Becoming Scientists:

Interpreting Visual Data

Grade Level: 5-12

Activity Duration:
Introduction: 10 minutes
Activity: 60-80 minutes
Wrap-up: 10 minutes

Overview:
Warm-Up: **Visualizing Data**
Fish Finder
Getting the Lay of the Land: **Map Interpretation**
Plotting Slope
Wrap-Up

Tool for Understanding the Nature of Science

http://undsci.berkeley.edu/

Summary: Discuss the variety of ways that data can be visually represented and understood. Dive into habitat structures that fish are most likely to use. Then examine satellite images, hill-shade maps, contour maps, and field notes to describe patterns and infer where potential fishing spots with ideal access points are located.

Topic: Interpreting Visual Data

Theme: Scientists represent data visually to better understand trends, exceptions and answer questions.

Objectives:

The students will:

1. Evaluate what can be inferred from different visual representations of data.
2. Suggest methods for collecting data required to create topographic maps.
3. Label the structures that define a river or stream.
4. Identify structures in a river or stream that provide fish habitat.
5. Translate visual data from aerial photographs, hill-shade maps, contour maps, and line graphs.
6. Generate a slope graph using x and y coordinates.
7. Justify evidence supporting possible fish habitat from maps and field notes.
8. Predict areas where access to a river is reasonable based on contour and hill-shade maps.

Suggested MN Science Standards:

This lesson may partially or fully address the following standards.

Grade 5:

5.1.3.4.2 - Create and analyze different kinds of maps of the student's community and of Minnesota. For example: Weather maps, city maps, aerial photos, regional maps, or online map resources.

Grade 7:

7.1.1.2.3 - Generate a scientific conclusion from an investigation, clearly distinguishing between results (evidence) and conclusions (explanation).
7.1.3.4.1 - Use maps, satellite images and other data sets to describe patterns and make predictions about natural systems in a life science context.

Grade 8:

8.1.1.2.1- Use logical reasoning and imagination to develop descriptions, explanations, predictions and models based on evidence.
8.1.3.4.1- Use maps, satellite images and other data sets to describe patterns and make predictions about local and global systems in Earth science contexts.

Grades 9-12:

9.1.3.1.2 - Identify properties of a system that are different from those of its parts but appear because of the interaction of those parts.
9.1.3.3.2 - Communicate, justify, and defend the procedures and results of a scientific inquiry or engineering design project using verbal, graphic, quantitative, virtual, or written means.

Environmental Literacy Scope and Sequence

Benchmarks:

- In social and natural systems that consist of many parts, the parts usually influence one another. (3-5)
- Social and natural systems may not function as well if parts are missing, damaged, mismatched, or misconnected. (3-5)
- Social and natural systems can include processes as well as things. (6-8)
- The output from a social or natural system can become the input to other parts of social and natural systems. (6-8)
- Social and natural systems are connected to each other and to other larger and smaller systems. (6-8)
- Interaction between social and natural systems is defined by their boundaries, relation to other systems, and expected inputs and outputs. (9-adult)

<u>Concepts partially or fully addressed in this lesson:</u> abiotic factors, properties, similarities and differences, cause and effect, ecosystem, patterns, probability, structure, boundary, habitat, scale

For the full Environmental Literacy Scope and Sequence, see:
www.seek.state.mn.us/eemn_c.cfm

Great Lakes Literacy Principles

*Only the **bolded** Great Lakes Literacy Principles are addressed in this lesson.*

- **The Great Lakes, bodies of fresh water with many features, are connected to each other and the world ocean.**
- Natural forces formed the Great Lakes; the lakes continue to shape the features of their watershed.
- The Great Lakes influence local and regional weather and climate.
- **Water makes the earth habitable; fresh water sustains life on land.**
- The Great Lakes support a diversity of life and ecosystems.
- **The Great Lakes and humans in their watersheds are inextricably interconnected.**
- Much remains to be learned about the Great Lakes.
- The Great Lakes are socially, economically, and environmentally significant to the region, the nation, and the planet.

