Mass Audubon
Protecting the Nature of Massachusetts
LTER

Lesson Name:	Inland Fish and Warming Waters
Name of Sanctuary:	Endicott
Grade Level:	3-High School.
Location Options:	Targeted Ponds or Streams
Time:	1-2 hours
For more info:	lduff@massaudubon.org or 781-392-6507

Program Description

This lesson explores the impact of temperature on 4 species of inland fish. A warming climate will increase the water temperature and decrease oxygen levels. Participants will investigate water temperatures and dissolved oxygen levels in local water bodies and consider how to improve habitat for native cold water fish.

Subject:

Biology, Ecology, Life Science

Essential Questions:

Are conditions favorable to brook trout in our local ecosystems? Can we improve conditions for local cold water fish? How is human behavior helping or harming fish species? How will warming temperatures impact fish populations?

*The Next Generation Science Standards that apply to this lesson are in the appendix.

http://www.nextgenscience.org/

Massachusetts Science and Technology/Engineering Current Curriculum Frameworks (October 2006)

Massachusetts Curriculum Frameworks for Grades 3-5

Framework:	Science and Technology
Strand:	Life Science
Topic:	Characteristics of Living Things Evolution and Diversity Living Things and Their Environment

Characteristics of Living Things

3-5 #3:	Plants and animals go through predictable life cycles, including birth, growth, development, production, and death

Evolution and Biodiversity

3-5 # 7:	Changes in the environment have caused some plants and animals to die or move to new locations.

Living Things and Their Environment

3-5 # 10: Organisms can cause changes in their environment to ensure their survival, which may affect the ecosystem.

Massachusetts Curriculum Frameworks for Grades 6-8

Framework: Science and Technology
Strand: Life Science
Topic: Living Things and Their Environment
Changes in Ecosystems Over Time

Learning Standards

Living Things and Their Environment

6-8 # 13: Give examples of ways in which organisms interact and have different functions within an ecosystem that enable that ecosystem to survive

Changes in Ecosystems Over Time

6-8 # 17: Identify ways in which ecosystems have changed throughout geologic time in response to physical conditions, interactions among organisms, and actions of humans. Describe how changes may be catastrophes such as volcanic eruptions or ice storms.

Massachusetts Curriculum Frameworks for Grades 9-12

Framework: Science and Technology
Strand: Life Science
Topic: Ecology

Learning Standards

Ecology

Central Concept: Ecology is the interaction among organisms and between organisms and their environment

9-12 # 6.2: Analyze changes in population size and biodiversity (speciation and extinction) that result from the following: natural causes, changes in climate, human activity, and the introduction of invasive, non-native species.

Massachusetts Curriculum Frameworks PreK-12

Framework: English Language Arts
Strand: Language
Topic: Questioning, Listening, and Contributing

Learning Standards

Questioning, Listening and Contributing

PreK-12 Language #2: Students will pose questions, listen to the ideas of others, and contribute their own information or ideas in group discussions or interviews in order to acquire new knowledge.

Lesson Objectives/Concepts/Desired Results

Concepts:

- Water temperature impacts the ability of fish species to survive.
- Warmer water holds less dissolved oxygen than colder water.
- Warming climates threaten some native fish species.
- Humans may be able to help native fish species survive.

Skills:

- Accurately measure and record water temperature
- Accurately measure and record dissolved oxygen readings
- Summarize how the amount of dissolved oxygen changes with water temperature
- Match fish, given their oxygen and temperature needs, with areas on a stream map where they could thrive.
- Students will predict where fish will survive and reproduce most optimally.

  Critical Thinking Skills: Students will apply this information to local ecosystems and propose ideas for improving habitat and reducing negative human impact to local fish populations.

Attitudes: Stewardship of other living things.

Materials

- Handout from Changing Climate, Greening Energy: An Eagle's EyeView http://www.fws.gov/northeast/pdf/coloringactivity.pdf pages 14-15 US Fish and Wildlife Service written by Laury Zicari and Kristen Randall of the Northeast Region's New York Field Office Published 2009
- Inland Fishes of Massachusetts, Karsten E. Hartel, David B. Halliwell, and Alan E. Launer, 2002. Massachusetts Audubon Society, Lincoln, MA. 328 pp. Hardcover, ISBN 0932691285.
- Paper, pencils
- Water thermometers
- "Low Cost Water Monitoring Kit" Green LaMotte ($37.950 in 2014) (for Dissolved Oxygen)
- Graph paper (big)

Vocabulary/Glossary

Dissolved Oxygen is the amount of oxygen that is present in the water.

Diffusion: the process whereby particles of liquids, gases, or solids intermingle as the result of their spontaneous movement caused by thermal agitation and in dissolved substances move from a region of

higher to one of lower concentration.

Ecosystem: a system formed by the interaction of a community of organisms with their environment.

Optimal: Best or most favorable.

Percent Saturation: The amount of a substance that is dissolved in a solution compared to the amount that could be dissolved in it.

Turbulence: Chaotic or unstable eddying motion in a fluid.

Watershed: is the area of land where all of the water that is under it or drains off of it goes into the same place.

Introduction/Background Information

Fish need oxygen to survive. They breathe dissolved oxygen through their gills. The warmer water is, the less oxygen it holds. Colder water holds more oxygen compared to warmer water. Dissolved oxygen gets into water by diffusion, turbulence, or waste products of plants. Trees provide shade and help decrease temperatures. Water may be warmed by pavement, before it runs into a river. Logs or stones in rivers can help increase turbulence, increasing oxygen in a river.

