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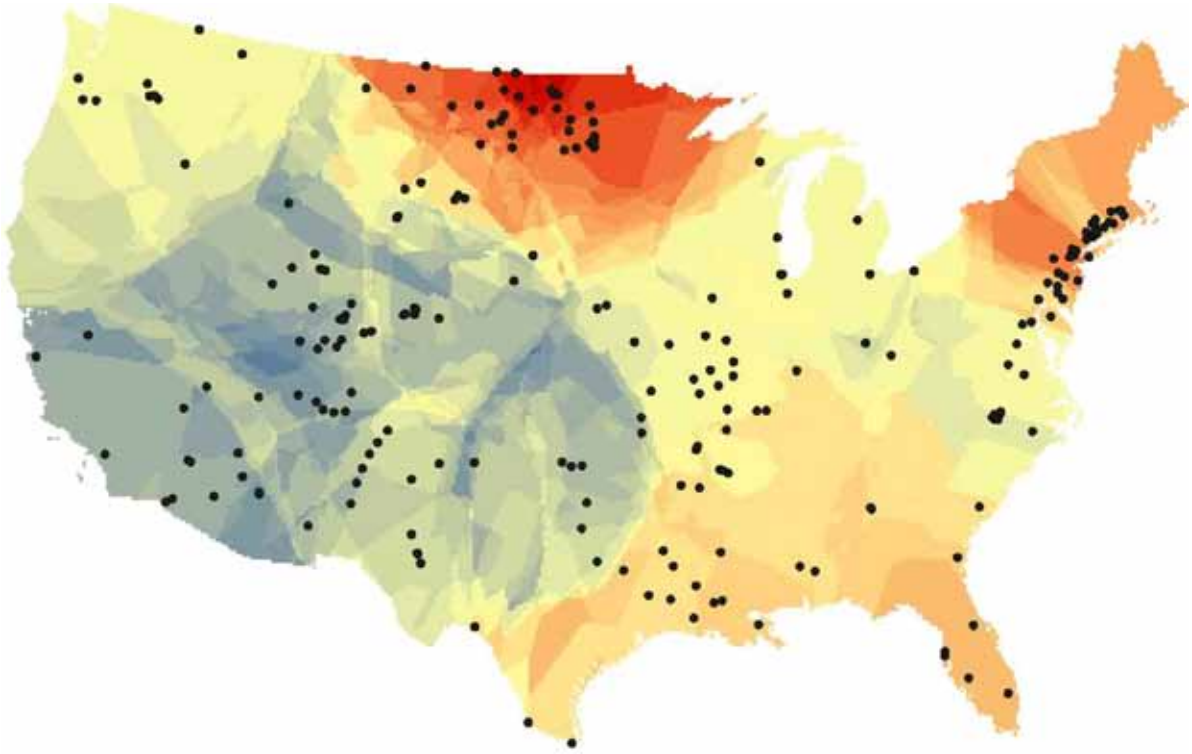
Old Salts and New Challenges



- Post Reprint: "The Nation's Rivers and Streams are Getting Dangerously Saltier"
- Student Background: Welcome to the Jubilee! Please pass the salt.
- Student Activity: Streams, Rivers and Salt
- Salt Lab: Duckweed and Salt Tolerance
- Student Lab: Human Influence on Rivers
- Word Find: Damaged, Restored, Protected Rivers
- Word Find Answers: Damaged, Restored, Protected Rivers

Through the centuries mariners have charted the seas, returning home with their catches, exotic foods and new routes. These old salts charmed with tales of sea creatures, mystic lands and enchanting people. Sailors ate biscuits, salt pork, meat preserved through salting and pickling, peas, cheese and beer. In addition to these provisions, some believed these sailors survived because of the power of salt to repel spiritual and magical evil.

Current challenges to clean water involve our rivers and streams getting dangerously saltier. Post reporters focus on the risks to drinking-water supplies. We provide resources for looking at the science-side as well as the infrastructure and government response side. In addition, students are asked to "adopt a river" to get acquainted with its current health. Suggested rivers are found in "Human Influence on Rivers" and "Damaged, Restored, Protected Rivers."