For more information about the Great Lakes Literacy Principles, visit:
http://greatlakesliteracy.net/

Materials:

- Sample Graphic Representations
  Includes: Word Cloud, Pie Chart, Data Table, Bar Graph, Map, Info-graphic
- USGS Cross River Topographic Map
- **River or Stream Habitat Sheet** – 10 copies
- **River or Stream Habitat Sheet** – KEY- 2 copies
- **Fish ID Cards** – White Sucker, Brook Trout
- **Cross River Fishing Evaluation: Data Collection Form** - Student graphic Organizer
- **Reach Slope Graphs** (Runs 1-10) ***Make copies for each group ahead of time
- Cross Creek River Map Packet:
  - **Map A**: Aerial Photograph
  - **Map B**: Hill-shade Map
  - **Map C**: Contour Map
  - **Map D**: Contour Map with Coordinates
  - **Sample Reach Slope Graph** *Specific to each run, provide each group with their own copy
  - **Field Notes**

*Dry Erase Markers **– not provided**

Vocabulary:

Aerial photo: a photograph taken from a plane, balloon, or satellite in flight.

Contour map: a two dimensional representation of an area's steep or flat terrain denoted by parallel lines.

Cover: a shelter for resting and protection from environmental elements and predators: one of the four basic habitat needs of most living organisms (food, water/oxygen, cover, and space). Or a fixture over the interior gears and spool of line on a closed-faced fishing reel.

Current: the rate of fluid flow, especially water in a river or ocean. A current can be any continuous, directed movement of a fluid of various speeds.

Cut-bank: the outside curve of a bend or meander in a stream that is scoured by the faster and more direct impact of the moving water removing sediment, sand, and other materials composing the bank. Hollows in the outer bank may result. Water not only flows faster along the outer bend, but also flows more directly and forcefully into the outer bend as it flows through a curve in a stream or river.

Eddy: pocket of slower water behind structures such as rocks or debris in a stream or river. An eddy provides cover or a good resting spot and a good place for fish to hide prior to darting out and grabbing passing prey from the currents.

Elevation: height of a point above sea level.

Habitat: an area that meets the survival needs of many organisms by providing food, water, cover, and space.

Habitat needs: the basic things an organism needs to survive where it lives: including food, water (in aquatic ecosystems, water also provides dissolved oxygen for respiration), cover (shelter), and space.

Hill shade map: a modified image of varied terrain that includes simulated shadows caused by the sun's rays on the landscape.

LIDAR: stands for *Light Detection and Ranging.* It is a remote sensing method that uses light in the form of a pulsed laser to measure variable distances to the Earth. These light pulses—combined with other data recorded by an airborne system— generate precise, three-dimensional information about the shape of the Earth and its surface characteristics.

Map: a diagrammatic representation of an area of land or sea showing physical features.

Point-bar: on the inside bend, the current velocity slows and sediment is deposited. This shallow inside bend is called a point-bar.

Pool: an area of slower, deeper water in a river or stream, typically downstream of riffles.

Riffle: shallow area in a stream where the water moves quickly over rocks and is distributed from one bank to another.

Riparian habitat: the green corridor of native trees, shrubs, and grasses that grow along lakes, rivers, ponds, or streams.

Run: when fish migrate or travel to another location to spawn.

River mile: a river mile is a measure of distance along the river bed in miles from its mouth.

Sediment: erosion from the watershed (silt, sand, and organic and inorganic material) that accumulates on lake, river, and stream bottoms.

Sedimentation: the deposition or settling of soil particles suspended in water.

Slope: how steep a straight line is. The slope of a line is calculated by dividing the change in height by the change in horizontal distance.

Snags: dead trees submerged in the water; snags provide cover and habitat for fish.

Spawning: the active process of a fish releasing and fertilizing eggs.

Structure: any lump, bump, hole, or hideaway in a lake or streambed that can provide cover or shelter for a fish. Structure also includes rocks, plant beds, stumps, logs, piers, drop-offs, and "points" of shallow water extending into deeper water.

Substrate: bottom materials such as rocks, gravel, or muck.

Survey: to gather long-term information on population size and structure (such as the proportion of fish in age or length groups), fish growth, reproductive success, species abundance, fishing pressure and harvest rates, seasonal fish movement or migration, and habitat conditions (including plants, plankton, and invertebrates).

Topographic map: a map showing topographic features, usually by means of contour lines.