Educator Background

To prepare for this lesson an Educator should:

- Familiarize self with procedure and dissolved Oxygen Test Kit.
- Make sure thermometers are working.

Assessments/Evidence of Understanding

How will you know that the students have met the standards?

- Participants accurately collect and record the temperature and dissolved oxygen readings.
- Participants accurately graph their data and draw reasonable conclusions from their data.
- Participants ask relevant questions.
- Participants make relevant comments during discussion.

Procedures

Timing: 30 minute intro, 2-3*15 min data collect, 45 min graph and present.

1. **Engaging Experience**: Educator will ask participants if they know ways that temperature might impact fish populations. Students will then take turns reading out loud the two page handout about the impact of warming temperatures on cold river fish and color in the 4 different rivers, depicting changing temperatures, responding to projected warming climate.
2. **Guiding Questions**: The Educator will lead a discussion with the following guiding questions:
    a. What questions does this raise for you about this region?
    b. What questions does this raise for you about your own watershed?
    c. How can we best protect the fish in this region?
3. Students will write down their answers, and pair and share, and share with whole group.
4. Investigations: Would brook trout survive in our local ecosystems?

Educator will divide students into groups to measure the temperature and dissolved oxygen levels of

various water samples such as tap water, water from the classroom aquarium, water in a local pond or stream, river water, fountain water, the ocean.

5. **Draw Conclusions and Present Findings**:
   Students will graph dissolved oxygen versus water temperature. Students will share whether the sites they measured would make good brook trout habitat. If not, which of the species mentioned could survive there.

6. **Assessment**: see above

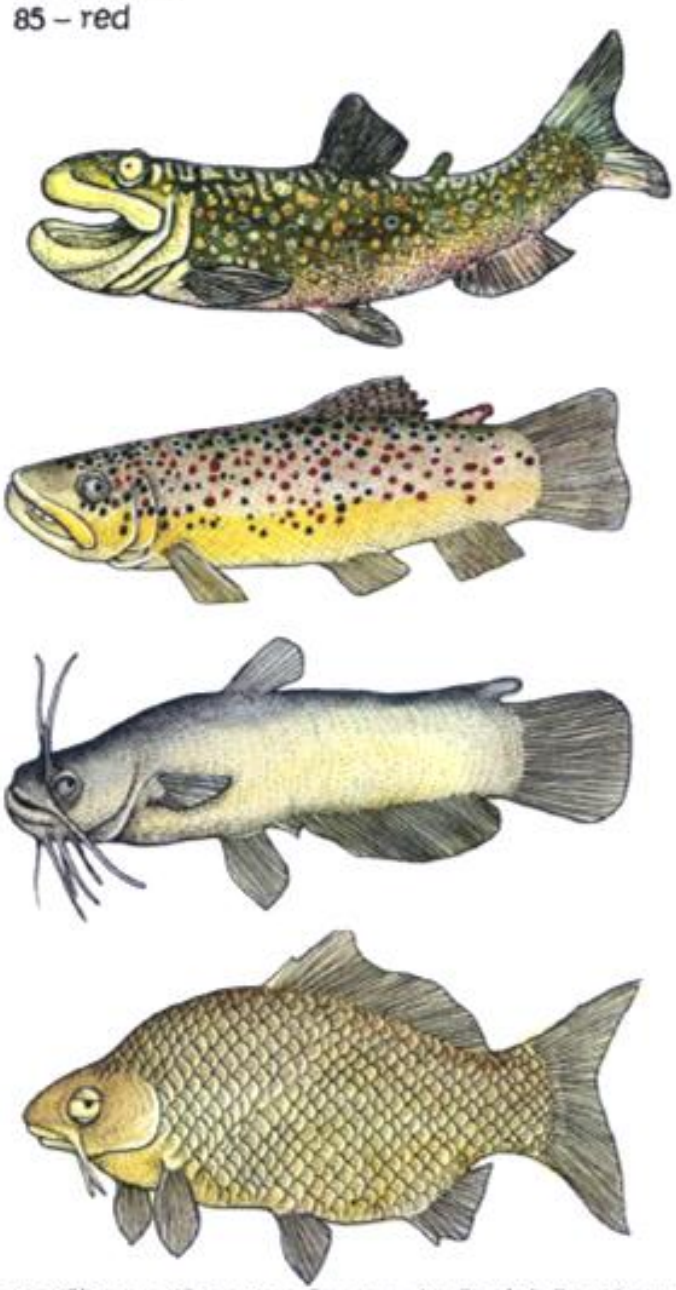
7. **Wrap Up**: Reflective journal writing

8. Extension: Practice and perform the "Fish Wish" song. Set intentions, with students for personal and/or class actions to help the fish.

But not only does climate change alter sea levels – it may change streams and rivers world wide. It doesn't take a huge temperature shift to cause certain fish to vanish – fish species that depend on colder water!

On the next page are four maps of the same watershed over a few decades of climate change. Barry's friend the brook trout needs cold water and prefers the water to be around 55 degrees F (blue), although they can survive in warmer water temps to about 65 degrees (green). As water temperatures warm (yellow, orange and red) the brook trout may be forced out of this watershed. Use the key to color by number to see what happens.