Lisa Wu, marine biology educator and director for the Oceanography/ Geophysical Systems Lab at the Thomas Jefferson High School for Science and Technology, wrote the "Duckweed and Salt Tolerance" lab and "Welcome to the Jubilee! Please pass the salt." and co-wrote "Streams, Rivers and Salt." She was a volunteer diver at the National Aquarium in Baltimore for ten years and served as Teacher at Sea for NOAA and is a member of the Corps of Exploration for the E/V Nautilus. Each year she takes students to study on the Potomac River as well as under the sea surrounding Maryland's eastern shore, the Bahamas, Florida Keys, Galapagos Islands, Bermuda, Indonesia and most recently Cuba.

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Energy and Environment

The nation's rivers and streams are getting dangerously saltier

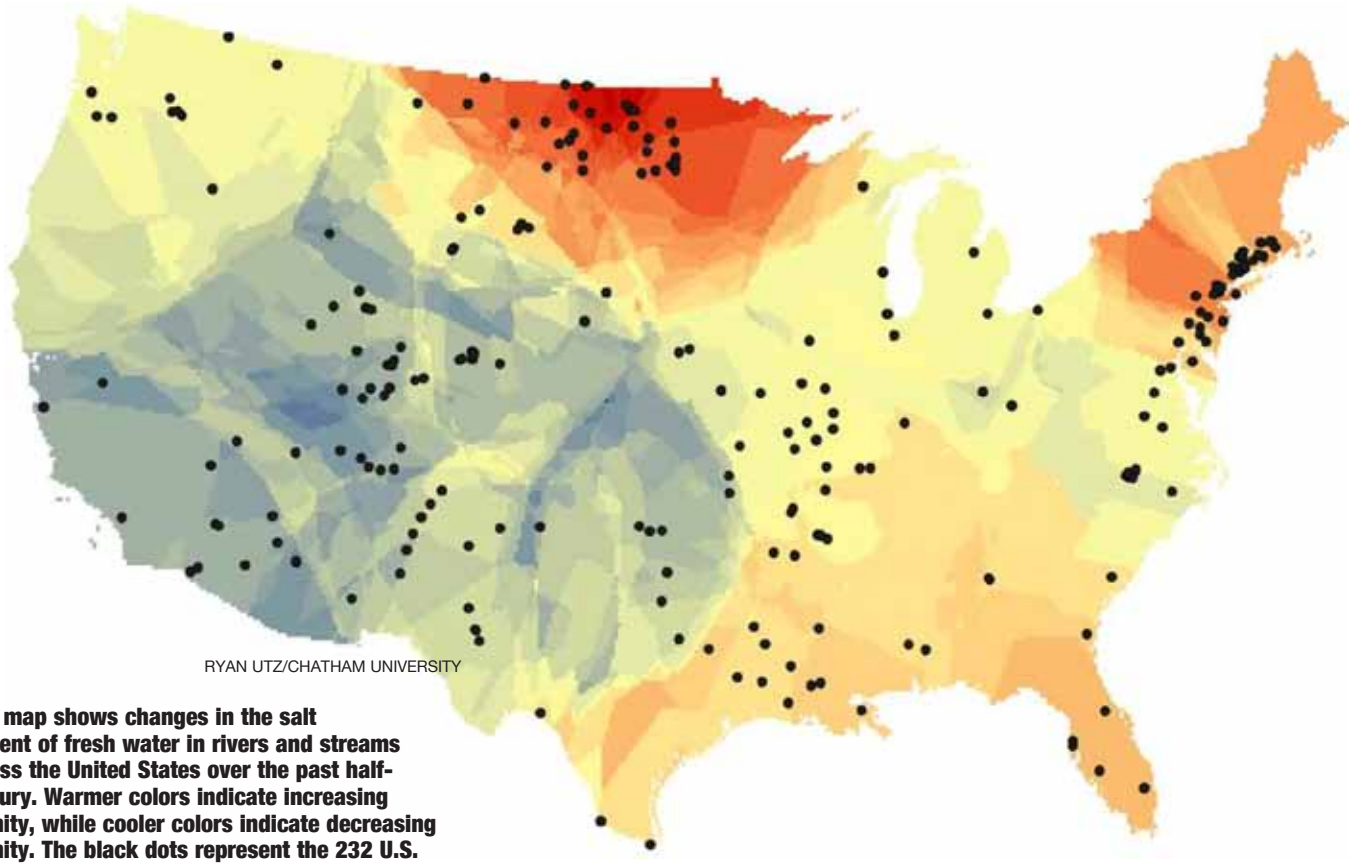
BY BRADY DENNIS

• *Originally Published January 8, 2018*

Nearly everywhere you turn during this frigid stretch of winter, much of the world seems covered in a layer of salt aimed at keeping our roads drivable and sidewalks free of ice. All that salt is one reason — although not the only one — that many of the nation's rivers and streams are becoming saltier, according to new research published Monday in the Proceedings of the National Academy of Sciences.

Increased salt poses risks to drinking-water supplies for millions of Americans, threatens urban infrastructure, and has the potential to upend ecosystems.

"The fact it is occurring so widely surprised us," said Gene Likens, an author of the new study who is a University of Connecticut professor and president emeritus of the Cary Institute of Ecosystem Studies. "The impacts we humans are having on natural systems are really widespread."



RYAN UTZ/CHATHAM UNIVERSITY

This map shows changes in the salt content of fresh water in rivers and streams across the United States over the past half-century. Warmer colors indicate increasing salinity, while cooler colors indicate decreasing salinity. The black dots represent the 232 U.S. Geological Survey monitoring sites that provided the data for a new study.

Researchers used five decades' worth of data from 232 U.S. Geological Survey monitoring sites to document long-term changes in the salinity of rivers and streams throughout the country, as well as changes in their acidity. They documented stark chemical changes in major waterways, such as the Hudson, Potomac and Mississippi rivers, which supply drinking water to major population centers.