Undercut: small caves or hollowed out areas in the banks of streams and rivers.

Watershed: an area of land that catches precipitation (rain, sleet, and snow) and drains into a body of water such as a wetland, stream, river, lake, or groundwater.

Instructor Background Information:

Data Literacy

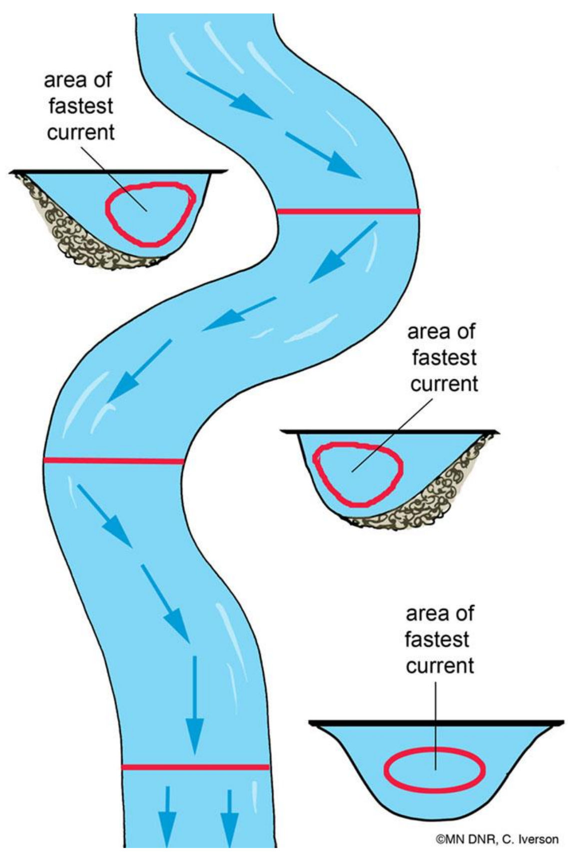
The following is excerpted from the NSTA "The Basics of Data Literacy-Helping Your Students (And You!) Make Sense of Data" by Michael Bowen and Anthony Bartley.

If you are a scientist or a science student, data literacy matters because it helps you make sense of information you have collected. We are surrounded by data – when you open a newspaper and see a graph or a table as part of an article, you are looking at data. When you listen to news on the television or radio, what you are hearing are conclusion drawn from data someone else has collected. This lesson is about developing data literacy in your students so they can make stronger arguments and better evaluate data presented to them. It is important to realize that everyone has an agenda of some sort, and being more data literate helps you understand if others are making a fair argument.

Understanding Streams and Rivers

The following is excerpted from MN DNR MinnAqua Program ***Fishing: Get in the Habitat!*** *Leader's Guide Lesson 1:5-Habitat Hideout.* http://tinyurl.com/habitat-hideout

Streams and rivers are dynamic—they're always changing. Streams and rivers have shallow and deep-water areas. Flowing water cuts into the banks on the outside bend of a **meander**, or curve in the course of a stream or river. When the water hits the outside bend, the water causes some of the bank to erode as it changes direction. This outside bend where soil is hollowed away is called the **cut-bank**. On the inside bend, the current velocity slows and sediment is deposited. This shallow inside bend is called a **point-bar**. The water sometimes carves deeply enough into the outer bank to form small caves that protect fish (such as trout or smallmouth bass) from the sun and from predatory birds. These small caves are referred to as **undercuts**. The current carries eroded silt and sand from cut-banks and undercuts downstream. As time passes, these natural stream formations migrate downstream so, several years later, they may be in different locations.