55 – blue
68 – green
74 – yellow
78 – orange
85 – red



Brook trout (*Salvelinus fontinalis*) In spite of their name, brook trout are often found in lakes and are also common in cold, clear headwater streams. Like most salmonid fishes, brook trout thrive in waters with low temperatures and high oxygen content.

Brown trout (*Salmo trutta*) can tolerate higher temperatures than other salmon and trout.

Yellow bullhead (*Ameiurus natalis*) live in pools and backwaters of sluggish streams, ponds and lakes.

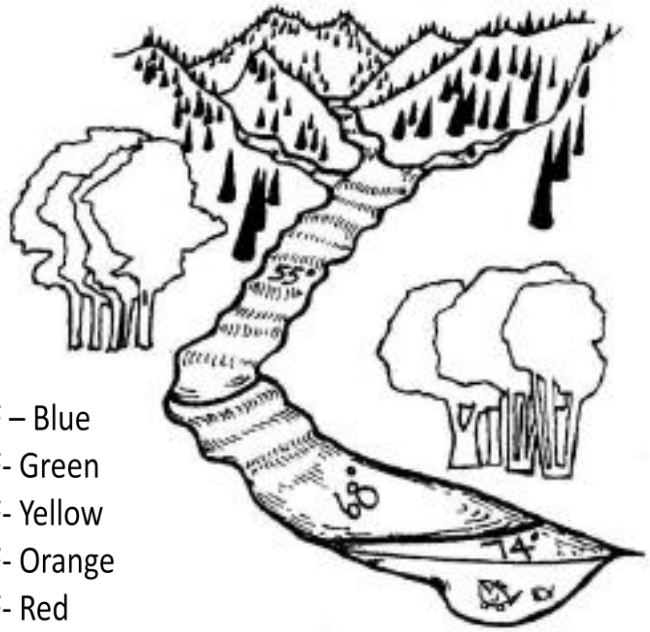
Carp (*Cyprinius carpio*) can inhabit turbid or clear water over mud and silt and are more common in warm water, even up to 100 degrees F.

SO a stream that historically supported brook trout could someday only support carp!

Changing Climate, Greening Energy: An Eagle's Eye View http://www.fws.gov/northeast/pdf/coloringactivity.pdf
US Fish and Wildlife Service. By Laury Zicari and Kristen Randall of the Northeast Region's New York Field Office
Published: December 3, 2009.

Student Version

1. This is the stream today – several different habitats represented by different water temps.



55°F – Blue
68°F- Green
74°F- Yellow
78°F- Orange
85°F- Red

2. Now advance into the future with a warming planet. Now there is less cool-water habitat and new, warm-water habitat.

3. The planet continues to warm and now the cool-water habitat is gone and more of the habitat is very warm water.

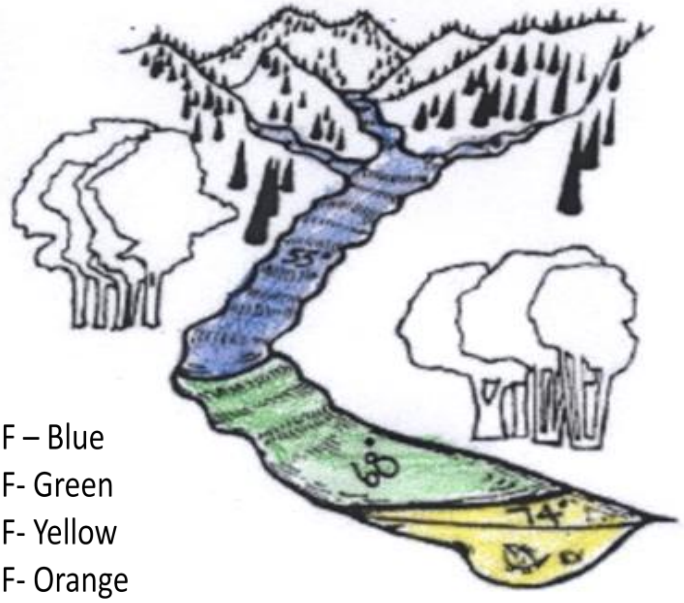
4. Finally, the entire stream is now a warm water stream, with likely little diversity in fish species as few can tolerate such warm water and low levels of oxygen.

Shared with Permission:
Credit: *U.S. Fish and Wildlife Service*

Changing Climate, Greening Energy: An Eagle's Eye View http://www.fws.gov/northeast/pdf/coloringactivity.pdf US Fish and Wildlife Service. By Laury Zicari and Kristen Randall of the Norheast Region's New York Field Office. Published Dec. 3, 2009.

