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NEW APPROACHES TO TEACHING WATER QUALITY USING EXAMPLES FOUND IN THE GREAT LAKES REGION

By

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A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Division of Science and Mathematics Education

2003

ABSTRACT

NEW APPROACHES TO TEACHING
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The purpose of this research project was to improve the water ecology unit taught in a high school ecology course, resulting in an improvement in the students' comprehension and enthusiasm for the content. Students were provided with a wide range of activities including labs, in-class activities, and research projects. These activities required both inquiry and problem-solving on the part of the students. For example, students were given problems regarding water pollution or water quality and asked to apply their knowledge to develop a solution. The sample population included juniors and seniors who may not be college bound and were enrolled in the Ecology course at Allegan High School. The students had completed two year-long coursed covering physical, life, earth and environmental sciences. A pretest which consisted of a variety of both objective and subjective questions including true and false, calculations, and short answer was given to the class prior to the start of the unit. A posttest consisted of the same pretest questions with additional questions added to allow for a formal test grade. When comparing the pretest and the posttest results, a substantial increase in objective and subjective scores was observed and the data were supported by statistical analysis using a paired t-test. The objective and subjective portions were supported with 99.5% confidence within 16 degrees of freedom. The T-statistic for the objective portion was 5.99, the subjective portion was 8.93, and when combined the overall T-statistic was 13.27.

TABLE OF CONTENTS

INTRODUCTION

STATEMENT OF PROBLEM AND RATIONALE FOR STUDY

The question addressed in this study was whether new activities would increase students' knowledge and understanding of topics discussed in the water ecology unit. Since teachers do not have the ability to take their students into the field for an entire unit, activities must be developed that model fieldwork within the classroom setting. To make the water ecology unit, projects were used that aim to model scientific investigation. Three methods were implemented into the unit through the chosen and designed activities: 1) using relevant ecology activities within the classroom, 2) using inquiry, or problem-solving, to model true scientific means, and 3) using authentic assessment to measure the students' understanding. Students completed investigative labs, in-class group activities, and research projects which connected the information to their own lives. Students were asked to investigate water ecology problems and develop solutions by applying the scientific method. Several methods of assessment were used; traditional, using objective and subjective questions, and authentic, using task driven observations.

The activities developed required students to use their new knowledge along with their prior knowledge of their local and/or regional environment. Students were asked to solve potential problems related to water issues that may actually arise in their living area. These activities required students to use this information to make their own lives richer and healthier. These methods including relevant ecology, inquiry through problem-solving, and authentic assessment are used instead of the traditional approach of having students reiterate the information onto tests and homework with no real life application.

The impetus for the work documented here was a conference focusing on using river studies in the classroom. The related project is called The Rabbit River Watershed and is supported by both the Allegan Math and Science Center and the Allegan Conservation District USDA Service Center. The Rabbit River is located in central and eastern Allegan County including Dorr, Leighton, Monterey, Hopkins, Wayland and Salem townships. Agricultural uses dominate the watershed impacting water quality and degrading the habitat. The Rabbit River Watershed Project is a volunteer monitoring program, in which teachers twice a year take students to sites along the river and analyze the water quality of the sites. The students rate the quality of the river sites based on four criteria: general information (stream name and location), weather (weather conditions, recent precipitation, air and water temperatures), stream habitat (surface water velocity, morphology, clarity, substrate, riparian vegetation, stream shading, and bank erosion), and macroinvertebrate sampling (involving collecting, identifying, and calculating the population). This information is then submitted to the Department of Environmental Quality, where it becomes part of a complete analysis of the Rabbit River quality. The Rabbit River conference initiated my analysis of the current water ecology unit I had been teaching. After close examination, I decided to alter my water ecology unit because I felt that many of my students do not possess relevant knowledge of their immediate surroundings and I did not previously address this in the water ecology unit. By using inquiry water-based activities, students should be able to see the relevance of water quality to their own lives (Green, 1996). Inquiry being the opportunity for students to be presented with a problem and allowing them the freedom to develop a solution to the problem by investigation. Allegan County, located 15 miles from Lake Michigan, has many bodies of water. Based on student comments and disinterest in related conversations, the students seem to have a loose grasp on the decisions being made about the quality of these areas. I felt that by using local sites as examples in the water ecology unit, the students would develop a more comprehensive understanding and appreciation of water ecology.

