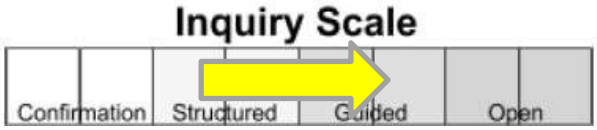
Investigation Title/Lesson Name: Inland Fish and Warming Waters

Name of Sanctuary:	Endicott
Grade Level:	Grades 3-8, with extension activities for grades 9-12 and further extensions for grades 3-12
Location Options:	Targeted Ponds or Streams
Time Required:	1-2 hours
Investigation Designer:	Liz Duff
For more info:	endicott@massaudubon.org or pie_im@mbl.edu



Unit Context: This investigation could fit within a unit about human impact. It will be used to highlight how human activities can change habitats, creating unsuitable conditions for the species that used to live there. This investigation should follow some discussion of different types of human impacts within watersheds – climate change, dams, paved surfaces, etc. The extension activities can be used to move into the final part of the unit: How can we reduce human impacts?

Investigation Focus

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. This lesson builds upon Plum Island Ecosystem-Long Term Ecological Research (PIE-LTER) science. Their goal of understanding the broad range effects of climate change in watershed communities can be aided by students developing the knowledge of how humans and the climate affect local ecosystems.

Subject:

Biology, Ecology, Life Science

Guiding 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?

State Learning Standards:

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

2016 Massachusetts Science and Technology/Engineering Curriculum Framework

3-LS4-4. Analyze and interpret given data about changes in a habitat and describe how the changes may affect the ability of organisms that live in that habitat to survive and reproduce.

5-ESS3-1. Obtain and combine information about ways communities reduce human impact on the Earth's resources and environment by changing an agricultural, industrial, or community practice or process.

7.MS-ESS3-2. Obtain and communicate information on how data from past geologic events are analyzed for patterns and used to forecast the location and likelihood of future catastrophic events.

7.MS-ESS3-4. Construct an argument supported by evidence that human activities and technologies can mitigate the impact of increases in human population and per capita consumption of natural resources on the environment.

7.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 size of populations in an ecosystem.

7.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.

7.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.

7.MS-LS2-5. Evaluate competing design solutions for protecting an ecosystem. Discuss benefits and limitations of each design

7.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.

8.MS-ESS3-5. Examine and interpret data to describe the role that human activities have played in causing the rise in global temperatures over the past century.

8.MS-LS1-5. Construct an argument based on evidence for how environmental and genetic factors influence the growth of organisms

Climate Literacy Principles that apply to this lesson:

GP) Humans can take actions to reduce climate change and its impacts:

B. Reducing human vulnerability to and impacts on climate requires multi-disciplinary integrated understanding.

Reducing human vulnerability to the impacts of climate change depends not only upon our ability to understand climate science, but also upon our ability to integrate that knowledge into human society. Decisions that involve Earths climate must be made with an understanding of the complex inter-connections among the physical and biological components of the Earth system as well as the consequences of such decisions on social, economic, and cultural systems.

EP 3) Life on Earth depends on, is shaped by, and affects climate.

A. Climate's role in habitats ranges and adaptation of species to climate changes.
Individual organisms survive within specific ranges of temperature, precipitation, humidity, and sunlight. Organisms exposed to climate conditions outside their normal range must adapt or migrate, or they will perish.

EP 4) Climate varies over space and time through both natural and man-made processes.

F. Evidence is that human impacts are playing an increasing role in climate change

Natural processes driving Earths long-term climate variability do not explain the rapid climate change observed in recent decades. The only explanation that is consistent with all available evidence is that human impacts are playing an increasing role in climate change. Future changes in climate may be rapid compared to historical changes.

EP 7) Climate change will have consequences for the Earth system and human lives.

E. Ecosystems on land and in the ocean have been and will continue to be disturbed by climate change.

Ecosystems on land and in the ocean have been and will continue to be disturbed by climate change. Animals, plants, bacteria, and viruses will migrate to new areas with favorable climate conditions. Infectious diseases and certain species will be able to invade areas that they did not previously inhabit.

Learning Outcomes:

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 – in °Celsius
- "Low Cost Water Monitoring Kit" Green LaMotte ($37.95 in 2014) (for Dissolved Oxygen)
- Salinity test kit (optional)
- Graph paper (big), and colored pencils (blue, green, yellow, orange, and red)

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.