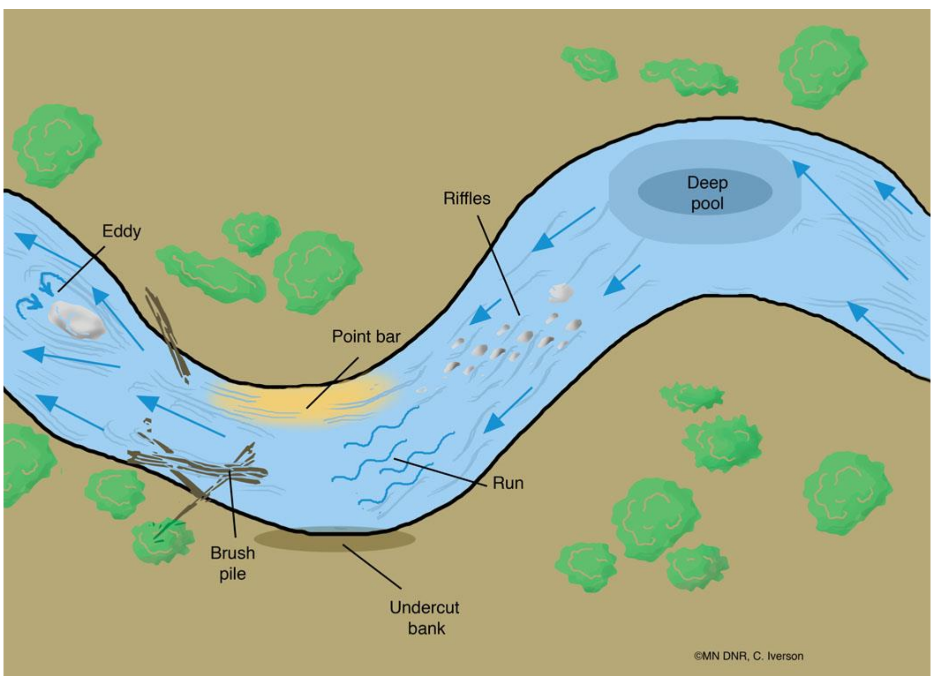


Structure

Structure can be any lump, bump, hole, drop-off or other hideaway in a lake or streambed. Submerged stumps, rocks, trees, plants, brush piles, boat docks, and fishing piers are examples of structure, too. Learning about the behaviors of fish species reveals clues about the types of habitats or structures that they prefer.

Fish are attracted to structure for many reasons. Structure provides a place for prey to hide from predators—it also gives predators a covert place from which to strike. On sunny days, structure provides shade for fish with light-sensitive eyes. River and stream fish find resting places where structure shelters them from strong currents. Structure sometimes serves as a landmark or place marker, just as a street sign tells us that we're home.

When flowing water hits an obstruction, such as a rock, brush pile, or log, it goes around it or over the top of the structure. The water curls and swirls around the structure, forming an **eddy** and often scouring a hole on the downstream side of the object. These spots make good places for fish to rest. Because it takes less energy to swim in these pocket areas, fish use less energy and need less food than they would if they spent all of their time swimming in the currents. From these resting spots, fish can dart out and capture passing prey from the currents. Carp, smallmouth bass, and trout can be found in eddies.



Shallow areas where the water moves quickly over rocks spread across the width of the stream are called **riffles**. (In larger rivers with greater water flow, these areas are called rapids.)

The turbulence of the flowing water hitting the rocks mixes oxygen from the air into the water, and frothy air bubbles can make the water appear white. Insects that require high levels of oxygen live on the rocks in riffles. Fish, such as trout, swim just below the riffle areas to catch the insects, such as stonefly larvae and mayfly larvae, that get knocked off or let go of the rocks to be carried downstream by currents. The areas of quieter water downstream of the riffles are referred to as **runs**. Quiet deeper areas where fish rest are called **pools**.

Examples of fish that live in streams include brook trout and smallmouth bass. Streams provide conditions that suit the needs of these fish, including higher dissolved oxygen levels, cooler water, abundant invertebrates, and adequate cover. The types of fish species that live in a stream can vary, depending on stream temperature. Trout need cooler streams, and smallmouth bass can be found in warmer water. (Although brook trout are typically found in cold water streams, some other species of fish, such as smallmouth bass, can be found in streams, rivers, or lakes.) Stream fish can be found in or behind structure such as pools, below riffles, in undercut banks, and behind rocks and brush piles.

Rivers can support a great diversity of fish species. Larger fish species that aren't found in small streams (such as sturgeon, paddlefish, catfish, and gar) live in Minnesota rivers. Rivers also contain some fish species usually found in lakes, including walleye, northern pike, and bass.

As in streams, areas of slow-moving water or structure provide good habitat for fish in rivers. Gar find respite from stronger currents behind logs, in brush piles, or in aquatic plants growing in the slow-moving backwaters. Catfish particularly like to sit in deep pools where they can rest from river currents. When they're hungry, the fish move to the front of the pool and wait for food to flow downstream to them.