Other factors contributed to my redesign of the water ecology unit. The labs and activities should require that my students get involved and work together. Students often do not know how to work as a team and adequately divide the tasks. One objective was to have them investigate real-life problems and work with each other in solving them. By working in small groups, students get a true experience of how real water quality problems are dealt with by private and public organizations. Secondly, students should be able to solve problems using the variety of resources available to them. Since we focused on the ecology of the Great Lakes region, the textbook used was not sufficient for them to complete the work. Students need to learn to use other resources such as maps, Internet, resource books, and journals.

The Ecology course typically covers a wide variety of topics, using an environmental science framework over one semester. The course begins with a defining environmental science from a global perspective. The main environmental problems are identified and compared between developed and developing countries. The tools used by scientists to solve environmental problems are presented and a decision making model is discussed. Next, students are introduced to ecosystems and how living organisms depend on each other within individual ecosystems. Abiotic and biotic factors are defined and the organization of an ecosystem is presented. The relationships between organisms are reviewed and evolution by natural selection is presented. Then, students study the flow of energy and cycling of materials within an ecosystem. Food chains and food webs are explained along with the carbon, nitrogen, water, and phosphorus cycles. The course also covers primary and secondary succession within ecosystems. Biomes are introduced and the earth is divided into land and water biomes. Students distinguish between the different forest, grassland, desert, and tundra ecosystems including abiotic characteristics and endemic biotic organisms. At this point, freshwater and marine ecosystems are described.

These topics should be review for these students. A majority of the material is covered in their tenth grade science class at Allegan High School. Of course, the ecology class takes a closer and more detailed look at these subjects, but overall it should not take long for the class to learn this material.

The class is now introduced to the topic of water ecology. Topics traditionally covered include water resources and the problems of freshwater and ocean pollution. The class then investigates the topic of air quality by defining air pollution and identifying the primary and secondary causes of air pollution. Health-related effects are discussed and indoor air pollution is identified. A discussion of acid precipitation completes the study of this topic. Next, the course looks at biodiversity and the current threats to biodiversity along with the various efforts to preserve it. The effect of humans and the importance of preserving biodiversity are discussed. Public policies and potential conflicts with legislation are introduced. The course concludes with a look at populations, primarily the explosion of the human population. Factors that affect population growth are discussed with an application of these factors to the human population. A description of how the human population has changed and a discussion of the different stages of population growth are presented. Problems that arise due to population growth are discussed.

Traditionally, the water ecology unit has been a short section of the class (2-3 weeks) that is covered midway through the semester. Students spend time learning about aquifers, watersheds, recharge zones, desalinization, point pollution, nonpoint pollution, wastewater treatment plants, bioaccumulation, thermal pollution, artificial eutrophication, and marine water pollution. The class did not take any fieldtrips. The water ecology unit required change including the implementation of more water-based labs and participation in fieldtrips that were relevant to the unit.

LITERATURE REVIEW

This attempt to introduce a more relevant water ecology unit into the classroom by using inquiry based activities and authentic assessment is not founded on new ideas. These methods have been tried many times since ecology was introduced to the scientific and public arena. Over a century ago, biologists began to analyze the impacts of human life on the environment. These scientists fought often fruitlessly to encourage ecology and environmental science to be studied in laboratories and taught in classrooms (Vandervoort, 1999). It was in 1866 that Ernst Heckel, a leader in the study of Darwinism, coined this portion of scientific study as "oecologie- the science of relations of living organisms to the external world, their habitat, customs, energies, parasites, etc." (in Worster, 1977). It seemed that at the time, the scientific world could not agree on the value of ecology. Charles Bessey, the founder of Harvard University's Department of Botany, referred to ecology as, "somewhat of a fad among a certain class of botanists" (in Tobey, 1981). The study of ecology was meet with resistance because it challenged the latest advancements in human civilizations. The controversy arose because these advancements, particularly in technology, have held strong on to the idea that natural laws do not affect these improvements (Vandervoort, 1999).

