Modeling the Dynamics of Aquatic Ecosystems:
Changes in Biotic and Abiotic Factors Resulting from a Disturbance

Overview: This task requires students to use inquiry to investigate how changing one or more factors in a simulated freshwater ecosystem will affect the equilibrium of the environment. Implications of human influence can be illustrated throughout the task from teacher questioning to research of actual environmental cases to study. Analysis of data from the investigation and connection to actual cases will connect how man’s influence on the biosphere is disruptive on all systems in nature.

Standards:

SB4 Students will assess the dependence of all organisms on one another and the flow of energy and matter within their ecosystems.
  c. Relate environmental conditions to successional changes in ecosystems.
  d. Assess and explain human activities that influence and modify the environment such as global warming, population growth, pesticide use, and water and power consumption.

SCSh1 Students will evaluate the importance of curiosity, honesty, openness, and skepticism in science.
  a. Exhibit the above traits in their own scientific activities.
  b. Recognize that different explanations often can be given for the same evidence.
  c. Explain that further understanding of scientific problems relies on the design and execution of new experiments which may reinforce or weaken opposing explanations.

SCSh2 Students will use standard safety practices for all classroom laboratory and field investigations.
  a. Follow correct procedures for use of scientific apparatus.
  b. Demonstrate appropriate techniques in all laboratory situations.
  c. Follow correct protocol for identifying and reporting safety problems and violations.

SCSh3 Students will identify and investigate problems scientifically.
  a. Suggest reasonable hypotheses for identified problems.
  b. Develop procedures for solving scientific problems.
  c. Collect, organize and record appropriate data.

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d. Graphically compare and analyze data points and/or summary statistics.

e. Develop reasonable conclusions based on data collected.

f. Evaluate whether conclusions are reasonable by reviewing the process and checking against other available information.

SCSh4 Students will use tools and instruments for observing, measuring, and manipulating scientific equipment and materials.

a. Develop and use systematic procedures for recording and organizing information.

b. Use technology to produce tables and graphs.

c. Use technology to develop, test, and revise experimental or mathematical models.

SCSh6 Students will communicate scientific investigations and information clearly.

a. Write clear, coherent laboratory reports related to scientific investigations.

b. Write clear, coherent accounts of current scientific issues, including possible alternative interpretations of the data.

c. Use data as evidence to support scientific arguments and claims in written or oral presentations.

d. Participate in group discussions of scientific investigation and current scientific issues.

SCSh7 Students will analyze how scientific knowledge is developed. Students will recognize that:

a. The universe is a vast single system in which the basic principles are the same everywhere.

b. Universal principles are discovered through observation and experimental verification.

c. From time to time, major shifts occur in the scientific view of how the world works. More often, however, the changes that take place in the body of scientific knowledge are small modifications of prior knowledge. Major shifts in scientific views typically occur after the observation of a new phenomenon or an insightful interpretation of existing data by an individual or research group.

d. Hypotheses often cause scientists to develop new experiments that produce additional data.

e. Testing, revising, and occasionally rejecting new and old theories never ends.

SCSh8 Students will understand important features of the process of scientific inquiry. Students will apply the following to inquiry learning practices:

a. Scientific investigators control the conditions of their experiments in order to produce valuable data.

b. Scientific researchers are expected to critically assess the quality of data including possible sources of bias in their investigations’ hypotheses, observations, data analyses, and interpretations.

c. Scientists use practices such as peer review and publication to reinforce the integrity of scientific activity and reporting.

d. The merit of a new theory is judged by how well scientific data are explained by the new theory.

e. The ultimate goal of science is to develop an understanding of the natural universe which is free of biases.

f. Science disciplines and traditions differ from one another in what is studied, techniques used, and outcomes sought.

**Enduring Understandings:**

- Human activities and natural phenomena often disrupt the environment causing changes in the population dynamics and steady state balances of the biotic and abiotic factors in the environment.
- Ecosystems result from dynamic relationships between organisms and their environment.

**Essential Question(s):**

1. What are the components of an ecosystem?
2. How does human activity impact an ecosystem?

**Teacher notes:**

This activity is an open-ended inquiry in which students investigate how one change in the steady state conditions of a simulated freshwater ecosystem by introduction of a foreign population or alteration in a single abiotic component can cause a variety of changes in other biotic and abiotic factors and in the dynamic equilibrium of the simulated system. It is suggested that a laboratory freshwater system such as a stable aquarium tank or a mature hay infusion be established and maintained in the classroom prior to the start of this activity (baby jars would also work for this task). This established micro-ecosystem should be subdivided into distinct sub-systems, one for each inquiry group, which are allowed to come to equilibrium before the inception of the student activity. Depending on the factors chosen for alteration in the inquiry and on the degree of alteration of the steady state of the micro-ecosystem, the length of the period of data collection could range anywhere from one to three weeks. Students will need to decide which ecosystem factors to use as their disturbance element and which other ecosystem factors to monitor during and/or following the disturbance with daily observations in their log books or lab notebooks. Further detail and suggestions can be found in the Lab Directions (if used as a guided inquiry activity) located at the end of this document.

