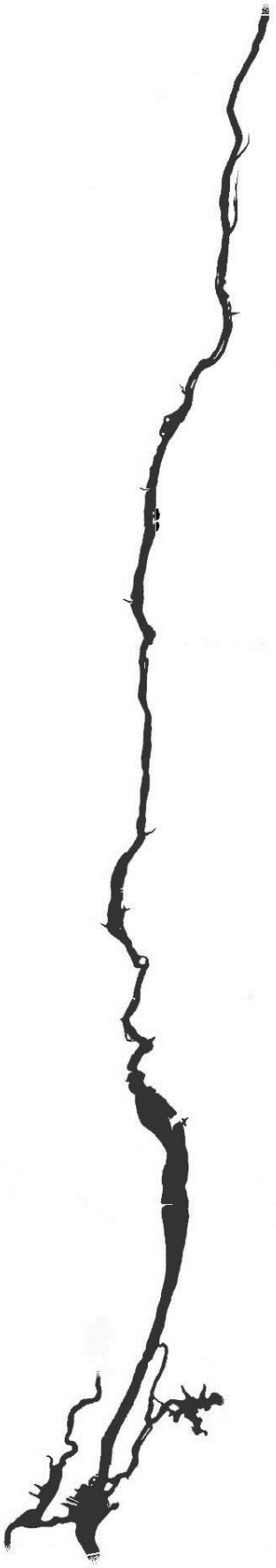

Tracking the Salt Front

Students will use Hudson River salinity data to practice math skills as they track movements of the salt front in response to storms and other weather events.

Objectives: Students will solve word problems that require them to:

- understand interactions between salt water entering the river from the sea and fresh water entering the river from its watershed;
- interpret data displayed in graphs and on maps;
- add and subtract river mile data to track salt front movements.

Grade level: Elementary (Grades 3-5)

Subject Area: Math, Social Studies (Geography), Science

New York State Learning Standards:
Mathematics, Science, & Technology Standards 3, 4
Social Studies Standard 3

Skills:

- Use graphs and maps to see patterns and relationships observed in the physical environment.
- Use whole numbers to identify locations and measure distances.
- Add and subtract whole numbers.
- Apply mathematics in real world settings.
- Reason mathematically.

Duration:
Preparation time: 5 minutes
Activity time: 1 hour (about 30 minutes for each worksheet)

Materials: Each student should have:

- ☐ Worksheet: Tracking the Salt Front
- ☐ Worksheet: Salt Front Math
- ☐ Hudson River Miles map
- ☐ Pencil

Background:
The lower Hudson is an estuary, where fresh water from the river's watershed and salt water from the Atlantic Ocean meet and mix. Seawater entering the Hudson is diluted by fresh water; its leading edge—the salt front—is where the concentration of chlorides (mostly sodium chloride, like table salt) reaches 100 milligrams per liter (mg/L).

Many people assume that tidal currents bring salt water into the river. However, they have only minor impacts, moving the salt front a few miles back and forth with each tide cycle. So how does seawater travel 50 miles or more up the Hudson?

Imagine an aquarium divided vertically by a panel separating salt water (colored green with food coloring) on one side from clear fresh water on the other. If the panel is removed slowly, the green salt water, being denser, will flow under the fresh water, which will in turn flow over the salt water remaining on the opposite side. Some mixing will occur, but two layers should be visible.

This phenomenon occurs in the Hudson, where it is called estuarine circulation. Tidal currents and wind tend to mix things up, blurring the layering, but denser seawater does push upriver under fresher water headed downriver at the surface.

How far upriver will the salt water go? That depends on the volume of freshwater runoff from the watershed. After heavy rains, runoff pushes the salt front seaward. During dry spells, seawater pushes further upriver. The salt front usually ranges between Newburgh and the Tappan Zee Bridge. Droughts may allow it to reach Poughkeepsie; major rainstorms may force the front downriver to Manhattan.