While the sources of excess salt in the water vary by region, in much of the country waters have been growing increasingly salty and more alkaline over time. In the Mid-Atlantic and Northeast, the heavy use of sodium chloride — better known as table salt — to maintain roads in winter was a main contributor. In the Midwest, certain fertilizers with high potassium content played a key role. In other areas, mining waste and the weathering of concrete, rocks and soils can release certain salts into nearby waterways.

Why does the growing salt content of fresh-water rivers and streams matter?

For starters, it can create serious problems for drinking-water supplies, as salt is difficult to remove during the treatment process. The changing composition of water supplies also threatens to wreak havoc on the nation's infrastructure — particularly aging underground pipes. The authors note that the water crisis in Flint, Mich., began when the city switched its water source in 2014 to the Flint River, which had a "high salt load" that contributed to dangerous amounts of lead leaching into pipes.

The researchers found that over the past half-century, 37 percent of the drainage area of the contiguous United States has experienced an increase in salinity.

"If you look at the trends from the past 50 or 60 years, they are pretty clear," said Sujay Kaushal, a study co-author and geology professor at the University of Maryland. "If you don't manage it, it's going to keep increasing."

Interestingly, researchers found that the trends of increased salinization held true even in places such as the Southeast, where there is far less salting of roads during the winter. And they noticed that the pH level in some rivers and streams began rising as early as the 1950s.

At the same time, the increases were not uniform across the country. In the water-starved Southwest, for instance, salt concentrations have traditionally been high. But the study's authors found a decrease in salinity there over time, a change they attributed in part to alterations in land and water use and efforts by local and state governments to closely manage water resources.

Such an approach, Likens said, should make it clear that there are solutions to the problem. He said evidence shows that applying brines can be more efficient than granulated salt to combat icy roads. Many cities also use salt-spreading equipment that is long overdue for an upgrade to more modern spreaders that conserve salt. Also, different salt compounds could help to melt snow and ice more efficiently. The researchers also have advocated for more judicious use of fertilizers and better land-use strategies, such as building farther from waterways and using more porous building surfaces.