Investigation/ 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**: Pre-activity assessment: None
   Embedded activity assessment: Observation of students' collecting temperature and dissolved oxygen data
   Post-activity assessment: Student conclusions about which sites would be suitable for brook trout

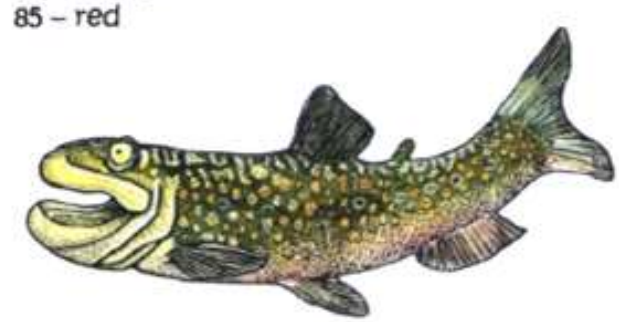
7. **Wrap Up**: Reflective journal writing. Practice and perform the "Fish Wish" song. Set intentions, with students for personal and/or class actions to help the fish.

Connection: This lesson links to science content learning in the 2018 MITS Summer Professional Development Institute *Investigating Ecosystems and Assessing Human Impact*. It investigates human impact on inland rivers. Students are actively involved in collecting data and thinking about how to have a positive impact on fish.

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!

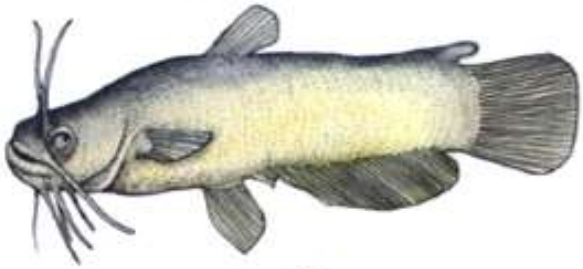
On the next page are four maps of the same watershed over a few decades of climate change. Barry's friend the brook trout needs cold water and prefers the water to be around 55 degrees F (blue), although they can survive in warmer water temps to about 65 degrees (green). As water temperatures warm (yellow, 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

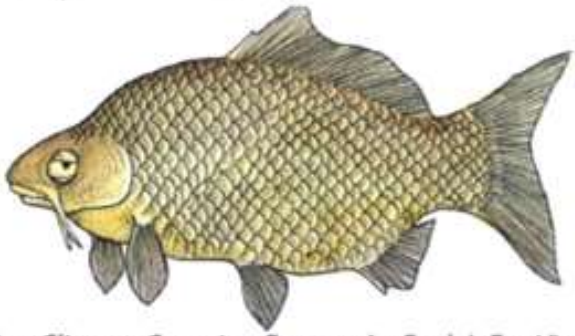


Brook trout (*Salvelinus fontinalis*) In spite of their name, brook trout are often found in lakes and are also common in cold, clear headwater streams. Like most salmonid fishes, brook trout thrive in waters with low temperatures and high oxygen content.

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.



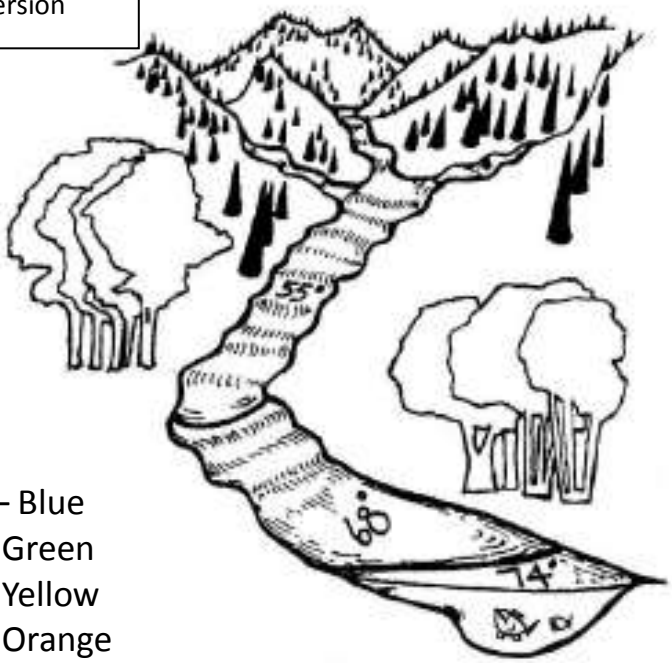
Carp (*Cyprinius carpio*) can inhabit turbid or clear water over mud and silt and are more common in warm water, even up to 100 degrees F.

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.