Encourage student groups to selected disturbances which simulate actual case study examples they have found in a literature search. Examples include: introduction of acid freshwater infusions such as simulated acid rain, heating the simulated ecosystem as a simulation of introduction of heated effluent from an industrial source of power plant, various levels of light intensity, introduction of various forms of contaminants (soil run off, oil, detergents, fertilizer) and introduction of an exotic species not naturally found in abundance in the system (yeast or aquatic floating plant varieties work well). You may want to ask the class to construct a matrix of common response factors to monitor daily in each perturbed system (number of individuals of three target or index species in a given volume of water, turbidity or water clarity, temperature, etc.) Daily postings of results to a class-wide graphic organizer would ensure that students could track results of their various perturbations and compare and discuss the results as the inquiry progresses. Discuss and assign monitoring of a control for the experiment.

Other Lab tips:  
Tap water can be used to replenish systems if left out overnight  
Use care to establish efficient lab protocols for daily data monitoring and posting of results.

Pre-Assessment:  
As a whole group activity, complete a T-chart to review abiotic and biotic factors in freshwater ecosystems. Then have students brainstorm possible conditions that would affect the stability of aquatic ecosystems.

<table>
<thead>
<tr>
<th>Abiotic Factors</th>
<th>Biotic Factors</th>
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<tbody>
<tr>
<td>Outcome/ Performance Expectations</td>
<td>Assess and analyze changes within an ecosystem including the impact of man's activities and possible solutions to ecological problems caused by introduction of small physical changes to aquatic ecosystems by the activities of man.</td>
</tr>
<tr>
<td>Write a concept statement...What kind of situation would cause this concept to become apparent in students' understanding?</td>
<td>What are the effects of alterations in a simulated freshwater ecosystem on the population dynamics and biotic and abiotic factors of the ecosystem?</td>
</tr>
</tbody>
</table>

Actual Case:  
Research the major environmental issues depicted in the story of Erin Brockovich: Please include the following in your research:  
1. What are the hazardous chemicals involved?  
2. How did it get into the environment?  
3. Who was responsible for the problem?  
From answering the 3 major questions involved from this impact on the environment, create a small presentation or multimedia movie addressing these three questions and the following themes:  
1. How are ecosystems interconnected to other ecosystems?  
2. What do social and cultural implications have on the environment?  
3. How is the survival of humans dependent upon sustainable systems on earth?  
Possible Resources:  

<table>
<thead>
<tr>
<th>Questions for Inquiry for lab investigation?</th>
</tr>
</thead>
<tbody>
<tr>
<td>How would you set up an experiment that models aquatic succession influenced by human impact?</td>
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<tr>
<td>Which variables would you manipulate to show the results of the disturbance?</td>
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<tr>
<td>What observations do you expect to see based on the manipulation of variables?</td>
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<tr>
<td>Identify necessary data and observation…</td>
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<tr>
<td>What data would demonstrate the mastery of the concept by ALL students in the classroom?</td>
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<tr>
<td>Record Qualitative Data (Color, Clarity, Odor, identification of organisms)</td>
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<tr>
<td>Record Quantitative Data: Using the data collection devices, record the pH, temperature, turbidity (if you do not have probes, just record temperature and pH. pH paper could be used or universal indicator. Could use the Tyndall Effect with paper to measure turbidity.</td>
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<tr>
<td>Once data is collected students will analyze changes in the simulated pond ecosystem and relate the simulation to examples in which man has changed the dynamic equilibrium of biotic and abiotic factors in freshwater ecosystems across several case study examples.</td>
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<tr>
<td>Teacher Note: For turbidity: Could use the Tyndall Effect with paper to measure turbidity. Teacher will have to explain this to students.</td>
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<tr>
<td>Write procedures that will cause students to organize data…</td>
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<tr>
<td>Test a procedure using known concepts.</td>
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<tr>
<td>TEACHER NOTES:</td>
</tr>
<tr>
<td>Inquiry protocol, materials list, and procedures should be approved by teacher</td>
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<tr>
<td>For basic students follow this [LINK] for materials and procedures.</td>
</tr>
<tr>
<td>Write questions or activities to use or apply the concept (represent, model, visualize, or design new experiments).</td>
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<tr>
<td>Write a data analysis conclusion in which the student must correlate all types of data to the impact of the disturbance introduced into their simulated ecosystem and compare the resultant changes in their ecosystem as compared with results of disturbances in other ecosystems under study.</td>
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<td>How is the outcome of this investigation similar to the effects of researched case studies of actual human impacts on the environment? Give specific examples and comparisons.</td>
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<tr>
<td>(Teacher note: You may refer back to the Erin Brockovich assignment or use the extension resources on Chernobyl)</td>
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### Homework/Extension