"The trends we are seeing in the data all suggest that we need to consider the issue of salt pollution and begin to take it seriously," Kaushal said in an announcement of Monday's findings. "The Environmental Protection Agency does not regulate salts as primary contaminants in drinking water at the federal level, and there is inconsistency in managing salt pollution at the local level. These factors are something communities need to address to provide safe water now and for future generations."

Brady Dennis is a national reporter for The Washington Post, focusing on the environment and public health issues. He previously spent years covering the nation's economy. Dennis was a finalist for the 2009 Pulitzer Prize for a series of explanatory stories about the global financial crisis.

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Welcome to the Jubilee! Please pass the salt.

What comes to mind when you think of salt? The sodium chloride on your kitchen table? Health advisories to reduce salt consumption? Road salt in winter or the salt roads of historic trade? Have you heard these expressions?

Being worth your salt	*Sitting above or below the salt*
Take it with a grain of salt	*He is the salt of the earth*
Rub salt in the wound	*She salted away a bounty of food*

Once salt's preservative qualities were discovered, people moved away from rivers and coasts and survived more harsh weather. Salt drove explorations across the globe and led to conflicts. So valued in ancient times it was used as trade and currency. The mineral is a valuable seasoning for which humans seem hardwired to crave. Iodized since the 1920s, sodium is essential to the functioning of the body. A common preservative, it extracts moisture and preserves the flavor of food. Today the gourmet salt market is projected to be worth $1.5 billion by 2022.

In the environment, we know the ocean is salty. Why is ocean water salty? The salt comes from hydrothermal vents, volcanic eruptions and cracks in the deep sea floor; from the erosion of rocks and minerals on land, dust precipitation; and from ground water runoff. Salinity in the ocean is more than the sodium and chloride ions. Salinity refers to the total amount of solids dissolved in the water.

Salinity affects not just the taste of the water but buoyancy, osmoregulation, deep sea circulation, and the density of water. Its chemistry reacts to corrode metals and its concentration levels in water affect the location of organisms and where they live.

All natural waters, including those described as fresh, contain salts. A stream emerging from a mountain watershed may contain as little as 50 parts per million (ppm) of "salt," or total dissolved solids, compared to ocean water which averages about 35,000 ppm dissolved solids.

The difference in salts affects how these waters interact. For example, as the freshwater of our major rivers enters our coastal areas and estuaries it creates fresh water lenses that sit above the denser saltwater from the ocean. In estuaries like the Chesapeake Bay this density difference affects migrations into the Bay and influences breeding. Mating of blue crabs occurs primarily in relatively low-salinity waters in the upper areas of estuaries and lower portions of rivers. The flow from the Mississippi River into the Gulf of Mexico, not only brings in the fresh water to sit above the saltier Gulf water, but also washes in nitrates, phosphates and chemicals that flow from farms along the river fertilizing these upper surface waters creating algal blooms.

When these algal blooms die, the bacterial decomposition utilizes the oxygen in the water column creating dead zones. These dead zones can move with currents. Shrimp in the Gulf are often "chased" by these anaerobic pockets. As the tides come in, the shrimp can be pushed up on the beach – an event referred to in the South as a jubilee.

Name _____ **Date** _____

Streams, Rivers and Salt

Although salt is considered essential to flavorful eating and safe roads and sidewalks, salt in excess can be dangerous to the health of people and pose challenges to animals and plants in aquatic environments.

Let's take a closer look at salt in rivers and streams.

Read "Welcome to the Jubilee! Please pass the salt."

1. Six examples of expressions using salt are cited. Sayings are often based in practices, culture and beliefs. Select and explain one of them.

2. What causes ocean waters to be salty?

3. Sketch and label an illustration to explain what takes place when freshwater meets saltwater.

Read The Washington Post article "The nation's rivers and streams are getting dangerously saltier."