At the beginning of the 19th century the interest in ecology was off to a strong start but soon began to wane. As is the case today, schools often have financial problems when trying to implement new programs along with the added difficulty of finding qualified instructors to teach the new courses. This seems to be the case when trying to implement a relevant ecology course (Vandervoort, 1999). In addition, too often ecology, which is appropriate for the high school level, is left to be taught with what time is left in a biology course and found in the last chapter of the text (Kuechle, 1995). In the 1960's, with the writings of Aldo Leopold and Rachel Carson, the nation began looking closer at the health of the earth. Currently, more schools and teachers are seeing the importance of teaching ecology and are thinking about the impact of humans on the environment (Vandervoort, 1999).

The increasing awareness of ecology and the environment has fostered an appeal for teachers to discuss the importance of monitoring water resources. As a result, more and more students of all ages are participating in water-quality monitoring. These hands-on activities can greatly encourage an appreciation of ecology, chemistry, and biology (Gannaway, 1996). Often students view these bodies of water as a place to go when the weather is nice and participate in recreational activities. Rarely do they see them as a complex and fragile ecosystem that can be damaged by carelessness. Students do not see these areas as places to conduct science labs and learn from their data (Turkall, 1996). When students are asked to study these areas and see the real-life connections they have an increased interest in the topic. That is one reason for fostering a partnership between schools and classes that study water ecology and the professional organizations that are funded to regulate such areas. These partnerships also help encourage public support of schools to increase their science offerings. Students are also introduced to careers in science that they may not have considered before by working with people in science-related fields. Of course, organizations benefit as well from this type of partnership. They are able to see the offerings and limits that dictate how a class is designed. In short, a partnership of students and professionals helps produce young people who are interested in preserving our natural resources (Hairston, 1997).

Strategies to develop and nurture ecological relevance beyond the field work and water studies have been repeatedly tested and tried by instructors. It seems obvious that students will enjoy and relate to the hands-on fieldwork, but a problem arises when teachers take the students back into the classroom. Since teachers are limited to how often they can have students away from the school; in-class assignments must be used that continue to foster this appreciation and model problem solving skills when back in the everyday setting of the classroom.

An interesting framework has been developed to assist teachers in using relevant science back in the classroom. The approach is called REAL (Realistic Experiences Activate Learning), and was designed by the SMILE (Science and Math Investigate Learning Experiences) program at Oregon State University. This program is a collaboration between the university and eight rural Oregon school districts. The goal is to provide science enrichment to both minority and disadvantaged school districts. The framework is based on the following 7 guidelines:

1) **Background knowledge.** Students need to acquire the basic knowledge that will be used in solving the problem.

2) **Problem exposition.** The problem should be a current real-life issue that will interest the students.

3) **Data collection.** Students are given the opportunity to observe and model how scientists collect the data in the field.

4) **Data analysis.** Students should be guided on correctly analyzing data.

5) **Data synthesis.** Students should collaborate to develop possible solutions to the posed problem.

6) **Solution presentation.** Students should present their findings to their peers.

7) **Career information.** Students should become more aware of scientific careers.

The SMILE program challenged high school students to use this framework to solve two scientific problems. The first problem was to analyze Hydroville's, a fictitious town, water supply and identify the contaminants present. The students had to advise the town on how to clean the water. The second problem was presented a year later and asked the students to assess the possible effects of a pesticide spill near Hydroville. The students had to devise a means to clean up the pesticide and make a recommendation to the town (Bloomfield, Dahl, and Paasch, 1996).

Inquiry is one way to continue the scientific based learning back in the classroom. By using inquiry, students apply the scientific method to answer a question or solve a problem. This process involves students using both their prior knowledge and new knowledge to formulate a hypothesis. Students discover that there are several means to an end and that a correct answer is not always the end product. Problem solving is often used synonymously with inquiry which is a technique that needs to be modeled and taught in the science classroom.

> "When science instruction is a verb -something that is done and not just something that is memorized, blindly followed or even conceptually understood- then science instruction is inquiry science" (Waterman, 1998).