The front's location is given in Hudson River Miles (HRM), starting at the southern tip of Manhattan. This spot, called The Battery, is HRM 0. Ocean tides influence the Hudson north to the Federal Dam at Troy (HRM 153).

Activity:
1. In preparation for this lesson, have students do the ELA lesson titled "From the Mountains to the Sea."
2. Discuss the concepts of estuary and salt front.
3. Introduce the Hudson River Miles system; show students the Hudson River Miles map.
4. Do "Tracking the Salt Front" worksheet in class; assign "Salt Front Math" as homework.

Assessment:
- Have students share answers to questions from worksheets, or collect and grade sheets.
- Make up similar problems for quiz.

Vocabulary:

current: water moving continuously in a certain direction
dilute: to lessen the amount of a substance dissolved in a liquid by adding more liquid
downriver: towards a stream's mouth
estuary: a body of water in which fresh and salt water meet
flood: a large flow of water that rises above and spreads out past a stream's banks
fresh water: water that is not salty (rainwater is freshwater)
Hudson River miles: distance measured north from the Battery at Manhattan's southern tip
salt front: the leading edge of seawater entering an estuary
salt water: seawater or other water that contains salt
scientist: a person skilled in science
seawater: salty ocean water
upriver: towards a stream's source
watershed: the area of land from which water drains into a body of water
tides: the alternate rising and falling of the surface of the ocean

Resources:

http://ny.water.usgs.gov/projects/dialer_plots/saltfront.html The U.S. Geological Survey Hudson River Salt Front website has historical data on the salt front's location plus real-time data on water temperature, tide stage, and other parameters from Poughkeepsie and Albany.

http://www.hrecos.org/joomla/ The Hudson River Environmental Conditions Observing System [HRECOS] measures salinity and other water quality and weather parameters at sites from New York City to Albany and uploads this data to the web. On the HRECOS website, click on the Current Conditions page to access this information. Dropdown menus allow users to select a station and parameter, choose units of measurement, plot continous readings (usually generated every 15 minutes) or daily averages, and specify start and end dates. One can also compare parameters by plotting two on one graph.

Tracking the Salt Front

The lower portion of the Hudson River is an **estuary**. Here **fresh water** flowing down the river meets **salt water** pushing in from the Atlantic Ocean. The leading edge of ocean water entering the estuary is called the **salt front**.

After heavy rains, lots of fresh water runs into the Hudson. It presses against the salty **seawater**, moving the salt front south down the river and closer to the ocean. In periods of dry weather, less fresh water enters the estuary. Ocean water pushes further north up the Hudson, moving the salt front inland.

Scientists track the salt front using **Hudson River Miles**, abbreviated HRM. Hudson River Miles start at the southern tip of Manhattan in New York City. This spot, called The Battery, is HRM 0. The George Washington Bridge is at HRM 12, the city of Kingston at HRM 91. Ocean tides reach the Federal Dam in Troy at HRM 153.

Using the graph "Hudson River Salt Front: Average Location by Month" and the map of Hudson River Miles, answer the questions below.

1. (a) In what month is the salt front closest to New York City? ***_April_***

   (b) In that month, where is the salt front located in Hudson River Miles?
   Hudson River Mile ***_37_***

   (c) On your Hudson River Miles map, mark this location with the numeral 1.

   What is the nearest town? ***_Haverstraw_***

2. (a) In what month is the salt front furthest north up the Hudson? ***_Sept_***

   (b) In that month, where is it located in Hudson River Miles?
   Hudson River Mile ***_66_***

   On your Hudson River Miles map, mark this location with the numeral 2.

   (c) What two towns are closest to it? ***_Newburgh_ _Beacon_***

3. On your Hudson River Miles map, what is the distance between the salt front's location at numeral 1 and its location at numeral 2? ***_29 miles_***

66
- 37
29 miles

The graph you just studied gives the <u>average</u> location of the salt front in each month. However, the salt front can move many miles over several weeks—even in a single day—depending on weather. Use the graph **Hudson River Salt Front Location: June 20 to July 10, 2006** to answer the questions below.