Teacher Version

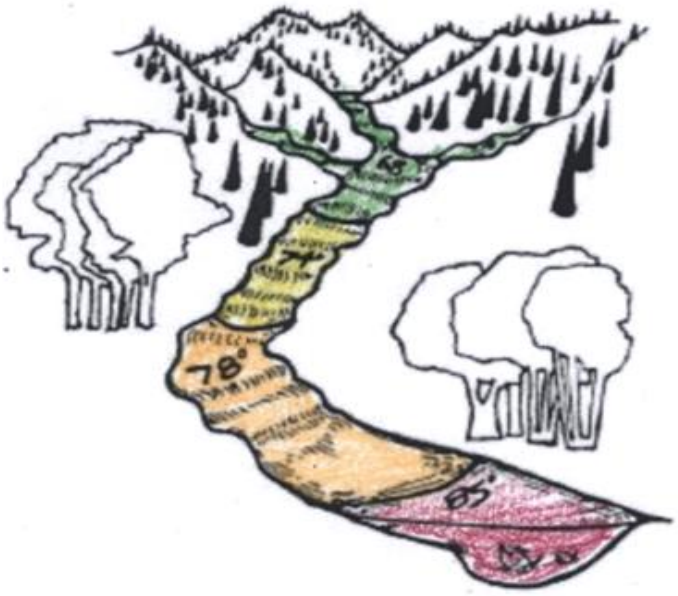
1. This is the stream today – several different habitats represented by different water temps.



55°F – Blue
68°F- Green
74°F- Yellow
78°F- Orange
85°F- Red

2. Now advance into the future with a warming planet. Now there is less cool-water habitat and new, warm-water habitat.

3. The planet continues to warm and now the cool-water habitat is gone and more of the habitat is very warm water.



4. Finally, the entire stream is now a warm water stream, with likely little diversity in fish species as few can tolerate such warm water and low levels of oxygen.

Brook Trout loses habitat. Carp gains habitat as temperatures rise over time.

Changing Climate, Greening Energy: An Eagle's Eye View http://www.fws.gov/northeast/pdf/coloringactivity.pdf
US Fish and Wildlife Service. By Laury Zicari and Kristen Randall of the Norheast Region's New York Field Office.
Published Dec. 3, 2009.

How can we improve habitat to help the brook trout and other cold water species?

Name _____ Date _____

1. Read page 11-12, Fish Habitat from *Changing climate, Greening Energy: An Eagle's Eye View*
2. Color in page 12, following the color codes on page 11.

Color	Fahrenheit	Celsius
Blue	55	12.8
Green	68	20
Yellow	74	23.3
Orange	78	25.6
Red	85	29.4

Brook Trout Prefer water to be around 55 degrees F (blue) but can survive to about 65 (green).

Carp can survive up to 100 degrees F. (Red)

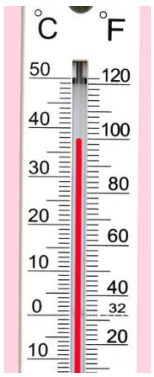
3. Record the questions this raises for you. Consider where you are right now, and the implications for that location. Also consider the implications for where you live.

Questions

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____

4. Put an "I" next to the questions to be investigated.
5. Put a * next to the questions that are "burning" questions for you.

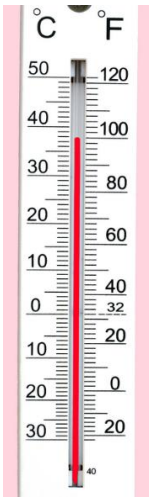
To convert Fahrenheit to Celsius: Read the thermometer from either side, or:
Begin by subtracting 32 from the Fahrenheit number
Divide the answer by 9
Then multiply that answer by 5
Here's an example to change 95 degrees Fahrenheit to Celsius: 95-32 = 63. Then 63/9 = 7.
Finally, 7 x 5 = 35 degrees Celsius.



To Convert Celsius to Fahrenheit:
Begin by multiplying the Celsius temperature by 9.
Divide that answer by 5.
Now add 32

Mass Audubon
Protecting the Nature of Massachusetts
LTER

Name _____ Date _____



Color	Fahrenheit	Celsius
Blue	55	12.8
Green	68	20
Yellow	74	23.3
Orange	78	25.6
Red	85	29.4

Brook Trout Prefer water to be around 55 degrees F (blue) but can survive to about 65 (green).

Carp can survive up to 100 degrees F. (Red)

Investigate: Do our local water bodies have optimal temperatures for brook trout?

Read and record the water temperature and its dissolved oxygen content.

Date	Water body	Temperature	What "color" is this closest to?	Dissolved oxygen	Saturation

Brook trout need cold water. They prefer water to be around 55 degrees F (blue), although they can survive to about 65 degrees F (green).

Create a graph depicting your results.

Discuss your findings:
Which of these locations has water temperatures suitable for brook trout?

Do you think the locations would be suitable for brook trout in July and August? Explain your answer.

Although temperatures might be good for brook trout, are there other factors that prevent some of the stations you measured from being good brook trout habitat?