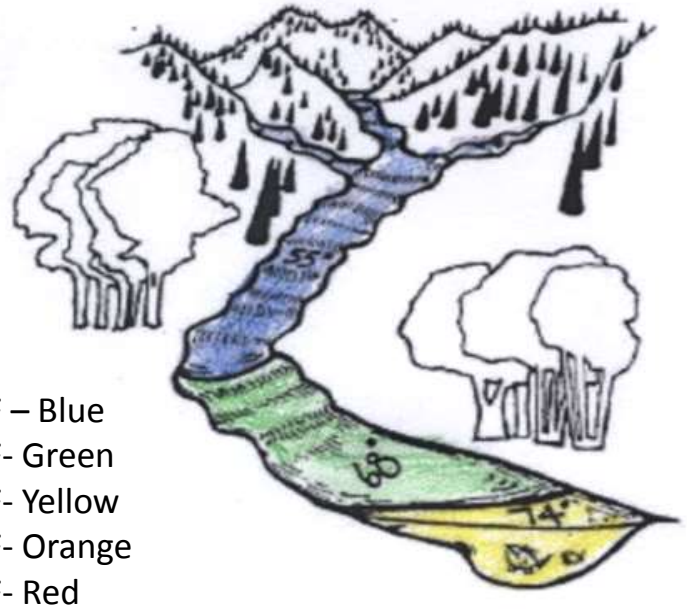
3. The planet continues to warm and now the cool-water habitat is gone and more of the habitat is very warm water.

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.

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
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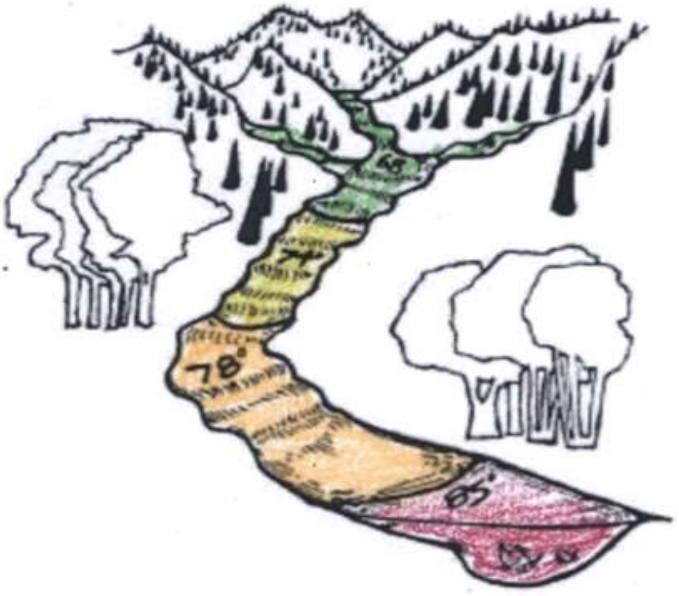


4. Finally, the entire stream is now a warm water stream, with likely little diversity in fish species as few can tolerate such warm water and low levels of oxygen.

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.

Name _____ Date _____

Student Instruction Sheets (Guided)

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

Engaging Experience:

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. Looking at pages 11-12, and given the information in the tables above, what questions do you have about trout and water temperature? Record the questions below. Consider your geographic location when you create your questions.

Questions

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

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

Procedure:

With a partner, or team, design an investigation based on one of your investigation questions above.

Describe the materials you will use to investigate this question, and list the steps below. **Check with the teacher before proceeding.**

Inland Fish and Warming Waters Extensions

Investigate Water Temperature Data on-line at US Geological Survey:
http://waterdata.usgs.gov/nwis/?IV_data_availability

Name _____ Date _____

Student Instruction Sheet (Structured)

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

Engaging Experience:

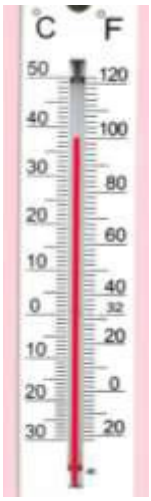
1. Read page 11-12, Fish Habitat from *Changing climate, Greening Energy: An Eagle's Eye View*
2. Color in page 12, following the color codes on page 11.

Materials:

- Paper, pencils
- Water thermometers
- "Low Cost Water Monitoring Kit" Green LaMotte (for Dissolved Oxygen)
- Graph paper, colored pencils
- Salinity test kit (optional)

Procedure:

1. Your teacher will divide you into groups. Each group will measure the temperature and dissolved oxygen levels of various water samples. Your teacher will tell you which samples your group will test from the following possibilities: tap water, water from the classroom aquarium, water in a local pond or stream, river water, fountain water, ocean water.
2. Follow directions in your LaMotte kit for testing dissolved oxygen.
3. If a salinity kit is available, follow the directions in the kit.
4. Record your data in the table provided
5. Use your water temperature data and the Color Chart below to decide what color is closest to your samples.
6. Share your data with other members of the class.



