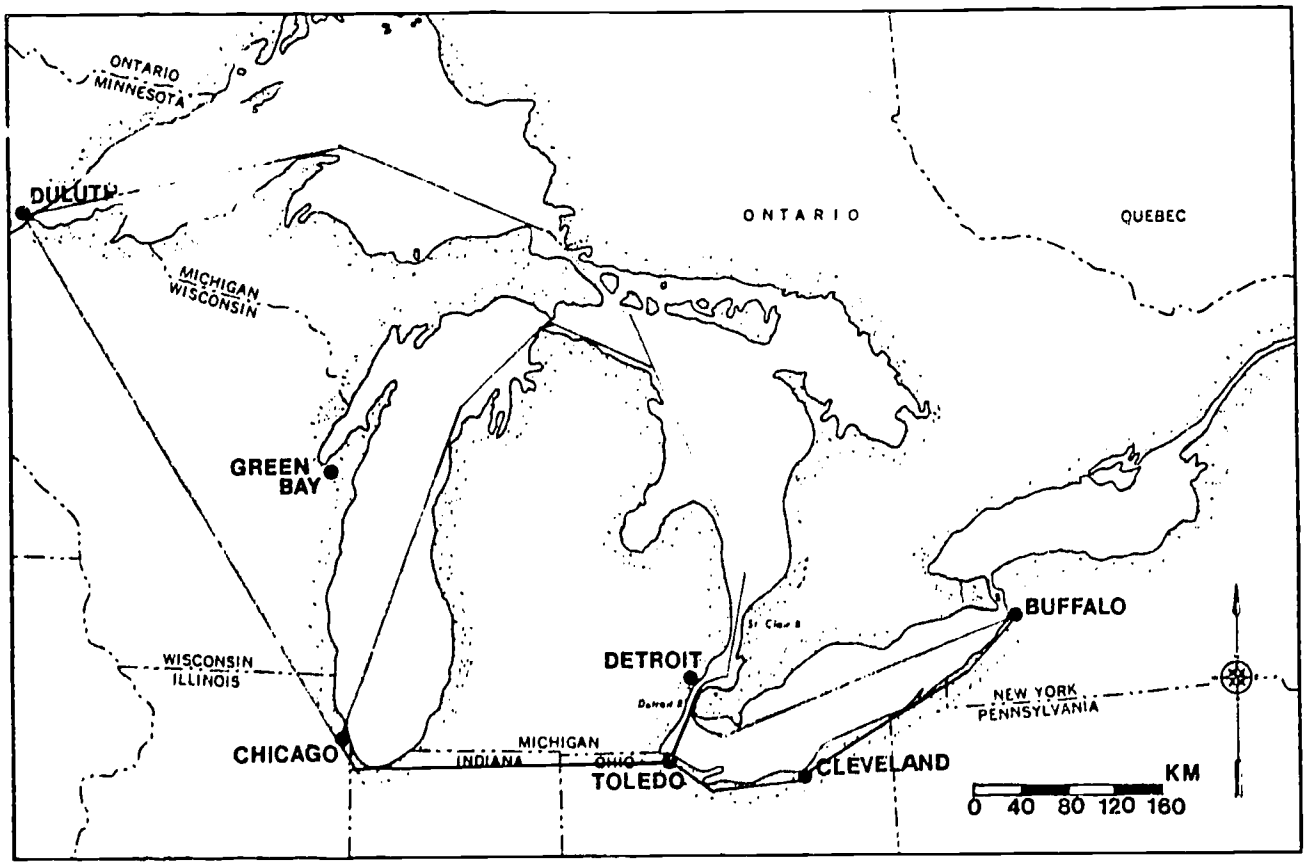

Figure TG-3. Land and Water Routes in the Great Lakes Region.

2. See Figure TG3.

3. See worksheet.

4. At this point students have no basis for selecting one or the other of the methods of transport. Ask them to justify any choice that they do make, but don't imply that there is a right or wrong answer to this question at this point.

5. See worksheet.

6. The cheapest method of transporting cargo from Duluth to Buffalo is by water.

7. The response here will depend upon their response to question 4.

8. Grain and iron ore have a very low cost per pound or gram, therefore, the method of transport has to be very inexpensive. If not, then the cost of transport will approach the price paid for the cargo, making the end product, bread or steel, quite expensive. Cars, on the other hand, are very expensive in comparison to bulk cargo. Therefore, even using expensive means of transportation, the cost of transportation per pound or gram will be relatively low. Speed of transport, then, becomes more important, so that the cars can be sold quickly, allowing the producing company to get its investment back more rapidly.

9-10. See worksheet.

11. Even though the distance of the water route is almost three times that of the land route, water is still the cheapest method of transport.

12. Yes.

13. Transporting materials by water between Duluth and Buffalo costs about a tenth that of transporting them by railroad. You might point out to students that truck transportation is 23 times as expensive as water transportation over that distance.

14. Railroad transportation costs about four times that of water transportation between Chicago and Toledo. It costs about ten times as much to transport materials by truck. Because of the disparity in the length of the transportation routes, a great deal of the cost advantage of water transportation has been lost.

15. Because of the great cost advantage, companies would be much more likely to ship grain by water between Duluth and Buffalo. Between Chicago and Toledo the cost advantage, although still sizeable, is not quite as great. There might be instances then, of grain shippers using the railroad, especially if time was a factor.

ACTIVITY C

WHICH TRANSPORTATION METHOD USES THE LEAST ENERGY?