4. Define the following terms that are used by Brady Dennis.
   a. Acidity
   b. Alkaline
   c. Brine
   d. Ecosystem
   e. Leaching
   f. pH
   g. Salinity
   h. Urban infrastructure

5. What information is given to support the validity of the research?

6. Why is increased salt presence in water dangerous?

7. Name approaches that have helped or solutions that are recommended.
   a.
   b.
   c.
   d.

8. If the "Environmental Protection Agency does not regulate salts as primary contaminants in drinking water" and there is no consistent management of salt solution across states, what do you think would be one measure that the National Governors Association should consider for adoption in their states?

Name _____ **Date** _____

Let's think like scientists.

9. How do scientists measure the salt content of water?

10. Consider the water cycle. Water evaporates from the ocean, leaving salts behind. The water vapor condenses into the skies forming clouds and rain. As precipitation falls, it picks up atmospheric gases, including carbon dioxide, and creates a weak acid. When this weakly acidic rain water falls on the earth's surface, it reacts with materials in the soils and rocks as it flows through streams to rivers, to lakes and seas. Materials dissolved in weak acids are taken up and increase the concentration of minerals in the water. Name the four most common minerals found in "fresh" water.
    a.
    b.
    c.
    d.

11. Carbon dioxide is not only picked up in the atmosphere. More is taken up when it infiltrates the soil, ponds, reservoirs and lakes. From what three sources does this additional carbon dioxide come?
    a.
    b.
    c.

12. We think of water as being plentiful and use large volumes of it over time. So water quality is a very important practical consideration for household and industrial plumbing, pumps, wells, tanks, reservoirs, and urban and suburban distribution systems. They must be kept working at the lowest possible cost.
    a. Consider what happened in Flint Michigan in 2014. Explain chemically, why the high salt level caused dangerous amounts of lead in the water system.

    b. How much lead is considered too much for healthy consumption?

    c. What economic effect does polluted water have on a family? On a community?

Name _____ Date _____

Duckweed and Salt Tolerance

Introduction

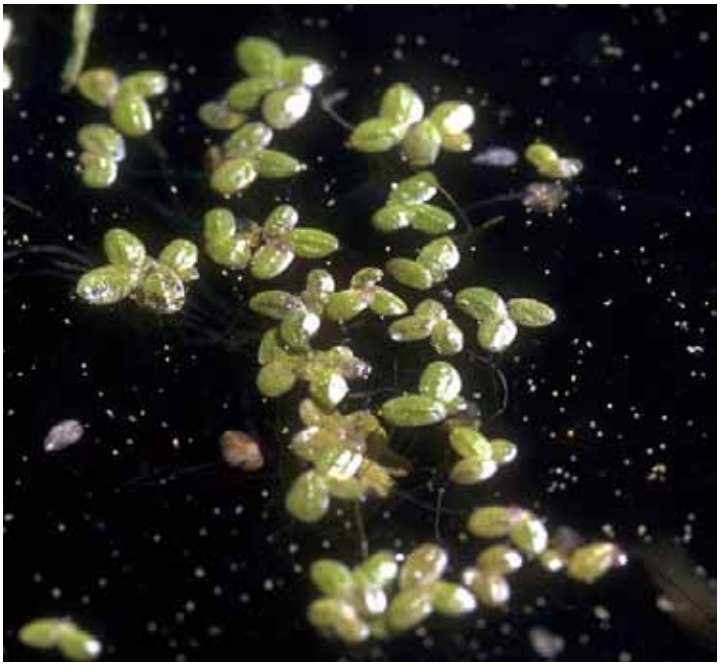
There are many ways that salt enters into our watersheds. There is run-off from sewage systems, water softeners, rock and soil erosion. When road salt is added for deicing, it eventually dissolves in water moving through soil or into surface water. Salt can affect living organisms even if it is not lethal to them. It affects their movement and migration in the ecosystem.

Salt accumulates over time, and, if conditions remain consistently at higher concentrations of salt, it is possible that invasive species that are more salt tolerant will replace the native species. In addition, the longer organisms are in an abnormally high salt environment, the more toxic the effects are to them. One method the Environmental Protection Agency uses to determine toxicity is called a TC50. TC50 is the toxic concentration that causes organisms to grow 50% as well as a control group.