Color Chart		
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 °F (blue) but can survive to about 65 °F (green).

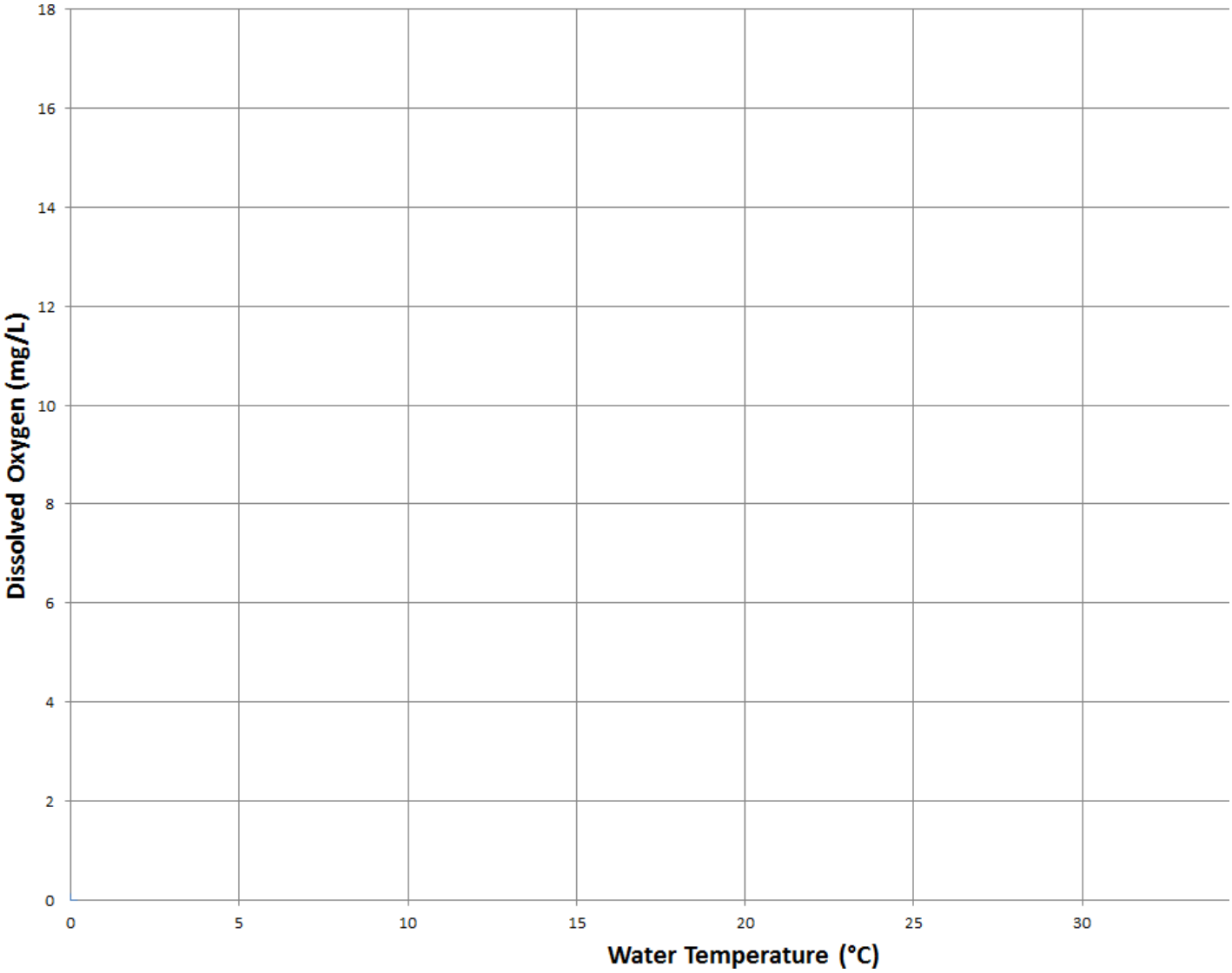
Carp can survive up to 100 °F. (Red)

To convert Fahrenheit to Celsius: Read the thermometer from either side,

Data:

Date	Time	Water Sample Location	Water Temperature	What "color" is this closest to?	Dissolved oxygen	(Optional) Air Temperature	(Optional) Salinity

Create a graph of your results, comparing dissolved oxygen to water temperature. Use the colored pencils that correspond to the temperature on the color chart.



Analyzing and Interpreting Data: Answer the following questions in your notebook.