Maps

Data, measurements and information can be gathered about the layout, features and scale of physical spaces and landscapes. A **map** is a visual representation of this information that highlights specific relationships between the objects represented. Maps can be both simple and complex. Similar to the representation of data on a table or graph, a map must include clear labels and a key in order for an individual to draw conclusions from it. A map for instance that does not identify the symbols used or provide a sense of scale would be little help in navigating a new landscape.

People use maps of many types in both research and everyday life. One might use a map to find their way to a museum or even within a museum. Scientists use maps to understand relationships between mountain ranges. Hikers use maps to find the next water source. Friends draw each other maps to find a new favorite restaurant. Cartographers and Geographic Information Systems (GIS) professionals spend their days gathering, verifying and organizing information as maps for similarly wide range of uses.

Additional Helpful Resources:

Introduction to contour maps – National Geographic:
http://education.nationalgeographic.com/education/activity/introduction-to-contour-maps/?ar_a=1

Teaching Students to create and interpret graphs:
https://www.teachervision.com/graphs-and-charts/lesson-plan/34514.html

Warm Up:

A (good) picture is worth a thousand words.

1. Share the sample graphic representations of data (data Table, bar graph, map, info graphic, ward cloud, scatter plot, pie chart) included in the kit with the class. Post on the board, or hand out sets to each group depending on class structure.

2. Review the different visual with the students:
   A. How they are used (media, research, decision making, etc.)
   B. Limitations
   C. What type of data can be represented (change over time, frequency, trends, stories, etc.)
   D. Do they have anything in common? (ALL based on DATA!)

3. Direct student attention to the **USGS Cross River Topographic Map** included in the kit.

4. Ask students to brainstorm and list on their **Data Collection Form**, individually or in small groups, the kinds of information you would need to gather to create this map.

   1. How would you get this information?
   2. Can you find it in a book or online?
   3. Could you visit the location and make observations/measurements yourself?

5. Explain that in this activity students will be using photographs, maps and data collected in the field to draw their own visual representation of a river. Students will transfer data from a map onto a graph with an x and y axis. (Refer to the sample graph shown at the beginning of the warm-up as a reference for using x and y coordinates.) Using their data they will be selecting locations to best access a river for fishing! First they will take a look into what makes good fishing habitat.

Activity:

*From Lesson 1:5 - Habitat Hide Out, MinnAqua Program **Fishing: Get in the Habitat!** Leader's Guide* http://tinyurl.com/habitat-hideout

Part 1:

1. Have students brainstorm ideas to the following prompts and record them on their **Data Collection Form**.

    a. Where do they catch fish when they go fishing (or where they think they would expect to find fish)?

    b. Describe the water, land, bank, tree cover, slope, sediment, etc.

    c. What leads them to think that they might catch fish in those spots?

    d. Why do they think the fish like those particular "hideouts?"

2. Ask students to think about these questions throughout the rest of the investigation.

3. Define the term structure for the students. Write the definition on the board.

    Structure: any lump, bump, hold, drop-off or other hideaway in a streambed.

4. Draw a stream outline on the whiteboard similar to the image provided on the **River or Stream Habitat Sheet**. Add the various types of structure to the stream drawing. Label and define each type of structure as you draw them:
    a. structure types for the stream or river: aquatic plants, fallen logs and brush piles, riffles, runs, deep holes or pools, cut-banks, undercuts, point-bar, rocks, and eddies

5. Explain that the drawing of the stream or river is a habitat map that illustrates a birds-eye view of structure and characteristics. Maps like this can help anglers locate likely fish habitat hideouts! They can use this drawing as a reference today while interpreting their maps of the Cross River.

Part 2: Identifying Habitat Hideouts

1. Pass out a **River or Stream Habitat Sheet** to each student or group. The drawings on the board should resemble those on the **River or Stream Habitat Sheet**.

2. Have a volunteer read the name and back of each **Fish Identification Card** (Brook Trout and White Sucker) to the class and decide where in the river or stream this fish might live. Is this fish most likely to be found in aquatic plants, in a brush pile, or in a pool?