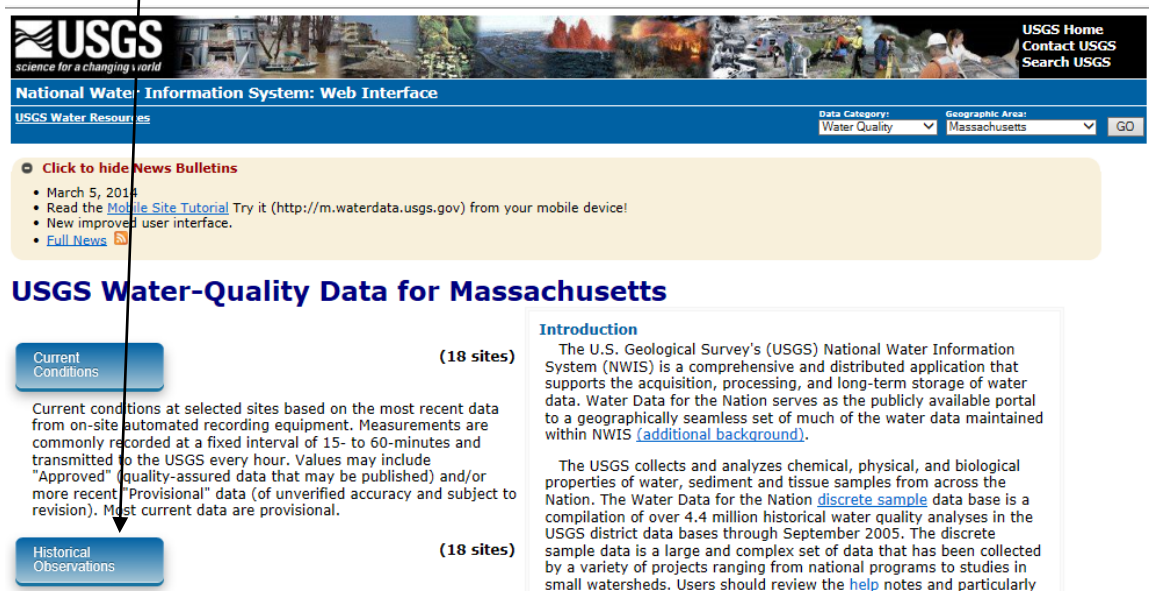
Suggested Follow up:
Investigate on-line data at: http://waterdata.usgs.gov/nwis/?IV_data_availability

Investigate Water Temperature Data on-line at US Geological Survey

USGS Water Data for the Nation

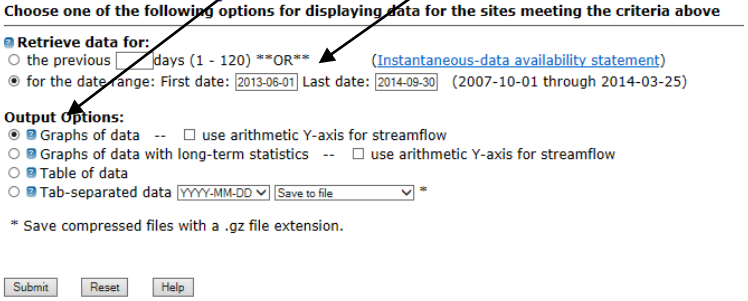
http://waterdata.usgs.gov/nwis/?IV_data_availability

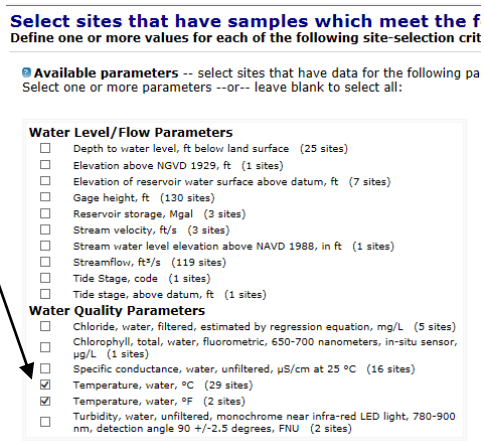
1. Type in "Water Quality" in the Data Category, and choose a state for "Geographic Area".
2. Click on"Historical Observations" to get data from the past.



3.Click "Submit" on the next page.

3. Set parameters: Click on "Temperature water, choose Celsius and/or Fahrenheit.
4. Set dates to include summer months: June-Sept.
5. Click on Output Options: "Graphs of Data"
6. Click submit



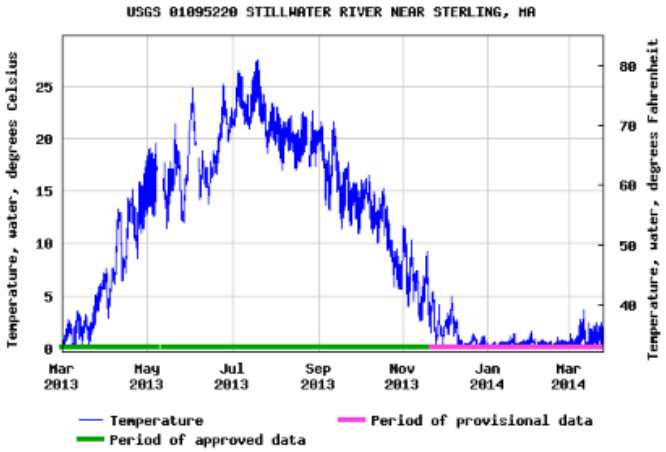


SAMPLE GRAPH From USGS Water Data for the Nation
http://waterdata.usgs.gov/nwis/?IV_data_availability

