Fishing for Answers – how does stress affect behavior in a threatened species?

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Grade level: 7th – 9th (see basic questions) or 10th – 12th (see advanced questions)
Class size: 15 – 30
Setting: computer lab (or students bring laptops)
Time needed: 50 minutes
Equipment needed: Computers with internet access (1 per student), graphing paper (1 or 2 sheets per student), calculators

Objectives

Composite learning objective: Students will comprehend the connection between environmental stressors and relevance for wildlife conservation, through investigating the effect of temperature on swimming activity in lake sturgeon larvae.

Knowledge outcomes:

- Students can explain why stress affects behavior, and more specifically, why changes in temperature affect lake sturgeon.
- Students can describe the importance of understanding how environmental stressors affect wildlife populations.

Skill outcomes:

- Students can collect data from a video of lake sturgeon larvae swimming activity.
- Students can calculate and visualize means of two treatments using a graph.
- Students can compare two treatments using graphed data and draw a conclusion about the treatment effect.

Disposition outcomes:

- Student develop an awareness of how environmental stressors related to climate change have a profound effect on threatened wildlife species.
- Students develop an appreciation for using animal behavior studies to help inform conservation and management efforts.
- Students develop an appreciation for quantifying stress or behaviors to gain a more complete picture of developmental mechanisms.

Background

Lake sturgeon (*Acipenser fulvescens*) are an ancient fish species. They've been around since the Triassic but are now regionally threatened in the Great Lakes Basin after their populations were decimated by humans. Before 1900, lake sturgeon were hunted for their eggs, served as a delicacy called caviar. Sturgeon have also been threatened by habitat disturbance and environmental stressors related to climate change.

Like sharks, lake sturgeon are a cartilaginous fish; unlike sharks, lake sturgeon lack teeth. Instead, they're bottom feeders, locating food using the 4 dangling sensory organs near their mouths, called barbels. They ingest bottom-dwelling organisms with their vacuum-like mouths. Lake sturgeon are the largest freshwater fish in the Great Lakes, growing up to 200 pounds and over 6 feet long.

Every spring, lake sturgeon leave their lake and travel upriver to spawn. Lake sturgeon are extremely long-lived (up to 80 or more years!) and don't start reproducing until around age 20. After laying eggs in the river, the adults return to the lake, and the offspring hatch a few days later. After hatching, lake sturgeon are known as "free embryos" and still have a yolk sac. They burrow into the riverbed substrate and live off their yolk sac until emerging to begin feeding as larvae. Lake sturgeon larvae are only about an inch long, and are vulnerable to predators while the drift downstream back to the lake from which their parents came. During their first year, lake sturgeon experience 99% mortality, due in part to predation. As they grow, lake sturgeon develop rows of armor-like bony scutes along their backs and sides that protect them from predators.

Hatcheries are an important part of the conservation efforts for threatened sturgeon populations. The Black Lake Sturgeon Facility in Onaway, MI, releases juvenile sturgeon every year into the local population. During the spawning season in May – June, researchers snorkel the river and capture adult sturgeon in large nets. Eggs and sperm are collected from the sturgeon and taking back to the hatchery, where the eggs are fertilized. These hatchery-produced sturgeon are maintained in the hatchery throughout the summer until being released in the fall. Every year, scientists working with the sturgeon group design experiments to further an understanding of the threats that sturgeon face, and what conservation programs can do to help their populations. Experiments can investigate ecology, genetics, and behavior of sturgeon throughout many life stages to explore the complex relationship between sturgeon and their environment. This research can inform management and conservation efforts, and help predict the fate of threatened lake sturgeon populations.

One important area of research is the effects of environmental stressors on lake sturgeon. High temperature have been shown to be stressful to lake sturgeon during early life stages, causing increases in cortisol (a stress hormone). In other species, stress triggers a variety of behaviors, including reduced risk-taking, social withdrawal, and intensified responses to an alarm. Stress-related behaviors are often involved with antipredator responses and thus may influence predation rates. Therefore, in lake sturgeon larvae, stress-related behaviors triggered by warm temperature may change antipredator responses, and by extension may change predation rates. Understanding the relationship between stress, behavior, and survival is important in understanding how the environment impacts lake sturgeon during their vulnerable early life stages.

Discussion questions (before activity)

Basic questions (7th to 9th grade):

1) What kinds of behaviors or swimming activity do you expect to see in stressed sturgeon larvae? In non-stressed sturgeon larvae?
2) What kinds of behaviors or swimming activity do you think might be important for sturgeon to avoid predators?