1. Which of the water sample locations has water temperatures that brook trout prefer? Which locations have water temperatures that brook trout can survive in?
2. Do you think the locations with appropriate water temperatures for brook trout right now would be suitable for brook trout in July and August? Explain your answer.
3. What patterns do you see in your dissolved oxygen data?
4. 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?

State Learning Standards:

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.

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.

HS-ESS3-3. Illustrate relationships among management of natural resources, the sustainability of human populations, and biodiversity.

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.

HS-LS2-1. Analyze data sets to support explanations that biotic and abiotic factors affect ecosystem carrying capacity.

HS-LS2-2. Use mathematical representations to support explanations that biotic and abiotic factors affect biodiversity, including genetic diversity within a population and species diversity within an ecosystem.

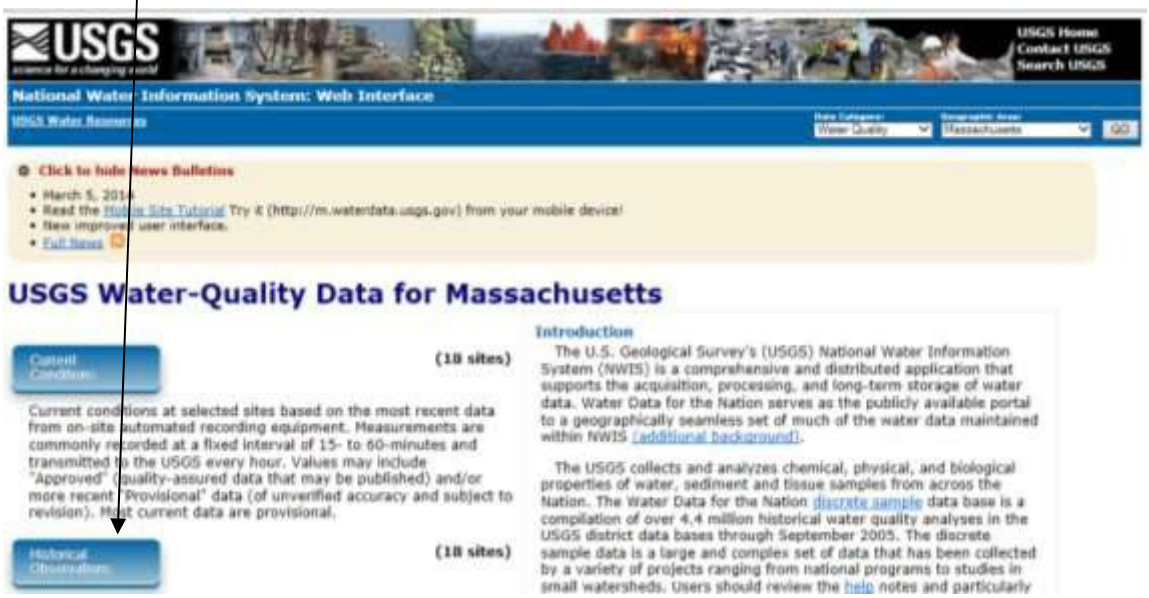
HS-LS2-6. Analyze data to show ecosystems tend to maintain relatively consistent numbers and types of organisms even when small changes in conditions occur but that extreme fluctuations in conditions may result in a new ecosystem. Construct an argument supported by evidence that ecosystems with greater biodiversity tend to have greater resistance to change and resilience.

HS-LS2-7. Analyze direct and indirect effects of human activities on biodiversity and ecosystem health, specifically habitat fragmentation, introduction of non-native or invasive species, overharvesting, pollution, and climate change. Evaluate and refine a solution for reducing the impacts of human activities on biodiversity and ecosystem health

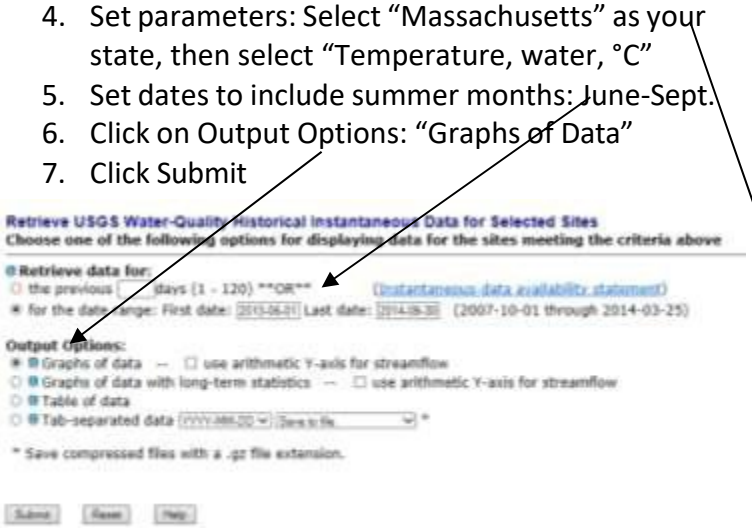
HS-LS4-5. Evaluate models that demonstrate how changes in an environment may result in the evolution of a population of a given species, the emergence of new species over generations, or the extinction of other species due to the processes of genetic drift, gene flow, mutation, and natural selection.