USGS 01095220 STILLWATER RIVER NEAR STERLING, MA

Temperature, water, degrees Celsius

Most recent instantaneous value: 0.4 03-25-2014 09:00 EDT

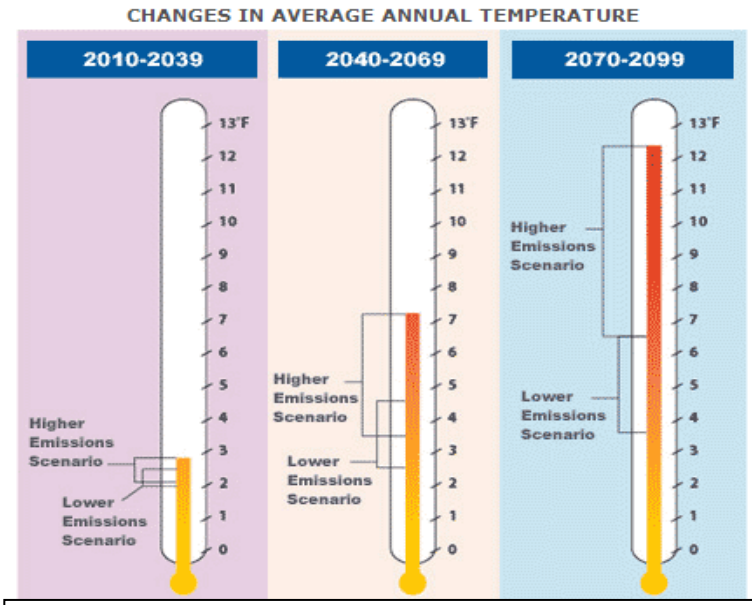


Analyze the graph: Would brook trout thrive in this river? Why or why not?

What state(s) or locations do you think a brook trout would historically thrive in? Investigate if the temperature found in those waters support your prediction(s).

Hint: The Brook Trout (*Salvelinus fontinalis*) is the state fish for 8 states:
Michigan,
New Hampshire,
New Jersey,
New York,
Pennsylvania
Vermont
Virginia
West Virginia

Given projections for future air temperatures, Where will brook trout be able to live by the end of the century?



Projected Future Air Temperatures in Northeast USA

http://www.climatechoices.org/ne/impacts_ne/temperatures.html

Inland Fish and Warming Waters Extensions

Guiding Question:

How can we best help the brook trout?

Time Required: 1-3 class periods. (1 to investigate resources, one to present, one to develop educational materials)

Investigation Focus:

Using resources provided, and their own imaginations, participants will investigate ways to help the brook trout survive. Knowing that the brook trout needs cool water, responses will likely include direct actions such as planting trees to provide shade, as well as personal actions we can take to reduce carbon emissions to reduce warming of our climate.

Learning Outcomes:

Humans have impacted native species such as brook trout.

Humans are capable of improving the situation for brook trout and other species.

Attitudes: Compassion, Stewardship, Respect for all species.

How can we best help the brook trout?

Using the resources below (and others)-investigate what actions would help brook trout (and other cold river species) survive in Massachusetts. With your team, discuss which action(s) we as a class or as individuals should take first. Each team will present their suggestions as a "commercial" designed to influence other members of the class. After the presentations the class will decide which actions to take individually and/or collectively.

Extension: Develop educational materials such as a poster, or videotape a public service announcement and post it on-line to encourage others to take stewardship actions to help the brook trout.

Vocabulary:

Carbon Footprint, Carbon Emissions

Assessment: Performance Based Assessment:

Students will draw accurate conclusions from the data they collect regarding brook trout habitat.

Students will analyze suggested actions from a resource

Students will effectively articulate reasons for suggesting specific actions.

Extension: Students will create educational materials designed to encourage effective stewardship action in others.

- **Resources/Recommended Reading/Useful Websites**
- *Journey for the Planet: A kids Five Week Adventure to Create an Earth-Friendly Life*
  By David Gershon Published by the Empowerment Institute www.empowermentinstitute.net
  Woodstock, NY. 1994.
- *Low Carbon Diet: A 30 Day Program to Lose 5000 Pounds*
  By David Gershon Published by the Empowerment Institute www.empowermentinstitute.net
  2006.
- *A Homeowner's Guide to Protecting Water Quality in the Blackstone River Watershed*
  http://www.zaptheblackstone.org/whatwedoing/Publications/Homeowner_Guide.pdf
  By Donna Williams, Broad Meadow Brook, Mass Audubon
  Page 18 is particularly useful regarding water temperature: "Life on the Edge of a Waterway Maintaining stream buffers and tree canopies"

Wrap up: Keep track of actions taken during the year.

Additional Useful links:

Blackstone River Watershed Interactive Water Quality Map
http://www.zaptheblackstone.org/interactive_map/index.php

Background Information

The Importance of Water Temperature:
USGS Water Science School
Temperature: http://water.usgs.gov/edu/temperature.html
Dissolved Oxygen: http://water.usgs.gov/edu/dissolvedoxygen.html

Waters The Matter: Measuring Dissolved Oxygen and its Affect on Water Quality
http://peer.tamu.edu/curriculum_modules/Water_Quality/module_3/lesson2.htm

On-Line Data:
USGS Water Data for the Nation
http://waterdata.usgs.gov/nwis/?IV_data_availability

If hot air rises, why is it cold in the mountains?
http://littleshop.physics.colostate.edu/tenthings/ExpansionCooling.pdf

Summarizer

How will the Educator close the lesson to see if students met the objectives?

- Students will assess how many pounds of carbon dioxide they have saved (or intend to save) through their actions. (See "Low Carbon Diet", or other Carbon emission calculators to assess.)

Mass Audubon Teacher Naturalist Reflections

Enjoy! Be ready to use yourself as a role model, and to be inspired by your students. I found students asked some really basic questions such as "Why is it cooler at the top of the watershed (in the mountains) compared to lower down? Isn't that closer to the sun?"