In this experiment we will determine the effect of rock salt (NaCl) on a common freshwater plant, *Lemna minor* (Duckweed).

Duckweed is a small (1-2 mm) aquatic plant that floats on the surface of ponds, wetlands and nutrient-rich lakes. Found worldwide, there are 20 species in the United States that serve as food for waterfowl and fish. Each plant consists of one or more fronds. The fronds look like little leaves but actually are a combination of leaf and stem, attached to a rootlet that dangles down in the water. Usually it reproduces through budding — new fronds grow from buds on the parent plant. Eventually these new fronds grow their own roots and break off to become independent plants. Because of its broad range of sensitivity, duckweed can be used as an indicator species to test landfill runoff, industrial effluent, groundwater quality, surface water quality and agricultural chemical runoff. An indicator species, does not measure the amount of contamination or what it is, but merely suggests that water quality has been affected and further methods of source contamination need to be investigated.

***Lemna minor* (Duckweed)**



Duckweed on the surface of a small pond in Utah. USDA FOREST SERVICE

Materials per group of 4 students

6 250 ml beakers or plastic cups

Scale

10 ml graduated cylinder (or pipette)

100 ml graduated cylinder

Pens/masking tape

Spring water or dechlorinated tap water or stream/ pond water (pH 6-8)

Sodium chloride (non-iodized) rock salt

Duckweed *(Lemna minor*) ordered from biological supply companies (such as Carolina Biological) or collected in the field

Forceps

Plastic wrap

Procedure

1. Label the six beakers with your name, the date, NaCl, and the following percent concentrations: 100%, 10%, 1%, 0.1%, 0.01%, and 0.001%. Make sure to record the concentration of your 100% solution (in mg/L).
2. Weigh out 12 grams of salt and place it in the beaker labeled 100%. Add 100 ml water and swirl gently until your compound is dissolved.
3. Using a 10 ml pipette or graduated cylinder, transfer 10 ml of your 100% solution to the beaker labeled "10%." Add 90 ml water to the beaker and gently swirl. Thoroughly rinse the pipette or graduated cylinder when finished.
4. Transfer 10 ml of your 10% solution to the beaker labeled "1%." Add 90 ml water to the beaker and gently swirl.
5. Repeat these steps until you have made all five dilutions. These can be made ahead of time. If you are not using them immediately, cover them tightly with plastic wrap to prevent water loss through evaporation.

Considering the salt concentrations that you have made, what is your hypothesis?

6. Count out 10 duckweed fronds and with forceps place in each solution. Lay plastic wrap on top of each beaker to prevent evaporation but do not seal tightly around the edges (this allows air to move in and out for respiration and photosynthesis but helps prevent evaporation).

7. Place in a well-lit area.

8. Collect initial data by counting the number of fronds in each beaker. Note any other observations.

9. Make a data chart and collect data every 24 hours for two weeks by counting the fronds and note any changes in color, frond size in relation to control, changes in appearance (for example, broken roots, colonies broken apart)

10. Use your data to determine the TC50.

    After you have estimated the TC50 for your experiment, you will be able to use this number to make a statement about the toxicity of the substance you were testing. This statement will be something like:

    The TC50 for salt and duckweed growth is in the range of ____ to ____.

Write up a lab report to share your results. Use this format.

1. **Title page.** Should have a title and your name, date, period

2. **Introduction.** Should include problem investigated, hypothesis, and background information using at least three sources.

3. **Materials and methods.** Should list the materials used and a detailed description of your experiment. Someone should be able to read your description and perform the exact same experiment.

5. **Results.** Should include your data tables and a graph of your frond counts. Also summarize your data in paragraph form.

6. **Conclusion and Discussion.** Should analyze and interpret the results you obtained in your experiment. You should answer the following questions in this section:

   a. How does salinity affect the growth of duckweed?
   b. Did your data support your hypothesis?
   c. Were there any dishes with results which surprised you? Which ones and why?
   d. If salinity has an effect on the growth of duckweed, explain the reason why.
   e. Can duckweed tolerate any salinity in its environment?

