NUMB3RS Activity: Barging In
Episode: "Finders Keepers"

Topic: Rates, Direct and Inverse Variation, Algebra   **Grade level:** 9 - 10
Objective: To use conversions and variation to solve a real world problem
Time: about 30 minutes
Materials: TI-83 Plus/TI-84 Plus graphing calculator

Introduction
In "Finders Keepers," the body of a diver is found in the ocean. The body is traced to a salvage barge that has a bloody handprint on it. After further investigation, it is discovered that the blood is not from the dead diver, but someone else who was murdered on the barge. The ocean is a big place and Don knows he needs Charlie's help to identify a search area to look for the other victim.

Charlie uses some specific information about the barge's last voyage to determine a maximum search radius. In particular, Charlie learns that the barge consumed 68 gallons of fuel on its last voyage, and the engine log shows that the barge was out for 16 hours. From this, Charlie calculates that the barge could not have traveled more than 20 miles. Because the barge started and ended its trip at the same location, he concludes that the missing bodies must be within a 10-mile radius of the dock.

Discuss with Students
Before starting the activity, you may want to review the concept of a rate by asking students questions such as:

- What does it mean when we say that a car is traveling at 65 miles per hour?
- If a car uses an average of 2 gallons per hour, how many gallons will be used for a trip that takes 6 hours?

Students will be asked to supply a formula for a quantity *d* that varies directly with a second quantity *f* and inversely with the third quantity *w*. To prepare them for this work, consider asking students the following question:

- If $d = \dfrac{kf}{w}$, where k is a constant, what happens to the value of *d* when:

    (i)   the value of *f* increases?
    (ii)   the value of *f* decreases?
    (iii)   the value of *w* increases?
    (iv)   the value of *w* decreases?
    (v)   the values of *f* and *w* increase?
    (vi)   the values of *f* and *w* decrease?

In this episode, the word knot is mentioned as a unit of measure. Students not familiar with this can learn more by visiting **http://www.onlineconversion.com/faq_07.htm** (What is a knot? What is a nautical mile?).

Student Page Answers:

1. *Assuming a maximum speed of 15 knots (about 17 miles per hour), the barge could travel about 270 miles in 16 hours.* **2.** $\dfrac{20 \text{ miles}}{16 \text{ hours}} = 1.25 \text{ miles per hour}$ **3.** *Charlie's estimate results in a much slower speed. The barge probably did not travel at maximum speed the entire time.*

4.

Barge Weight (tons) w	Amount of Fuel (gallons) f	Distance (miles) d
1	1	500
1	2	1000
2	1	250
10	1	50
50	1	10
100	15	75
500	2	2
1000	100	50

5. $d = \dfrac{500f}{w}$ **6.** $d = \dfrac{(500 \text{ ton-miles per gallon})(68 \text{ gallons})}{(1500 \text{ tons})} = 22.67 \text{ miles}$ **7.** *Fairly close, but any differences are due to the estimates for fuel efficiency and weight of the barge.* **8.** *Fuel consumption gives a better estimate, because distance is directly related to fuel consumption. Distance is not directly related to time because the average speed of the barge is not known.*

Name: _____ Date: _____

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1. Estimate (or research) the maximum speed of a salvage barge. About how far could the barge have traveled in 16 hours?

2. If the barge traveled only 20 miles as Charlie suggested, what was its average speed?

3. How does your estimate from Question 1 compare with Charlie's estimate? What might explain any difference?

4. The fuel efficiency of a salvage barge is about 500 ton-miles per gallon. That is, one gallon of fuel can move a one-ton barge about 500 miles. Complete the table below.

Barge Weight (tons) w	Amount of Fuel (gallons) f	Distance (miles) d
1	1	500
1	2	
2	1	
10	1	
50	1	
	15	75
500		2
	100	50

5. Write a rule that describes the relationship between the barge weight *w*, the amount of fuel *f*, and the distance that the barge can travel *d*.

6. Assume that the salvage barge weighs 1,500 tons. How far can it travel on 68 gallons of fuel?

7. How does your estimate from Question 6 compare with Charlie's estimate of 20 miles? What might explain any difference?

8. Which constraint gives a better estimate for the distance traveled by the barge: the number of hours in the engine log, or the amount of fuel that was consumed? Justify your answer.

The goal of this activity is to give your students a short and simple snapshot into a very extensive math topic. TI and NCTM encourage you and your students to learn more about this topic using the extensions provided below and through your own independent research.

Extensions

The resulting equation from Question 5 is $d = \dfrac{500f}{w}$. This equation is an example of

variation; that is, the value of *d* changes as a result of changes in *f* and *w*. Research the following terms related to variation:

- Direct variation
- Indirect variation
- Joint variation
- Constant of variation

1. Is the equation $d = \dfrac{500f}{w}$ an example of direct, indirect, or joint variation? Is it an example of more than one type of variation? How do you know?

2. In the equation $d = \dfrac{500f}{w}$, what is the constant of variation?

3. Find an example of each type of variation in the real world. (Note that some situations can describe more than one type of variation, depending on which variables are dependent and independent.)

Additional Resources

Another factor that can affect the speed of objects in the water is water currents. Information about how currents change in the oceans can be found at:
http://drifters.doe.gov/track-a-yoto/track-a-drifter.html

The Department of Transportation of Minnesota has an activity comparing the efficiency of using barges versus semi-trailers to transport goods. The activity can be found at:
http://www.dot.state.mn.us/aero/aved/pdf/TEA%20lessons/ barge%20efficiency2003.pdf