Appendix

New Draft Generation Science Standards

Fish Wish: a song by By Liz, Lindsey and Jenny Duff 2011

*The Next Generation Science Standards that apply to this lesson are:

http://www.nextgenscience.org/

3.Interdependent Relationships in Ecosystems: Environmental Impacts on Organisms

3-LS4-4. **Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.** [Clarification Statement: Examples of environmental changes could include changes in land characteristics, water distribution, temperature, food, and other organisms.] [*Assessment Boundary: Assessment is limited to a single environmental change. Assessment does not include the greenhouse effect or climate change.*]

MIDDLE SCHOOL (Next Generation Final)

MS.Human Impacts

MS-ESS3-2. **Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.** [Clarification Statement: Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods). Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts).]

MS-ESS3-3. **Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.*** [Clarification Statement: Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).]

MS-ESS3-4. **Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.** [Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human

populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.]

MS-ESS3-5. **Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.** [Clarification Statement: Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities. Emphasis is on the major role that human activities play in causing the rise in global temperatures.]

MS.Matter and Energy in Organisms and Ecosystems

MS-LS2-4. **Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.** [Clarification Statement: Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems.]

MS-LS2-2. **Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.** [Clarification Statement: Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of the relationships among and between organisms and abiotic components of ecosystems. Examples of types of interactions could include competitive, predatory, and mutually beneficial.]

MS-LS2-5. **Evaluate competing design solutions for maintaining biodiversity and ecosystem services.*** [Clarification Statement: Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.]

High School:

HS.Interdependent Relationships in Ecosystems

HS-LS2-1. **Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.** [Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.] [*Assessment Boundary: Assessment does not include deriving mathematical equations to make comparisons.*]

HS-LS2-2. **Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.** [Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.] [*Assessment Boundary: Assessment is limited to provided data.*]

HS-LS2-6. **Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.** [Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.]

HS-LS2-7. **Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*** [Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]

HS-LS2-8. **Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.** [Clarification Statement: Emphasis is on: (1) distinguishing between group and individual behavior, (2) identifying evidence supporting the outcomes of group behavior, and (3) developing logical and reasonable arguments based on evidence. Examples of group behaviors could include flocking, schooling, herding, and cooperative behaviors such as hunting, migrating, and swarming.]

HS.Natural Selection and Evolution

HS-LS4-5.	**Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.** [Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.]
HS-LS4-6.	**Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.*** [Clarification Statement: Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.]
HS-ESS3-4.	**Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*** [Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).]

MA Draft Revised Science and Technology/Engineering Standards

http://www.doe.mass.edu/stem/review.html (December 2013) The Department will make the draft revised standards public but will not be moving them forward to a public adoption process until the 2015-16 school year.

Biological Evolution: Unity and Diversity

(Based on 3-LS4-d)

3-LS4-4. Analyze and interpret data about changes **in the environment in an area and describe how the changes may affect the ability of organisms that live in that area to survive and reproduce**. [Clarification Statement: Environmental changes should include changes to landforms, distribution of water, climate, and availability of resources. Changes in the environment could range in time from a season to decades. Data should be provided.] [Assessment Boundary: Assessment is limited to a single environmental change, however, it is understood that environmental changes are complex.]

5-ESS3 Earth and Human Activity
5-ESS3-1. Obtain and combine information about ways communities reduce the impact on the Earth's resources and environment by changing an agricultural, industrial, or community practice or process. [Clarification Statement: Examples of changed practices or processes include treating sewage, reducing the amounts of materials used, capturing polluting emissions from factories or power plants, and preventing runoff from agricultural activities.] [Assessment Boundary: Assessment does not include social science aspects of practices such as regulation or policy.]

Grade 7 MS-LS2 Ecosystems: Interactions, Energy, and Dynamics
MS-LS2-1. Analyze and interpret data to provide evidence for the effects of periods of abundant and scarce resources on the growth of organisms and the number of organisms (size of populations) in an ecosystem.
MS-LS2-2. Describe how relationships among and between organisms in an ecosystem can be competitive, predatory, parasitic, and mutually beneficial and that these interactions are found across multiple ecosystems. [Clarification Statement: Emphasis is on describing consistent patterns of interactions in different ecosystems in terms of relationships among and between organisms.]
MS-LS2-4. Analyze data to provide evidence that disruptions (natural or human-made) to any physical or biological component of an ecosystem can lead to shifts in all its populations. [Clarification Statement: Focus should be on ecosystems characteristics varying over time, including disruptions such as hurricanes, floods, wildfires, oil spills, and construction.]
MS-LS2-5. Evaluate competing design solutions for protecting an ecosystem. Discuss benefits and limitations of each design.* [Clarification Statement: Examples of design solutions could include water, land, and species protection, and the prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.]
MS-LS2-6(MA). Explain how changes to the biodiversity of an ecosystem—the variety of species found in the ecosystem—may limit the availability of resources humans use. [Clarification Statement: Examples of resources can include food, energy, medicine, and clean water.]

Grade 8: Life Science

Grade 8 MS-LS1 From Molecules to Organisms: Structures and Processes

MS-LS1-5. Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. [Clarification Statement: Examples of local environmental conditions could include availability of food, light, space, and water. Examples of genetic factors could include the genes responsible for size differences in different breeds of dogs, such as Great Danes and Chihuahuas. Examples of environmental factors could include drought decreasing plant growth, fertilizer increasing plant growth, and fish growing larger in large ponds than they do in small ponds. Examples of both genetic and environmental factors could include different varieties of plants growing at different rates in different conditions.] [Assessment Boundary: Assessment does not include methods of reproduction, genetic mechanisms, gene regulation, biochemical processes, or natural selection.]