3. Discuss why the fish might prefer that location and habitat. What kind of food does it eat? Where does it find its food? Are its eyes sensitive to light?

4. If the fish can be found in more than one place, have the student choose one likely location and, using the drawings on the whiteboard, point to this habitat or structure.

5. Use the center card to confirm the actual location.

6. Bring the focus back to the topographic map of Cross River. Identify the mouth of the Cross River found near Schroeder, MN. Use a dry-erase marker on the topographic map to circle the mouth. Explain that each **River Map Packet** contains several maps detailing a 2 kilometer reach of the Cross River. Reach 1 begins at the mouth of the river as it spills into Lake Superior. Reach 2-10 are north of this first reach and are separated into 2 kilometer sections.

Part 3: Interpreting Maps for Fish Habitat and River Access Points

Section I Getting the Lay of the Land

1. Divide your students into 10 teams.

2. Provide each group a **River Map Packet**. Each group will also need a copy of the corresponding **Reach Slope Graph**. These packets contain maps and other field data that will help the group locate potential fishing locations on the Cross River. The teams will report back to the group throughout the course of this investigation.

3. Instruct students to wait for instructions of when to look at the contents. This will encourage greater interpretation of the maps. Each **River Map Packet** has one of the following:
    a. Aerial photo of a portion(Reach 1-10) of the Cross River – **Map A**
    b. A hill-shade relief map of the same reach of the Cross River – **Map B**
    c. A contour map of the same reach of the Cross River – **Map C**
    d. A second contour map with (x,y) coordinates – **Map D**
    e. Sample blank **Reach Slope Graph** paper*provide a new copy to each group
    f. **Field Notes** data sheets for the portion of the Cross River shown on the student's map

4. Explain to students that we are now going to plan a fishing trip along the Cross River by evaluating visual data (in the form of maps) and field notes taken by local scientists. It's a long river though and we don't know how far we'll need to hike to find good fishing habitat or where we will be able to easily access the river.

5. Have the students open their packets and pull out _JUST_ the aerial photo-**Map A.** Let your students know that this is a "birds-eye view" of the Cross River and that each team has a unique reach of the river, so each team has different maps. Have students discuss and record answers to the following questions on their **Data Collection Form**:
    a. What can you see on the aerial photo?
    b. What can you learn about this section of the river by looking at this photo?
    c. What additional information is needed in order to see where potential fish habitat and access to the habitat may be? Would it be easier to see the river without the trees in the way?

6. Now have the students pull out and only look at the hill-shade relief map - **Map B**. Explain that this is a 3-D map that shows what the surface of the earth looks like around Cross River. It was created using a computer program to show ground elevations by adding sunlight which causes shading. Discuss and record answers to the following questions on your **Data Collection Form**.
    a. What can you see in this hill-shade map?
    b. Have teams identify the different types of information found on this map (or complete as a whole group).
        i. Elevation
        ii. Stream channel
        iii. Hills, ridges
        iv. Human structures (roads, trails, bridges, dams, etc.)
    c. What can you learn about this section of the river by looking at this map?
    d. What additional information is needed in order to see where potential fish habitat and access to the habitat may be?
    e. Where/how might we access the river on this fishing trip?

7. Ask the students to now pull out only the contour map- **Map C**. Have the students look at the contour map (also called a topographic map), **Map C** and record their responses on the **Data Collection Form**:
    a. What can you see on this map?
    b. What do you think the lines on the map mean?
    c. Do you need more information in order to see where potential fish habitat may be?
    d. Where/how might we access the river on this fishing trip?
    e. Compare **Map A** to **Map C** – locate the numbered points on **Map A** and locate the corresponding location on **Map C** as a way to help with orientation.

8. Reference again the full topographic map of the Cross River. Explain to students that this type of map uses parallel lines to show changes in elevation. The closer

the lines are together, the more rapidly the slope or steepness of the hill is changing. Lines that are farther apart represent a more gradual slope or flat area.

9. Ask students to find:
   a. The area on their map that has the steepest slope (or lines that are the closest together).
   b. An area on their map that represents a flat area.
   c. Have each team locate their reach on the full topo map.

   Note: All student maps are different. Some may show more varying topography than others.