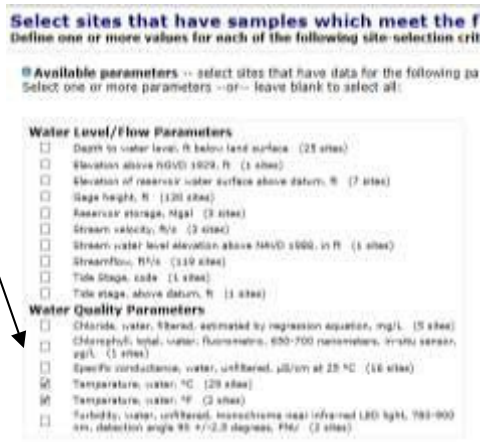
USGS Water Data for the Nation
http://waterdata.usgs.gov/nwis/

1. Click on “Water Quality” in the Data Category.
2. Click on ”Historical Observations” to get data from the past.



3. Click “State/Territory” under Location, then click “Submit”.
4. Set parameters: Select “Massachusetts” as your state, then select “Temperature, water, °C”
5. Set dates to include summer months: June-Sept.
6. Click on Output Options: “Graphs of Data”
7. Click Submit



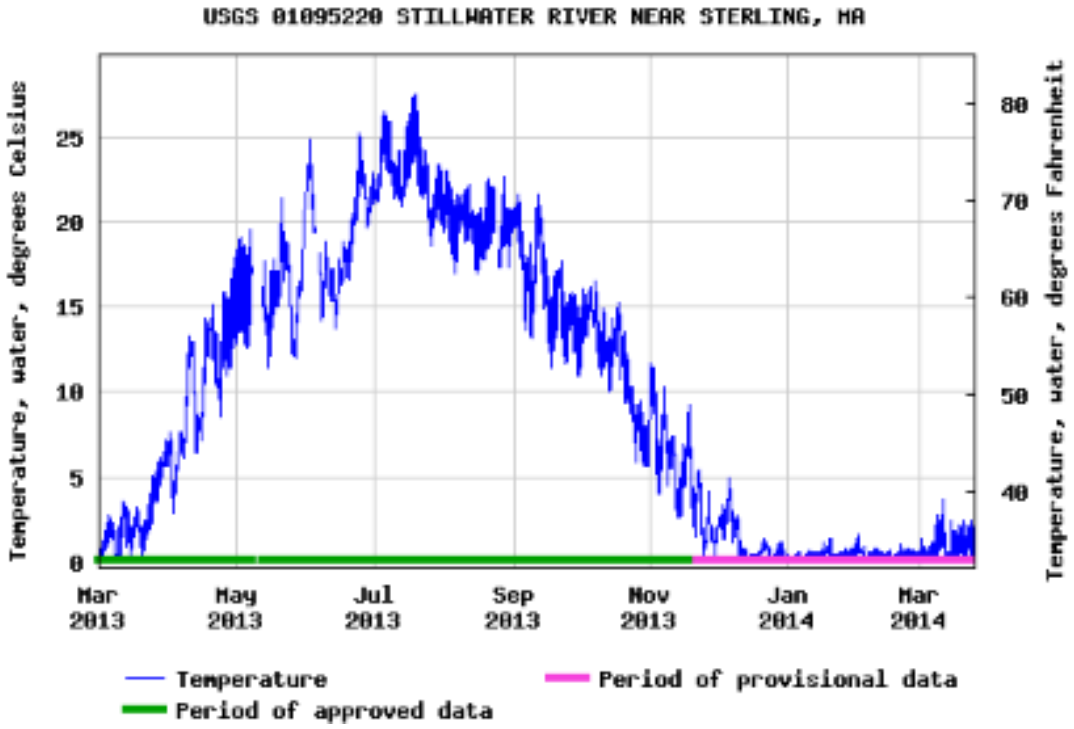


SAMPLE GRAPH from USGS Water Data

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:

Describe what is happening with water temperature on this 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).

