An Introduction to River Water Quality Monitoring

Target Grade Level
AP Biology (11th-12th Grade)

Unit Summary:

This unit is designed to introduce students to the scientific process and conducting research. Rather than having students work on one aspect of research (e.g. hypothesis development, writing a protocol, collecting data, etc.) they are tasked with creating a sampling protocol for a stream, collecting water quality and stream characteristic data, analyzing collected data, and interpreting the data in order to develop a report that will help make fish management decisions.

This unit will give students the opportunity to take ownership over the data they collect. Rather than only work on one aspect of this unit, such as collecting the data or interpreting graphs, students will see the stream water quality sampling process from beginning (i.e. writing a stream monitoring protocol) to end (i.e. writing a formal report giving recommendations an agency). Students will practice their technical writing skills through developing a clear sampling protocol and writing a formal report. The students will become familiar with basic statistics (mean, median, and standard deviation) and how they are calculated using a spreadsheet, as well as basic graphing methods and what important information should be included in a graph (e.g. titles, proper units).

In addition to applying the scientific method, students will gain knowledge about the ecological consequences of water quality and overall stream “health”. Throughout the lessons in this unit students will be tasked with calling upon prior knowledge (prior to this unit and concepts taught in this unit) to synthesize ideas and develop a greater understanding of some of the things that can influence the health of fluvial aquatic ecosystems.

Many of the concepts covered in this unit can be related to other unit topics such as: ecosystems, habitat degradation, spatial and temporal variability, water chemistry, aquatic organisms, and geomorphology. For example, in this unit students will consider spatial differences in water quality, which can be related back to concepts covered in watershed science (e.g. impacts to the source of a watershed have downstream implications).

The first lesson in this unit will familiarize students with some basic concepts of water quality in streams (e.g. what is dissolved oxygen, pH. why they are important to monitor). As an activity, students will develop a sampling protocol for a local stream or river. In the protocol students will need to develop a sampling regime as well as determine what statistical and graphical methods they hope to use to analyze data.

Lesson two has students implementing their sampling protocol on a local stream/river. Prior to sampling, students will become familiar with various water quality monitoring equipment (e.g. Vernier unit and probes) as well as tools used to characterize physical aspects of a stream such a calipers used for measuring substrate size.

After stream water quality data is collected students will conduct an analysis on the data for the monitored stream along with data provided for two additional streams in lesson three. Measures of central tendency (i.e. mean and median) and measures of dispersion (i.e. standard deviation) will be calculated using spreadsheet software such as Microsoft Excel. Students will create graphs of means and medians as well as graph stream profiles, and will answer questions that require them to interpret the graphs they develop.

Lesson four requires students to compare the data they collected, analyzed, and interpreted to water quality/stream physical characteristic requirements for three species of fish. The goal of lesson four is to have students make management recommendations to a state or federal agency (e.g. Department of Natural Resources) about the appropriateness of each stream/river as habitat for each fish species. The students will write a professional report to the agency giving their recommendation on stocking each fish based on their interpretation of data collected in streams/rivers and that of habitat requirements for each fish.

Students should have basic prior knowledge in chemistry (e.g. what is pH), ecology and biology (what is a watershed, what is an ecosystem, what is ecology, examples of how organisms interact with their environment), word processing using Microsoft Word (or similar software), measures of central tendency such as mean and median, and use of a spreadsheet to make and interpret graphs.

Next Generation Science Standards:

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-LS4-6: Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.
HS-ESS2-5: Plan and conduct an investigation of the properties of water and its effects on earth materials and surface processes.

Lesson Title- Brief Description	**Learning Objectives** Students will be able to:	**NGSS Addressed (codes)**	**Materials**
Stream Water Quality Monitoring This lesson explores various ways water quality is monitored along with why it is important to monitor streams. Students will take what they learn about monitoring water quality and will write a sampling protocol for a local stream/river. The students will choose appropriate statistical methods (i.e. means/medians) to assess the data collected.	• Design a water quality monitoring program for a stream/river. • Write a clear and concise protocol for sampling a stream/river. • Identify the appropriate basic statistical methods to be used for data and justify their reasoning. • Choose and justify a graphing method that allows comparisons of data between sampling locations.	HS-LS2-2 HS-LS4-6	• Water Quality Monitoring Intro PowerPoint • Stream Water Quality Monitoring Student Worksheet • Computers with word processor and spreadsheet software • Overhead projector/ monitor
Collecting Water Quality Data Students will expand on their water quality monitoring protocol by developing data sheets to be used for recording data. Additionally, students will become familiar with using water quality monitoring equipment as well as tools used to characterize the physical conditions in a stream. Finally, students will implement their previously developed sampling protocol using the data sheets they develop in this lesson along with their newfound skills in using water quality monitoring equipment.	• Develop data sheets for measuring water quality, water velocity/depth, and substrate sample sizes. • Correctly use water quality sampling probes. • Correctly measure water velocity and depth in order to estimate stream discharge. • Correctly use calipers or a ruler to measure the diameter of substrate particles.	HS-LS2-2 HS-ESS2-5	• Collecting Water Quality Data Intro PowerPoint • Plastic bags or tubs • Water quality probes: pH, Turbidity, Conductivity, Temperature • Velocity probe • Vernier unit or alternative • Calipers or rulers • Student Data sheets (to be made by students) • Waders • Overhead projector/ monitor