Additional questions (10th to 12th grade):

1) How can understanding the connection between stress and behavior help inform lake sturgeon conservation programs?
2) We usually think of stress as a bad thing, but some stress-related behaviors can help animals avoid predation. However, behaviors that are helpful in the short-term can have long-term costs. Come up with three stress-related behaviors that were mentioned today. For each one, propose a short-term advantage and a long-term cost.

Activity

The videos are stored in this google drive:
https://drive.google.com/open?id=1qnHRWB35sprlYLMuF4lPcGI72D6THShc

In the google drive are 10 videos of cold treatment larvae and 10 videos of warm treatment larvae. In each video are 10 petri dishes, each of which contain 6 larvae. Students can choose any petri dish and any larvae to track. If you have more than 20 students, some will need to track larvae from different petri dishes in the same video (for example, one student can track the upper left petri dish in Cold Treatment 1, and one student can track the upper right). If dividing up videos this way, make sure students know which petri dish to choose.
Note that some of the larvae may remain stationary throughout the entire observation. If students choose one of these larvae and report 0 seconds active, make sure they know that their data point is still useful.

Instruct each student to pick one larva in their chosen petri dish, and to be careful to track this individual and not mix it up with any of the other larvae in the dish. Starting at video time 0:00, track the activity of the larva by letting the stopwatch run while the larva is moving, and pausing when the larva stops. Continue tracking for 1 minute, then pause the video. Pick a different individual (either from the same petri dish or a different one). If students are tracking multiple larvae in the same petri dish, they should be careful to not unintentionally pick the same individual twice. Continue until each student has tracked 4 larvae for the first minute of the video. Students should end up with 4 datapoints, each of which is a larva's total seconds of activity for the first minute of the trial.

To track activity, students will need a stopwatch. Either physical stopwatches or an online stopwatch will work. An online stopwatch can be used in a smaller window so that students can operate it while simultaneously watching the video.

Once students have collected data from 4 larvae, have students share the total seconds active that they recorded for each individual. Combine all of the datapoints into a dataset, separating warm treatment from cold treatment. Students can then calculate a mean for each treatment and make a bar graph. The bar graph should have two bars (one for each treatment) that indicate the mean. Axes should have numbers and labels. Remind students to include the units the appropriate. In this case, the y axis should be labeled something like "Mean Activity (seconds)."

For advanced students (10th to 12th grade), calculate the standard deviation for each treatment. Discuss how it's useful to know the variation around the mean, since that provides more information about the dataset and about the effect of the treatment. Add error bars to the graph showing standard deviation for each treatment.

$$s = \sqrt{\frac{\sum(x - \bar{x})^2}{n - 1}}$$

Have students combine into pairs or small groups to discuss their findings. Encourage them to work together to draw a conclusion, using their bar graph, of the effect of temperature on lake sturgeon larvae activity, and on the broader implications of their finding. Then have each pair or group report their thoughts to the rest of the class. For smaller class sizes, discussion can be class-wide rather than in smaller groups.

Discussion questions (after activity)

Basic questions (7th to 9th grade):

1) What's the difference in activity between the two treatments? What does this tell you about how temperature affects lake sturgeon?
2) How do you think the behaviors you observed will influence the sturgeon larvae's ability to avoid predation?
3) If you were a scientist studying lake sturgeon, what kind of experiment would you do next to find out how stressors affect them?
    a. What is your hypothesis?
    b. What kind of data would you collect?

Additional questions (10th to 12th grade)

1) What is the broader implication of our discoveries from this experiment? What kind of "big picture" do we now have about how climate change might be affecting threatened wildlife species like lake sturgeon? What pieces of the picture do we still need?

2) How are the results of this information useful to conservation and management for lake sturgeon specifically? How about for threatened wildlife generally?
3) If you want to better understand the effects of temperature on lake sturgeon behavior and predation, what kind of experiment would you design next?
    a. What is your hypothesis?
    b. What kind of data would you collect?

4) If you want to better understand how climate change may be changing predation rates of a threatened species, what other kinds of studies would be useful?
    (It's also important to understand the other side of the coin – how is the population and behaviors of the predator being affected? Also mention that ecological factors are complex and usually there are interactions between factors.)