Keywords: liter, metric ton, kilometer, energy efficiency

PROCEDURE

1. See worksheet.

2. On the Duluth-Buffalo route, water is the most fuel efficient method of transport.

3. See worksheet.

4. Because of the shorter distance, railroads are the most energy efficient in carrying freight from Chicago to Toledo. You might point out to your students that trucks require 4 times the amount of energy of either railroads or water.

5. Even though railroads are the most energy efficient, over this route they are not the cheapest. This is because of the greater labor required on railroads, both for running the trains and for maintaining track.

6. As energy becomes scarce, and expensive, we would expect that water transportation will become more and more important between Duluth and Buffalo. Even manufactured goods will be transported in this manner. Between Chicago and Toledo we might expect truck transportation to become less and less important because of its low energy efficiency. Railroads will take on an increasing share of the transportation of materials from trucks and perhaps even from water transport.

7. Accept any reasonable ideas the students suggest. It would be good to have a class discussion on this topic. Ideas you might expect include:

Tracks must be constructed by the railroad. This can result in the disruption of scenery, and the exposing of rock and soil to erosion. The companies must purchase, maintain and pay tax on the land for the right of way for their tracks. This can be an economic benefit to those areas traversed by the railroad. Railroad engines cause some noise and pollution, however, it is limited to the area of the railroad tracks and terminals. Accidents can release hazardous materials.

Trucks use the same highways as passenger cars and buses. Because of their size, this causes a hazard for other users of the highway. Highways are not maintained by the trucking industry, but by the public. Although trucks pay taxes through registration and fuel use, the taxes are much less than the industries' share of the cost of construction and maintenance. Being the least energy efficient, trucks produce the most air pollution of the three types and a great deal of noise. Because of the greater prevalence of trucks and the extensive network of roads, this noise is quite widespread. Accidents can release hazardous materials in populated areas.

Lake freighters use the water and, therefore, save costs of construction and maintenance. What air pollution is produced is widely disseminated. They tend to be the least disruptive of the environment. There can be spills of diesel oil used as fuel and this can harm the aquatic environment. Also a ship may sink, causing the spreading of a certain amount of debris. If the ship is carrying a hazardous cargo, such as chemicals, such an accident could have a very serious effect on the part of the lake where the accident occurred. Such accidents, however, seldom occur, and when they do, they do not affect heavily populated areas.

8. This may be a difficult question for the students to answer. If we are considering the negative impact upon the environment per pound or gram of material carried, then trucking would have the greatest negative impact because of its extremely low fuel efficiency. This means that much more fuel must be burned, producing a much greater quantity of pollutants than either of the other forms of transportation. In addition, since trucks travel the same roads as you and I do, hazards they cause, such as possible accidents, are much more likely to impact us.

REVIEW QUESTIONS

1. The major products carried by lake freighters are bulk products such as iron ore, grain, cement, sand, gravel, limestone and fuel oil.

2. Shipping by water (freighter) is the cheapest method of transporting bulk cargo on the Great Lakes.

3. Shipping by water (freighter) is the most energy efficient means of transporting cargo, unless the route traveled is much longer than the route traveled by railroad. In that case, the railroad may be more energy efficient.

4. Water transportation has the least impact on the environment since it uses already existing routes, i.e., the water, and can carry much larger cargoes in a single shipment, using much less fuel per metric ton/km.

5. The use of lake freighters should increase in the future as energy becomes scarce and expensive. The use of railroads will also increase whereas the use of trucks should decrease. The major reason is the relative energy efficiencies of the three methods of transportation. Students may come up with other reasons as well.

REFERENCES

Great Lakes Basin Commission, Great Lakes Basin Framework Study, Appendix C9, Commercial Navigation, published by the Commission, 1975.

EVALUATION ITEMS

1. Which of the following is not a product that is usually shipped on the Great Lakes?

   1. Grain
   2. Iron Ore
   *3. Vegetables
   4. Limestone

2. The major type of product carried by Great Lakes freighters is

   1. manufactured goods.
   2. fresh food products.
   *3. bulk products.
   4. chemical products.

3. The equation: cost x metric tons x km equals _____

   1. amount of money saved.
   2. amount of energy conserved.
   3. total number of liters of fuel used.
   *4. total cost of shipping.

4. The cheapest method of shipping iron ore from Duluth, MN, to Buffalo, NY, is by way of

   1. truck.
   2. train.
   3. airplane.
   *4. lake freighter.

5. When finding out which type of shipping will cost the least amount of money, you consider several things. Which of the following is most important?

   1. Time of year
   *2. Distance
   3. Weather conditions
   4. The direction in which you are shipping your product

6. Grain is usually shipped from most other ports on the Great Lakes to which other port?

   1. Toledo, OH
   2. Duluth, MN
   *3. Buffalo, NY
   4. Chicago, IL

7. When shipping bulk cargo, such as iron ore, the cost of transportation is a major consideration because of the

   1. difficulty of handling bulk cargo.
   *2. low unit price of bulk cargo.
   3. price of diesel fuel.
   4. amount that has to be moved.

8. Which of the following transportation methods has the greatest effect on the environment?

   1. Lake freighters
   2. Trains
   *3. Trucks

9. Which method of transportation is the most energy efficient for transporting cargo between Duluth and Buffalo, NY?

   1. truck
   2. train
   3. plane
   *4. lake freighter

ON METHOD	Duluth-Buffalo			Chicago-Toledo		
	Distance	Cost	Fuel (1)	Distance	Cost	Fuel (1)
	1180 km	$ 7,080.00	13,615	330 km	$1,980.00	3,808
	1180 km	$15,009.60	47,200	330 km	$4,197.60	13,200
Freighter)	1280 km	$ 691.00	5,953	880 km	$ 475.20	4,093

WORKSHEET FOR ACTIVITY B AND C.