Analyzing Water Quality Data Students review measures of central tendency (mean and median) and variation around a mean (standard deviation) as well as graphical methods used in excel. They then analyze the data previously collected along with data from two additional streams (to be given by the instructor), create appropriate graphs from the analyzed data, and interpret the graphs by answering questions that challenge them to not only compare graphs, but call on prior knowledge of what can influence water quality in a river.	• Calculate the mean, median, and standard deviation of water quality data. • Calculate discharge of a stream based on depth and velocity data. • Graph, interpret, and answer questions about water quality and stream discharge data.	HS-LS2-2	• Analyzing Stream Data Intro PowerPoint • Analyzing Water Quality Data Student Worksheet • Computers with word processor and spreadsheet software • Overhead projector/ monitor
Stream Water Quality Report Students will act as scientists working for an agency and apply their interpretation of data from the previous lesson by comparing it to habitat requirements for three species of fish. The students will write a repot to the agency giving their recommendation on stocking of each species in each of the rivers. Students will be required to interpret their graphs and the habitat conditions for each species and justify the suitability of each river as fish habitat.	• Interpret water quality and substrate data and draw conclusions on the abiotic conditions in a river. • Develop and justify reasoning for the suitability of rivers as fish habitat based on data interpretation. • Write a professional report to an agency outlining the results of an abiotic survey of a stream.	HS-LS2-2	• Stream Water Quality Report Intro PowerPoint • Stream Water Quality Report Student Worksheet • Computers with word processor and spreadsheet software • Overhead projector/ monitor

Safety Considerations:

Collecting Water Quality Data lesson has an outdoor lab component where students will sample/measure water quality features at locations along a river. Students should wear appropriate field clothing, as they will be working near water. Being outside and near water, students should be cautious about slipping on wet rocks as well as falling into the river. All other aspects of this unit are in the classroom or in a computer lab and therefore do no require additional safety considerations.

Evaluation Plan:

Formative Assessment Tools:

- Students will work in pairs and develop a water quality sampling protocol for a local stream.
- Students will work in groups while learning how to utilize water quality monitoring probes, stream velocity probes, and calipers.
- Students will work in groups and create water quality sampling data sheets based on the sampling protocol they develop
- Students will work in groups while measuring various water quality metrics in a local stream.

Summative Assessment Tools:
- Students will analyze the data they collect by calculating basic summary statistics and creating graphs.
- Students will be tasked with interpreting graphs by answering various questions that deal with similarities and differences between sampling locations.
- Students will write reports that require them to compare their graphs/data to additional datasets and draw conclusions/make recommendations based on their interpretation.

Resources (websites):
- http://www.vernier.com/support/manuals/ - Vernier Manuals and Reference Guide
- http://water.usgs.gov/owq/FieldManual/ - USGS Water Quality Field Manual
- http://water.epa.gov/type/rsl/monitoring/vms50.cfm - U.S. EPA Water Quality Monitoring
- http://www.michigan.gov/deq/0,4561,7-135-3313_3682_3714-69714--,00.html - Michigan DEQ Developing an Approvable Watershed Management Plan
- http://www.hrwc.org/publications/watershed-management-plans/ - Huron River Watershed Council Watershed Management Plans
- http://www.michigandnr.com/PUBLICATIONS/PDFS/ifr/ifrlibra/special/reports/Draft/1CheboyganRAssessDRAFT_TFT.pdf - Michigan DNR Cheboygan River Assessmen
- http://www.michigandnr.com/PUBLICATIONS/PDFS/ifr/ifrlibra/Special/Reports/sr21.pdf - Michigan DNR Manistee River Assessment

Brief description of how this unit relates to your graduate research:

The topics in this unit dealing with water quality monitoring and instream physical habitat assessment closely align with my research as part of a project aimed to assess the suitability of habitat in the Big Manistee River Watershed, MI for reintroduction of an extirpated species of fish, the Arctic Grayling. In my research we were to determine if the physical habitat characteristics in eight tributaries to the Big Manistee River were within the range of what is considered suitable for Artic Grayling based on reference conditions for past and current Arctic Grayling in North America. We were to decide which, if any, of the tributaries to the Big Manistee River were suitable for potential reintroduction based on physical habitat characteristics (water “quality”, substrates, stream morphology).

An important component of my research has been to monitor water “quality” in the form of temperature, dissolved oxygen, pH, and turbidity. Arctic Grayling are considered by many to be a cold-water species, and have been documented to show signs of stress and mortality when temperatures reach certain thresholds. Based on a literature review we determined a range of conditions in water “quality” where Arctic Grayling have been known, or are known to exist. As a part of this unit, the students will be measuring water quality at multiple

locations in a stream and comparing what they find to data for additional streams. This component of the unit is similar to what my research entailed in the eight tributaries we sampled.

In addition to collecting data for conditions of water quality, substrate, water velocity, and stream channel depth were assessed in each of our tributary streams. Substrates important to Arctic Grayling spawning were measured using various methods including “pebble counts” using calipers. The use of a pebble count in this unit was deliberate because of the ease of conducting one (students only need a pair of calipers, which are relatively inexpensive) and that pebble count data can be used for so much more than calculating a mean or median pebble size for a stream. In this sense, students can combine pebble count data with other information they gather for a particular stream (e.g. comparing pebble size distribution in different habitat types of a stream).

Each of the lessons in this unit tap into various components of my research, such as developing a sampling protocol, collecting and analyzing data, and writing up a report that states a recommendation based on scientific reasoning and data interpretation. One of the goals in this unit is that students will be acting as scientists and will be given an opportunity to participate in nearly all aspects of what scientists do on a daily basis. Emphasizing to students the importance of this unit and how similar it is to how research is done by scientists may help those thinking about a career in science or research dealing with aquatic ecosystems.