EXTENSION: You are a civil engineer in Coastal Georgia who has to run sewer lines in a new housing development. Wetlands are nearby. You goal is to protect the integrity of the wildlife and wetlands. What precautions would you need to consider in constructing your sewer lines? Remember, the Georgia Department of Natural Resources (DNR) must approve your proposal.

*Teacher Notes: Students may need to consult construction policy in wetland preserves or interview an agent from the DNR.*

### Instructional Tasks Accommodations for ELL Students

- Create a word wall with illustrations for vocabulary; word wall can be an interactive whereby students use yarn to make connections with key vocabulary
- Modify language requirements for written lab report
- Provide paragraph summary template (fill in the blank format) for lab report—procedure and conclusion
- Pair with more advanced native language speaking partner (allow for translation in native language for comprehension) as needed
- Provide bilingual support using word to word translation such as dictionaries, and glossaries

### Instructional Tasks Accommodations for Students with Disabilities

- **Review and Implement IEP accommodations for specific student needs**
- Provide paragraph summary template (fill in the blank format) for lab report—procedure and conclusion
- Word bank for written work—lab report
- Create a word wall for key vocabulary; word wall can be an interactive whereby students use yarn to make connections with key vocabulary
- Make check off sheet for lab procedures

### Instructional Tasks Accommodations for Gifted Students

- Using multi-media, student may research 3 mile Island and how it has impacted the ecosystem. Students will create a public service announcement.

Case Study Extension (optional): Teacher Note: After the completion of this task, the teacher may choose to use the resources using the events that occurred in Chernobyl Russia as an extreme example of how human society has affected the environment? The following three questions could be asked to students to answer individually or in groups.

1. How are ecosystems interconnected to other ecosystems?
2. What do social and cultural implications have on the environment?
3. How is the survival of humans dependent upon sustainable systems on earth?

Chernobyl Resources:
Chernobyl was a place in Russia that had a nuclear meltdown that caused high nuclear radiation levels to negatively affect surrounding ecosystems for hundreds of miles.  
http://en.wikipedia.org/wiki/Chernobyl

Segment was called “ACCIDENTAL FALLOUT”

Modeling the Dynamics of Aquatic Ecosystems: Changes in Biotic and Abiotic Factors Resulting from a Disturbance (back to teacher notes)
Problem: How does human manipulation of biotic and abiotic factors result in ecosystem disturbances?

Materials per group:  
- 3 clear jars
- Bottled water
- Microscope
- Slides with cover slips or depression slides
- 3 droppers
- Pond water with plant materials
- Cooked rice (not instant)

Procedures:
1. Label jars A, B, & C.
2. Place same amount of water in each jar.
3. Place the following materials in the jars:
   - Jar A - water only
   - Jar B - water and 3 grains of rice
   - Jar C - water, 3 grains rice, 2 Tablespoons pond water with plant material

4. Determine the environmental conditions under which your jars will be placed. (Note: all three jars should be placed under the same condition).
5. Hypothesize what will occur in each jar.
6. Record hypotheses in lab notebook or on a data sheet.
7. Make observations (using naked eye and microscope)
8. Record information on data sheet
8. Make observations daily or at least 2-3 times per week for 3 weeks.

After 3 weeks:
Write a formal lab report; be sure to include the following:
   a. Description of the experimental set-up, including the need for the three jars.
   b. Data tables showing results from the 3 week period.
   c. Conclusions that discuss the possible reasons for their results and whether or not their results supported their hypotheses.

Teacher notes:
This activity will be ongoing for approximately 1-3 weeks; students will need to make daily observations in their log books or lab notebooks.
Encourage groups of students to simulate different environmental conditions such as light, dark, cold, hot, outside, colored bottles, contaminants (soil run off, oil, detergents, fertilizer) covered, not covered. You may want to include a graphic organizer at the end of the three weeks for students to compare and discuss the results under different conditions.
Discuss and assess the need for the three different jars in order to establish a control for the experiment.
Other Lab tips:
Use glass jars or plastic soda bottles
Tap water can be used if left out overnight
Use 1 dropper per jar, do not cross contaminate
Clean up of equipment each time is crucial.