Inquiry-based learning began to stand out in education in the late 1950s and early 1960s. Many new curricula of the time encouraged the use of inquiry in science classrooms, one being the Biological Sciences Curriculum Study during the post-*Sputnik* era. The science reform committees have recently encouraged the use of inquiry in school science classes. The *National Science Education Standards* stated that inquiry is fundamental to teaching the method of science (Chiappetta, 1997). So why is it that inquiry is not often used in the classroom? This question was presented to several teachers and their responses are as follows (Costenson and Lawson, 1986):

- 50-90% of all K-12 teachers base their instruction on a single book
- Most questions arise from the textbook and are over terminology and definitions
- Students are taught to find the correct answers from the text
- Less than half of all biology teachers regularly use lab activities, and 25% report that they never, or no more than once a month use lab activities
- Instruction usually follows the "assign, recite, test "pattern based on the text

It is evident that the traditional lecture-memorize method of teaching science is not effective when students often say," We did it, but we don't know why" (Waterman, 1998).

Several studies analyze whether or not inquiry is a better method of instruction. Lott completed a meta-analysis of 39 studies published from 1957 to 1980 to see if this was in fact the case. He found that performance of students was significantly better when the inquiry approach was used. The results showed that high levels of thought were invoked which led to better student scores and equal student scores on low level cognitive outcomes. This mega-analysis indicated that students perform better when lab-based inquiry methods are used in a science classroom.

So, the question arises as to why more teachers are not using this method of instruction in their classrooms. When presented with this question, teachers responded with the following comments (Lott, 1983).

·Inquiry requires too much time and energy to implement

·Inquiry requires too much time away from the curriculum

·Administration will not understand the inquiry method and will feel time is being wasted in the classroom

·Students are too immature to use inquiry in the classroom

·I do not want to change my style of teaching after doing it this way for so long

·It is too expensive to run an equipped inquiry lab

These comments seem to hold no validity when analyzed closely. In actuality, inquiry labs require less set-up then the traditional "cookbook" labs. If teachers focused on their students mastering the material rather than quickly getting through chapters, they would see an increase in understanding. It is the responsibility of the instructor to educate the administrator in the correct use of inquiry in the classroom. Wasting time and being off task is an issue of classroom management, not a problem with inquiry learning. Experienced teachers can learn new ways and will want to when it is evident that inquiry learning results in better student understanding. Many items for inquiry learning can be purchased at local stores or donated by parents. It seems as though there is need by teachers for a better understanding of what inquiry learning entails. Teachers need 1) training in methods of inquiry, 2) involvement with actual biological research that models inquiry, and 3) assurances that teachers can distinguish between valid concepts and the trivial (Costenson and Lawson, 1986).

It is true that inquiry-based science classes have shown marked improvement over the traditional science classrooms. Inquiry, just like any other method of teaching, is not designed to be the method for everyday instruction. Students do need the important content information and conceptual ideas to apply to an inquiry activity. Teachers must be able to know when it is appropriate to use inquiry methods and when it is beneficial to the students to use more traditional methods. Inquiry activities seem to be most effective when a new topic is introduced, to reinforce the scientific process, or to apply the learned information to solving a problem (Waterman, 1998).

Many different activities can foster the learning of students in an inquiry-based classroom. It is important for teachers to use different types of activities to address the needs of all their students and at the same time introduce students to the methods of scientists. This will enhance both the students' interests and their scientific abilities. Many different activities can accomplish this task, but some specific ideas include cooperative learning by research and communication of their research to their fellow classmates. It is important to make use of the collaborative idea because this directly models the world in which scientists work. Most research today is done by teams of scientists dividing up the tasks and working together. One way for high school students to express their findings is by the use of a presentation and poster. The format of using a poster to illustrate the information researched displays the product in a brief visual form which allows the students to express their creativity in a different way. The creators of the poster are also available to answer any questions that may arise, which in this case, is the rest of the class (Mulnix and Penhale, 1997).