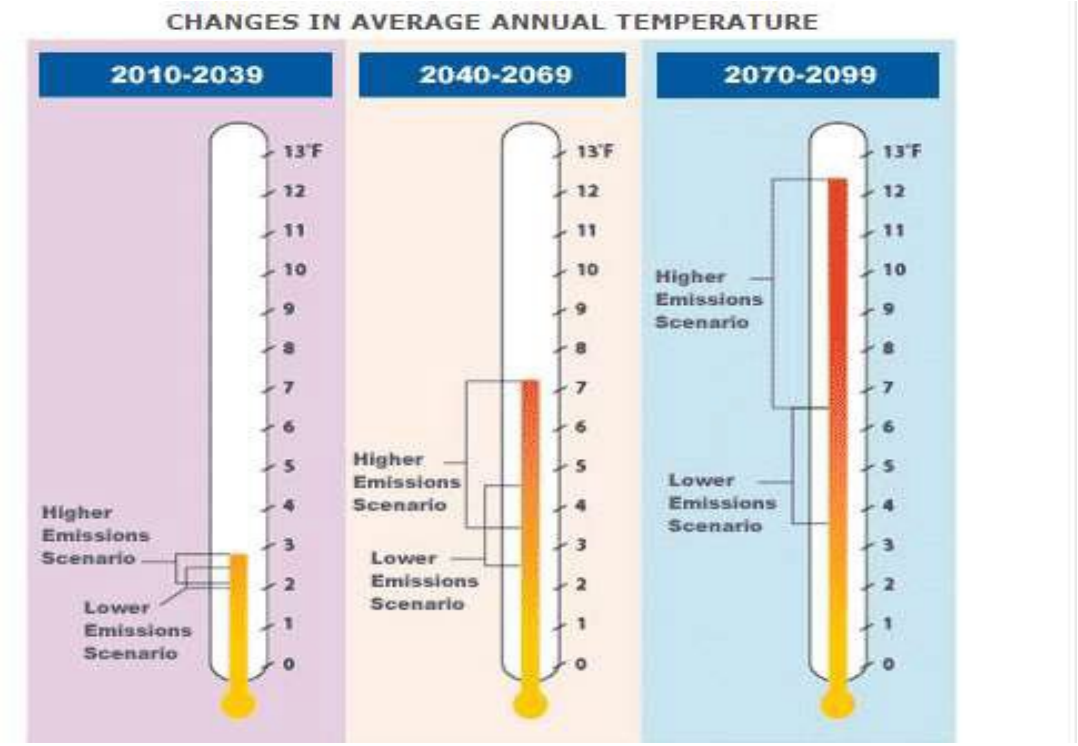
Hint: The Brook Trout (Salvelinus fontinalis) is the state fish for 8 states:

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



Based on the chart below, what are some human activities that could contribute to brook trout losing suitable habitat?

Horizontal cooling towers: riverine ecosystem services and the fate of thermoelectric heat in the contemporary Northeast US

OPEN ACCESS at Environmental Research Letters, Focus on Electricity,Water and Climate Connections (http://iopscience.iop.org/1748-9326/8/2/025010/article) Robert J Stewart[1], Wilfred M Wollheim[1,2], Ariel Miara[3], Charles J Vörösmarty[3,4], Balazs Fekete[3,4], Richard B Lammers and Bernice Rosenzweig

Table 3. Increases in unsuitable thermal habitats for various fish species in river segments downstream of thermoelectric plants. The total length of all river segments downstream of plants is 7530 km.

Fish species		Maximum average weekly tolerance[a] (°C)	Unsuitable habitat without thermoelectric plants considered (km)	Increase in unsuitable habitat due to thermoelectric plants (km)	Per cent increase in unsuitable habitat (%)
Brook trout	*Salvelinus fontinalis*	22.4	7526.6	3.9	0.1
Rainbow trout	*Oncorhynchus mykiss*	24.0	7451.1	45.5	0.6
Longnose dace	*Rhinichthys cataractae*	26.5	6100.1	191.8	3.1
Creek chub	*Semotilus atromaculatus*	27.1	5712.9	240.3	4.2
Northern pike	*Esox lucius*	28.0	5260.9	227.8	4.3
Walleye	*Stizostedion vitreum*	29.0	4687.1	461.1	9.8
Smallmouth bass	*Micropterus dolomieui*	29.5	4275.3	648.3	15.2
Bluntnose minnow	*Pimephales notatus*	30.1	3852.7	708.7	18.4
Golden shiner	*Notemigonus crysoleucas*	30.9	3177.5	773.4	24.3
River Carpsucker	*Carpiodes carpio*	32.1	2293.8	906.5	39.5
Red shiner	*Cyprinella lutrensis*	34.0	1452.8	782.5	53.9
Largemouth bass	*Micropterus salmoides*	35.5	917.6	738.6	80.5

[a] From Eaton and Scheller (1996).