Section II: Plotting data points to visualize slope

1. Ask students to now pull out and look at **Map D**. This map is the same contour map that students examined earlier. Red data points mark actual location along their section of river where a scientists estimated slope from a straight transect of the 2km reach (x= river miles in meters) and elevation (y= elevation in meters).

2. Explain to students that the slope of the river, a hill or a line can be measured and visually represented several ways. The slope or rate of change in elevation on the contour maps was represented by the relative distance between parallel lines. Slope can also be represented by a line on a graph with an x and y axis. Because the slope represents the change in elevation from one point to another, you need at least two points to calculate the slope.

3. Explain to students that they will use the coordinate points on the contour **Map D** to make points on a graph. Notice that the points on the contour map are associated with an "x" value and a "y" value. The height of a point, in this case, above sea level will be plotted on the y or vertical axis. The distance of that point from the last point, or in this case, from the river mouth can be plotted on the x or horizontal axis. Ask them to remove their unique graph paper from their packet.

4. Demonstrate plotting several sample points using a projection of a graph found on the kit CD. Ask a student from the group with the first reach of the river to provide you an "x" value. Demonstrate finding the corresponding value on the x axis. Ask the student for the "y" value. Demonstrate finding the corresponding value on the y axis. Use your finger or a pencil to trace a line from these locations on each axis. Place a dot or data point where the two lines intersect. Repeat this process for at least one more x:y coordinate. Draw a line between the two points on the graph with a ruler or straight edge. Remind students that the change in elevation or how steep the line is between the points represents how steep the river actually is between those two points.

5. Ask students to plot the data points found on **Map D** on their unique **Reach Slope Graph**. Each group has a unique part of the river. Therefore, the values on both the x and y axis are unique to each group. As students plot the data, ask them to keep an eye out for parts of the line that have the steepest slope. These are likely locations for riffles or even waterfalls!

6. Invite each group to share their observations about their section of the river with the class. Start with the group that had the mouth of the river and work upstream. Post each graph at the front of the room to create a continuous stream profile. Have students indicate on their graph if and where potential fish habitat and river access points may be on the Cross River. Students may find after reflecting on the data from the entire class that an area they considered to have a steep slope is minor related to another section of the river.

7. Finally, have students look at the **Field Notes** for their reach. Looking at the data table and images have students discuss:
    a. Does your field data suggest possible fishing habitat?
    b. What specific evidence supports or eliminates this area as possible fish habitat?
    c. Would you be able to easily access this area?
    d. Did the images and data confirm or change your image of the reach from interpreting the maps and graphing the slope?
    e. From the listed "Location of data collection point" in the **Field Notes** have students locate the collection site on **Map C** (they can additional locate the same point on **Map A** and **Map B**).

Wrap Up:

1. In their small groups have your students answer one or more of the following questions, justifying their answers using the data they collected:

    a. Are there questions that the maps were not able to answer?

    b. Is there a section of river that you'd like to learn more about?

    c. What features on the maps sparked your interest?

    d. How would you go about finding the answer to your questions?

    e. Did the maps give you information that data points alone would not have? Explain.

2. Have the small groups create a summary of their data and report their findings to the class. This could be done in a variety of ways, such as a PowerPoint presentation, poster, oral presentation, or video, etc.

Extensions:

1. Calculate the slope of a section of the river or the landscape using only the contour maps (**Map C**) provided.

2. Conduct a field study that measures the slope of a local topographic feature.

3. Have students predict how changes in the habitat might benefit or harm fish.

4. Have students plan a fishing trip including: budget (food, gas), safety concerns (life jackets), list of materials/gear, what state and federal regulations they will need to know (fishing season, trout stamps, park permits, etc.), what access point they will use, how they will avoid transferring invasive species, what their best bait option might be, and of course what location on the Cross River they will fish!

References:

1. "Topographic map" Def. 1. *Dictionary.com*. Web. 24 Oct. 2014.

2. Bowen, Michael & Anthony Bartley. 2014. "*Introduction to Chapter 1" The Basics of Data Literacy: helping your students (and you) make sense of data.* NSTA Press.

3. MN DNR MinnAqua Program. (2010). Fishing: Get in the Habitat! Leader's Guide "Lesson 1.5- Habitat Hideout."

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