One type of approach to inquiry that should not be forgotten is problem-solving. This method causes students to become active in the learning process. Most importantly, the learning can become relevant and important to the student. Problem solving encourages the student to apply the scientific method (Chiapiatta, 1997). The problem solving method is so vital because it can be performed within or outside a lab-based environment. Students can be instructed to solve a problem in verbal, written, or illustrated form. This method of inquiry is often used at the end of the learning process and may double as an assessment piece. Students take the knowledge they have acquired and apply it to a real-life problem. The solution should be based on both what they have learned and their prior knowledge.

Finally, to adequately determine if students have acquired the intended knowledge base, an instructor must use the appropriate means of assessment. In any learning situation, authentic assessment is vital to monitor the growth of the student's understanding of the topic, in this case water ecology. Authentic assessment can be defined as a way of genuinely evaluating the academic growth of a student. The assessment asks the students for the application of knowledge, skills, and work habits through a performance task (Brualdi, 1998). Authentic assessment can involve observing students as they complete a task or project but it does not mean to evaluate completely on the basis of a standardized test.

Students in this study were assessed in a variety of ways. Students did take a standardized pretest and posttest along with three quizzes. Authentic assessment was also used when students were asked to complete a task or project. The authentic assessments used asked students to develop a concept map, illustration or drawing, and to solve problems. These assessments allowed students to use their creativity and prior knowledge along with the new information.

The growing awareness of authentic assessment is due in part to the accountability of school districts to score well on standardized tests. In the 1960s standardized testing was launched district-wide. Then in the 1970s, statewide testing programs were designed and are implemented in every state in the country. Recently, President Bush has signed a law that requires every student in the country to take a standardized test in mathematics and reading every year in grades 3-8. It seems as though the importance of these types of assessments will not wane (Stiggins, 2002).

Ironically, these tests do not always model authentic assessment of the students they are targeted to measure. To encourage the responsibility of schools to "raise the bar" on education, politicians have often rewarded success with financial gains for the school and/or student. While teachers and schools should have to show evidence of learning, the assessments used to gage this growth should be a legitimate tool. There seems to be confusion between using assessments to monitor learning and using assessments to encourage learning (Stiggins, 2002).

Assessment should be blended into instruction and will then possess the ability to inform the teacher of what is needed to enhance the learning process. The correct level of teaching should be identified. The teacher can appropriately plan which activities and assignments will most effectively work within the classroom. Using assessments in this manner will identify when it is time to move on to another topic or when it is appropriate to give more instruction over the topic (McMillan, 2000).

There are several basic fundamentals of using assessment for learning and they are as follows: (Stiggins, 2002)

- Teachers identify and state prior to teaching the goals students should accomplish.
- These goals should be stated at a level the students can understand
- Teachers should be able to produce assessments that monitor the student's progress toward these goals.
- Assessments are used in the classroom to encourage students to do better and strengthens their confidence.
- Results of the assessments are presented in a non-judgmental manner.
- Students understand their own progress and work closely with the teacher to reach their goals.
- Teachers will change the instruction to meet the needs of the students.
- Students can communicate their growth to others.

One way to use assessments for learning is to implement performance-based assessments into the class. The first step in using any assessment is to determine its purpose more specifically: what skill or concept is being assessed. After the purpose of the assessment is identified then the teacher must determine the activity to be used. Factors that influence this discussion include: amount of time required, resources available to be used, and what amount of data is need to adequately assess the task. Every hands-on activity is not considered a performance-based assessment, but most require the student to apply their knowledge to complete a task (Brualdi, 1998).

Two types of performance-based assessment that can be used in the classroom have been identified. Informal assessment may occur when the student does not know they are being assessed. This is often done by teachers to assess a student's behavior in the classroom and/or skill at a particular task. Formal assessment differs because the student is aware of the evaluation process being performed. The student is often asked to complete a task or perform a skill. The teacher can then evaluate the performance as it occurs or the final product that is created (Stiggins, 1994). One way for teachers to evaluate performance is by using a checklist. This simply requires that the elements that are being considered are present or absent in the completed assessment. Teachers can then provide a written evaluation or a grade to the student. Another idea is to have students assess themselves, providing them with the checklist. This method involves the student in his or her own learning process and often teachers find that students assess themselves with careful scrutiny (Brualdi, 1998).