Table 1. Stewart et al 2013. This PIE-LTER research table shows warming climate is not the only factor heating up fish habitat in the northeastern U.S.: thermoelectric power plants are too.

Extension for Grades 3-12

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 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.

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.

MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.*

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.

MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

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.

MS-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.*

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.

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. [

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.

HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*

HS-LS2-8. Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.

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.**

HS-LS4-6. **Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity**

HS- ESS3-4. **Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.***
[

Connections to Common Core ELA

Grade 6-8 Literacy

CCSS.ELA-Literacy.RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks

CCSS.ELA-Literacy.RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

Grade 9-10 Literacy
CCSS.ELA-Literacy.RST.9-10.3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
CCSS.ELA-Literacy.RST.9-10.9 Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.
Grade 11-12 Literacy
CCSS.ELA-Literacy.RST.11-12.3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
CCSS.ELA-Literacy.RST.11-12.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

Writing Grades 6-12
CCSS.ELA-Literacy.WHST.1 Write arguments focused on *discipline-specific content*
CCSS.ELA-Literacy.WHST.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
CCSS.ELA-Literacy.WHST.6 Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently
CCSS.ELA-Literacy.WHST.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

Reading Grades 6-12
CCSS.ELA-Literacy.RI.11-12.1 Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text, including determining where the text leaves matters uncertain.

CCSS.ELA-Literacy.RI.11-12.2 Determine two or more central ideas of a text and analyze their development over the course of the text, including how they interact and build on one another to provide a complex analysis; provide an objective summary of the text.
CCSS.ELA-Literacy.RI.11-12.3 Analyze a complex set of ideas or sequence of events and explain how specific individuals, ideas, or events interact and develop over the course of the text.

Connections to 21st Century Skills

Civic Literacy

- Understanding the local and global implications of civic decisions

Environmental Literacy

- Demonstrate knowledge and understanding of the environment and the circumstances and conditions affecting it, particularly as relates to air, climate, land, food, energy, water and ecosystems
- Demonstrate knowledge and understanding of society's impact on the natural world (e.g., population growth, population development, resource consumption rate, etc.)
- Investigate and analyze environmental issues, and make accurate conclusions about effective solutions
- Take individual and collective action towards addressing environmental challenges (e.g., participating in global actions, designing solutions that inspire action on environmental issues)

Work Creatively With Others

- View failure as an opportunity to learn; understand that creativity and innovation is a long-term, cyclical process of small successes and frequent mistakes

Critical Thinking and Problem Solving

• Use various types of reasoning (inductive, deductive, etc.) as appropriate to the situation
Systems Thinking
• Analyze how parts of a whole interact with each other to produce overall outcomes in complex systems

Make judgments and decisions

- Interpret information and draw conclusions based on the best analysis
- Reflect critically on learning experiences and processes

Solve Problems

- Identify and ask significant questions that clarify various points of view and lead to better solutions

Communication and Collaboration Communicate Clearly

- Articulate thoughts and ideas effectively using oral, written and nonverbal communication skills in a variety of forms and contexts

Collaborate with Others

- Demonstrate ability to work effectively and respectfully with diverse teams
- Exercise flexibility and willingness to be helpful in making necessary compromises to accomplish a common goal
- Assume shared responsibility for collaborative work, and value the individual contributions made by each team member

Produce Results

- Demonstrate additional attributes associated with producing high quality products including the abilities to: - Work positively and ethically - Manage time and projects effectively - Multi-task - Participate actively, as well as be reliable and punctual - Present oneself professionally and with proper etiquette - Collaborate and cooperate effectively with teams - Respect and appreciate team diversity - Be accountable for results

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 and tune)
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

Plum Island Ecosystems LTER (PIE-LTER|)

The Plum Island Ecosystems (PIE) LTER is an integrated research, education and outreach program. Its goal is to be able to predict the long-term effects of human activities on land, climate change, and sea level rise on the health of estuaries. While our studies are focused on a single system, this system can be considered a model for what is happening in estuaries worldwide. We seek to apply our ecological knowledge of how this system works to help in the management and development of policy that protects the natural resources of this and other estuaries in the U.S coastal zone. PIE-LTER has been investigating the ecology of Plum Island Sound estuary, in Massachusetts, since the late 1980s with support primarily from the National Science Foundation. The Plum Island project is one of only 4 LTER sites that study the effects of human activities in watersheds on estuaries. The PIE LTER has developed an extensive database open to the public via the Internet that includes our results from long-term field observations and experiments in the Ipswich, Parker and Rowley River watersheds and the Plum Island Sound estuary.

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.