Optional extension

This extension can be used for more advanced students or to extend the lesson time. After students have collected data from the videos, students pair up. One member of each pair has data from a warm treatment video, the other member has data from a cold treatment video. Each student pair makes a bar graph comparing warm treatment and cold treatment, based on only their 8 data points. Then student pairs share their results with the class – which temperature resulted in higher larval activity?

After this, pool the data from the entire class for both treatments. Student calculate a mean for each treatment, make a bar graph comparing means, and draw a conclusion about the effect of temperature on larval activity.

Discussion questions:

1) Was your conclusion different when you used just two datapoints vs. when you used the class dataset? Why do you think this was?
2) Which sample size do you think is more accurate, and why?
   (Larger sample size is more accurate.)
3) What is the value of using a mean to compare treatments? Are there other ways to describe the datasets that would also be useful?
   (Things like variation and distribution are also useful things to know about datasets and can make the picture clearer of how temperature affects behavior. Mention that there are different kinds of descriptive statistics and statistical tests that can help us understand datasets.)
4) If you were designing another experiment about sturgeon behavior, how would you incorporate these insights about sample size?
   (Planning a large enough sample size is an important part of designing an experiment. If a researcher knows approximately what kind of means and variation to expect, they can calculate "power" – a way to know ahead of time how large your sample size has to be in order to detect a difference between treatments.)

Note: For larger classes, students can form groups of four rather than pairs. Each group of four should have two members that investigated warm treatment videos, and two members that investigated cold treatment videos. Students then calculate means based on two datapoints per treatment.

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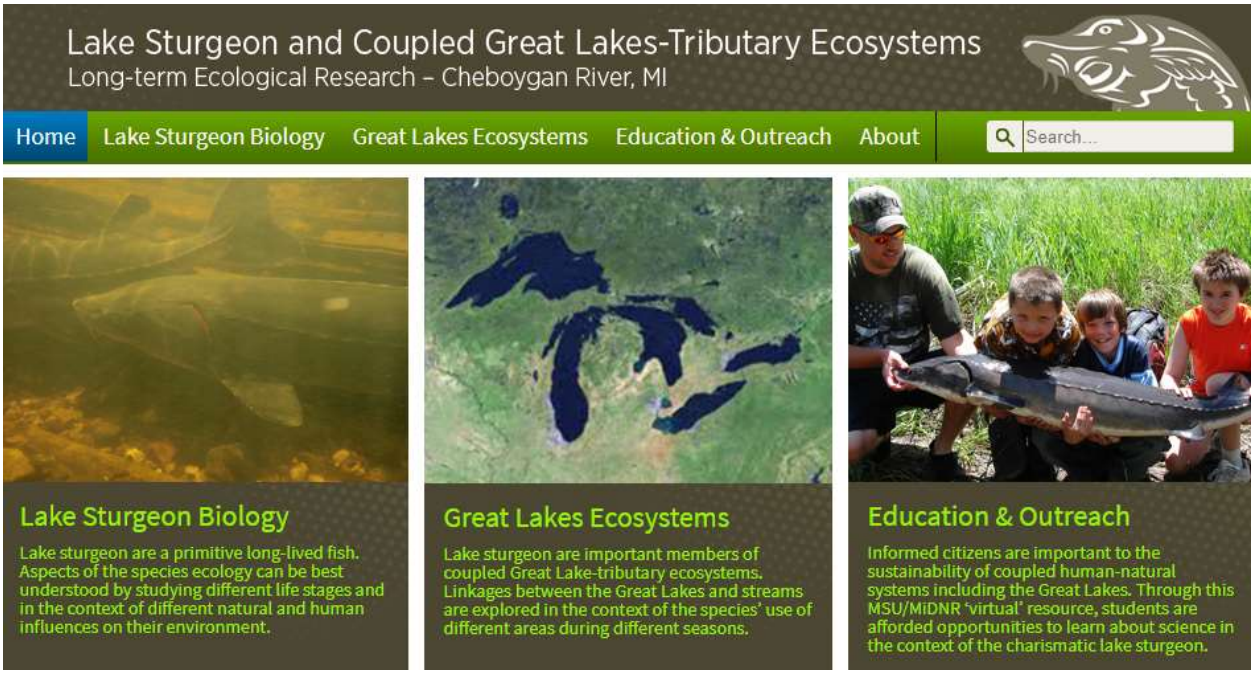
https://www.glsturgeon.com/



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of behaviors or swimming activity do you expect to see in stressed sturgeon larvae? In non-stressed sturgeon larvae?