7. **Literature cited.** List your references.

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Human Influence on Rivers

Rivers provide physical and spiritual nourishment. They have allowed communities to be built, commerce to expand and poetry to be written. Their rapids and whitewater exhilarate and challenge; their calm movement inspires solitude and renewal. As they benefit life, rivers cannot be taken for granted. They require intelligent conservation, generous protection and judicious use.

From the hundreds of long and small rivers that flow, a list is provided for your exploration. Will you be able to swim, paddle or fish in these streams? Are they clean or endangered? What is being done to revive or preserve them? Read about them and tell others about them.

American Rivers

Atchafalaya, Louisiana — river basin, cypress forest swamp
http://www.katc.com/story/37597157/rivers-on-the-rise-in-louisiana
http://www.nola.com/environment/index.ssf/2017/12/rising_river_bottom_could_swit.html

Colorado River — water-sharing agreement with Mexico
nature.org/coloradoriver

Connecticut River — basin, outdated dams
https://www.americanrivers.org/region/northeast/

Navarro River — habitat for endangered coho, watering of vineyards
http://www.casalmon.org/salmon-snapshots/about/navarro-river-1

Penobscot River, Maine — whitewater rapids and fly-fishing
https://www.cbsnews.com/news/maines-penobscot-river-finally-runs-free-after-huge-restoration-project/

Puyallup — Mount Rainier to Puget Sound, watershed and floodplain
http://puyallupriver.org

Rappahannock River — aquaculture, oysters, sanctuary reefs
https://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/virginia/placesweprotect/rappahannock-river-lands.xml

Rivers Around the World

Amazon — indigenous communities, deforestation and urbanization
https://amazonaid.org/understanding-gold-mining/

The China Urban Water Blueprint — 135 lakes and rivers tapped by the 30 largest cities
https://global.nature.org/content/china-urban-water-blueprint

Nile — world's longest river
https://www.washingtonpost.com/news/theworldpost/wp/2018/03/22/egypt/?utm_term=.5bef7de97c10

Tonle Sap River, Cambodia — shelter from persecutionAmz
http://pulitzercenter.org/reporting/persecuted-land-minority-cambodia-takes-shelter-water

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Word Find: Damaged, Restored, Protected Rivers

Rivers are endangered or threatened, wild and scenic, refreshing and challenging. They are important to the livelihood and recreation of the communities they support. Find the rivers listed below. Like rivers, their names may be found running left to right, up and down or on the diagonal.

S	O	S	O	L	A	F	F	U	B	C	R	S
A	L	A	G	N	A	K	V	E	O	H	A	N
Y	N	L	R	E	D	E	A	N	D	S	P	A
A	A	M	A	E	O	R	N	A	A	I	P	K
L	V	O	N	R	E	E	I	R	R	M	A	E
A	A	N	D	G	C	T	A	H	O	O	H	S
F	R	N	E	T	S	M	E	O	L	K	A	A
A	R	K	I	O	A	U	N	N	O	Y	N	V
H	O	C	C	L	G	E	O	E	C	K	N	I
C	U	A	D	O	E	S	U	E	N	S	O	K
T	N	A	R	L	P	O	T	O	M	A	C	E
A	M	A	Z	O	N	N	O	A	T	U	K	W
T	O	C	S	B	O	N	E	P	E	A	R	L

Alagnak
Amazon
Anacostia
Atchafalaya
Bear
Buffalo
Colorado
Connecticut
Eel
Eno
Grande
Green
Lamar
Mad
Navarro
Neuse
Nile
Noatuk
Pearl
Penobscot
Potomac
Rappahannock
Red
Rhone
Rogue
Salmon
Skykomish
Snake
Wekiva

1. After you have completed the word find, locate three of the rivers on a map. Where are they located? What topographic features are present?

2. Do further searching to dive below the surface to find out more about one of them. Early communities formed along riverbanks and coastlines. Was this one of those rivers? What is its current condition and use? Is it a protected river? What factors influence its current status?

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Word Find Answers: Damaged, Restored, Protected