4. (a) Where was the salt front located (in Hudson River Miles) on June 26?
Hudson River Mile ***_48_***

Mark this spot on your Hudson River Miles map and label it June 26.

(b) Where was it on July 2? Hudson River Mile ***_9_***

Mark this spot on your Hudson River Miles map and label it July 2.

(c) How many miles apart are these two locations? ***_39 miles_***

48
- 9
39 miles

5. What do you think caused the salt front to move down the river between June 26 and July 2? Support your answer with evidence from the text above.
Heavy rains caused lots of fresh water to run into the Hudson where it pushed the salty seawater south, closer to the ocean.

6. (a) During the period shown by this graph, when did the salt front make its biggest move from one day to the next? ***_July 2 to July 3_***

(b) How far did it move? ***__18__*** miles

27
- 9
18 miles

(c) Did it move **upriver** (north) or **downriver** (south)? ***_upriver (north)_***

Salt Front Math: ANSWER KEY

Salt Front Math

*Heavy rains in the Hudson's **watershed** may cause **floods** along streams that flow into the estuary. How might these rains affect the salt front?*

In the Hudson River estuary, fresh water flowing from the Hudson's watershed meets seawater pushing in from the Atlantic Ocean. The fresh water **dilutes** the incoming salt water, but scientists can detect the leading edge of this ocean water—the salt front.

The salt front moves up and down the Hudson depending on how much fresh water is flowing off the watershed. This usually means that the salt front is closest to the ocean in spring, when there's lots of rain and snow is melting. The front moves upriver in the drier weather of summer and early fall. However, extreme weather events—major storms, for example—can upset this pattern.

This worksheet explores how weather and other factors control the salt front's location. Use the Hudson River Miles map to help answer the questions.

Example: On March 28, 2005, the salt front was at Hudson River Mile (HRM) 62. On your Hudson River Miles map, this is near Newburgh. A heavy rain began that day and lasted overnight. Three days later the salt front was at HRM 31. How many miles did the front move? Did it move downriver towards the ocean or upriver towards the dam at Troy?

HRM 62
- HRM 31

31 miles downriver towards the ocean

NEW YORK STATE OF OPPORTUNITY | Hudson River Estuary Program
A Program of the New York State Department of Environmental Conservation

1. Spring 2002 was rainy. In early June, the salt front was at HRM 32. Then the rain stopped, and the weather stayed dry into fall. By September 10, 2002, the salt front had pushed north 49 miles.

(a) What was the Hudson River Mile location of the front on September 10?

32
+ 49
81 miles

81 miles

(b) On September 10, the salt front was closest to which town on your Hudson River Miles map?

Poughkeepsie

2. On December 5, 2003, a foot of snow fell on the Hudson Valley. Five days later, a big rain storm hit the valley. As the rain began, the salt front was at HRM 62. The rain melted the snow, sending lots of fresh water into the Hudson. By December 13, the salt front was at HRM 40.

(a) How many miles did the salt front move because of the rain? ***_22 miles_***

62 – 40 = 22

(b) Did the salt front move downriver (south) towards the ocean or upriver (north) towards the dam at Troy? ***_downriver (south)_***

3. Native Americans called the Hudson "The River That Flows Both Ways." About every six hours, **tides** make the river **current** reverse direction. This affects the salt front. On January 8, 2005, at 12:00 noon the salt front was near West Point at HRM 52. At 6:00 PM, the front was near the Bear Mountain Bridge at HRM 47. How many miles and in what direction did the salt front move between 12:00 noon and 6:00 pm? ***_5 miles downriver (south)_***

52
- 47
5 miles

Challenge questions:

At which time – 12:00 noon or 6:00 PM – was the tide high? At which time was it low? ***tide high at 12 noon, low at 6 PM***

Later on, at midnight, would the salt front be closer to West Point or the Bear Mountain Bridge? Why? ***at midnight, salt front near West Point because current reverses direction and flows upriver between 6 P.M. and midnight***