HS-LS4-5. Evaluate evidence that demonstrates how changes in environmental conditions may result in the emergence of new species over generations and/or the extinction of other species, and that these processes may occur at different rates depending on the conditions. [Clarification Statement: Examples of the processes occurring at different rates include gradualism versus punctuated equilibrium and background extinction versus mass extinction).]

HS Human Sustainability

Earth and Space Science HS-ESS3 Earth and Human Activity

HS-ESS3-1. Construct an explanation based on evidence for how the availability of key natural resources and changes due to variations in climate have influenced human activity. [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils (such as river deltas), high concentrations of minerals and fossil fuels, and biotic resources (such as fisheries and forests). Examples of changes due to variations in climate include changes to sea level and regional patterns of temperature and precipitation.]

HS-ESS3-2. Evaluate competing design solutions for minimizing impacts of developing and using energy and mineral resources, and conserving and recycling those resources, based on economic, social, and environmental cost-benefit ratios.* [Clarification Statement: Examples include developing best practices for agricultural soil use, mining (for metals, coal, tar sands, and oil shales), and pumping (for petroleum and natural gas).]

HS-ESS3-3. Illustrate relationships among management of natural resources, the sustainability of human populations, and biodiversity. [Clarification Statement: Examples of factors related to the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors related to human sustainability include agricultural efficiency, levels of conservation, and urban planning. Examples of factors related to biodiversity include habitat use and fragmentation, and land and resource conservation.]

HS-ESS3-5. Analyze results from global climate models to describe how forecasts are made of the current rate of global or regional climate change and associated future impacts to Earth systems. [Clarification Statement: Climate model outputs include both climate changes (such as precipitation and temperature) and associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).] [Assessment Boundary: Assessment is limited to one example of a climate change and its associated impacts.]

Fish Wish
By Liz, Lindsey and Jenny Duff 2011
(Tune somewhat like Popeye the Sailor Man)

I sing now of the local brook trout
In cold water they swam about
Generations of fish
Had homes they cherished
They were happy beyond any doubt

I sing now of the native brook trout
Who thought they had life figured out
But as earth gets hot
These cool fish cannot
Find a way to make their lives workout

(Chorus has a different tempo)
Are you willing to recycle and bicycle for icicles?
Are you willing to compost, & eat less roast for the coast?
Are you willing to car pool & use less fuel? Come on its cool!
Are you willing to use man-power, take a sun shower, & buy local flowers?
Help fulfill the wish of these cold-water fish!

If temperatures exceed the norm
Their lives will most certainly transform
They can't stand the heat
Other fish will compete
For the rivers and streams that are warm

Are you willing to take the lead, and plant a tree, we're gathering speed.
Are you willing to use a pen again and again to encourage a friend?
Are you willing to use clothes pins, it's time to begin, and we'll all win.
Are you willing to sing a song, to right a wrong, & carry on?

Save the cool brook trout so they don't fade out.
What are you willing to do for the cool brook trout?

(invite audience to call and response.)

Are you willing to recycle and bicycle for icicles?
Are you willing to compost, & eat less roast for the coast?
Are you willing to car pool & use less fuel? Come on its cool!
Are you willing to use man-power, take a sun shower, & buy local flowers?

Let's all give a shout for the cool brook-trout!
Our actions will surely help out

(Final Verse)
Remember the native brook trout
They're grateful to you
For all that you do
Please don't leave these cool fish in doubt

Mass Audubon
Protecting the Nature of Massachusetts
LTER

Mass Audubon School Programs

At Mass Audubon we strive to create learning experiences that are enriching, innovative, meaningful, and engaging. All our school programs are aligned with Massachusetts Curriculum Frameworks. Our network of wildlife sanctuaries and nature centers located in urban, suburban, and rural communities around the state enable us to have strong relationships with local schools.

Our Education Foundations

- Place-based education is an educational philosophy that connects learning to what is local for an individual. We help build conservation communities, working with students and teachers in cities and towns to develop place-based environmental education that is linked directly to their home community.
- Inquiry-based learning is focused on teamwork, being learner-centered, questioning ourselves and the world around us, providing a more focused, time-intensive exploration, promoting lifelong learning, communication, and learning as fun.
- We are fully committed to creating a positive and supportive environment for all learners.
- We strive to be culturally sensitive, recognizing and embracing cultural differences.

Differentiated Instruction

- We strive to create a positive learning environment that is inclusive, supportive to all learners, and sensitive to cultural diversity.
- Outdoor classroom experiences are structured to meet the needs of the particular learners.
- Students work in small groups using hands-on materials.
- A variety of educational media are used, including colorful illustrations.
- With advance notice, efforts will be made to accommodate all learning styles and physical needs.

Notes

- Nature exploration is dependent upon the weather and other conditions. A class might observe different wildlife than they expected to see. An outdoor lesson can sometimes provide unexpected, but enriching teachable moments on a natural history topic that was not planned.
- Mass Audubon nature centers each have a unique landscape and will customize programs to work best at their particular site.
- Our lessons can be adapted to incorporate a classroom teacher's needs.