Ecology, particularly water ecology, is a fundamental topic in any biology course. The topic of water ecology can truly excite high school students by showing relevance and importance of it in their own lives. The problem of teaching it arises when a teacher is unable to set up the classroom along side a river for 4 weeks. How then does a teacher sufficiently instruct students on this topic? Inquiry-based learning and performance-based assessing are two ways that can enhance this topic in the classroom. Every class and student benefits from diversified instruction and these two methods can add to the many styles of teaching and encourage young thinkers.

Demographics of class

Allegan High School, the location of this study, is situated in a relatively rural area of Southwestern Michigan and has approximately 860 students. The majority of the students are from lower middle class to middle class families. Most high school students are Caucasian with fewer than 5% being minorities. The importance of education is not always reflected by the parent population. This is seen in the level of parent involvement at the high school. At the fall 2001-2002 Parent Teacher Conferences held in November, 63% of students were represented. At the spring conferences held in late March, 47% of students were represented. The graduation rate is 95.5% with a 1.3% dropout rate. At Allegan High School 42% of the students tested received the Michigan Merit Award scholarship for their demonstrated proficiency in all four areas of the MEAP test with the state average being 54%. Allegan High School also offers Advanced Placement courses across all subject areas. In the 2001-02 school year, 112 AP exams were taken and 63.8% scored at a 3 or above with the state average for these scores being 50.7%.

The ecology course is not required for graduation. In their ninth grade year students take an Integrated Science course which primarily focuses on physical and earth Science. In their tenth grade year students take an Integrated Science course that focuses on environmental and life Science. At Allegan High School, students are required to take two years of Science and are strongly encouraged to take at least a third year in their junior year to assist them in preparing for the MEAP.

My one semester ecology class in which this study was performed enrolled 18 students. Eight were seniors and ten were juniors with seven females and eleven males. All students were considered regular education students. The ecology class is usually made up of non-AP students and non-college bound students. Each student was given the option of participating in the study. Those not choosing to participate in the study, of which there was one male, did the same work but their scores and answers were not included in the results. A parent consent form (Appendix A) was sent home and returned in a sealed envelope, which was not opened until after the semester grades were tabulated.

IMPLEMENTATION OF UNIT

The ecology class in which the study took place is a course that has been offered for the past six years. It was designed by a teacher who accepted a teaching position elsewhere the summer prior to its first year being taught. Although I did not develop this class, I have taught this course from its beginning and have slightly changed the topics and activities each year. This course is a one-semester fall course offered to juniors and seniors. The class meets everyday for 57 minutes.

I started teaching the water ecology unit on October 2, 2002. It immediately follows the ecology review unit consisting of four chapters at the beginning of the semester. I thought it would be a good idea to implement this unit at that time so as not to have to contend with the weather in late fall. I was planning on taking the class on several fieldtrips and did not want to have to eliminate them due to inclement weather. I also felt that after reviewing the first four chapters of the course, my students would feel confident and ready to begin some new material with a positive attitude. Also, I felt that after the review material, my students would be able to reflect back on that knowledge and apply it to the water ecology unit. For all of these reasons, I decided to implement water ecology unit in the early middle of the ecology course.

The greatest problem I had planning the water ecology unit was working around all of the disruptions that commonly occur in the fall semester. Despite careful planning, there is never a perfect time to implement an entire unit. High school classes require some degree of flexibility by both the instructor and the students. Although I thought I had planned appropriately, there were some interruptions that disrupted the desired implementation of the unit. First, teaching in Allegan, Michigan always involves some number of fog delays in the fall. During the fall of 2002 we called a delay three times due to fog. Unfortunately, the ecology class was scheduled for the first hour of the day and therefore was greatly impacted. Next, I began the water ecology unit during the week of Allegan's Homecoming festivities. The typical events planned during this time usually cause some minor disruption to the normal class time, as was the case this year. The main problem is a decrease in focus of the students for the week. Allegan Public Schools Parent Teacher Conferences fell in the middle of the unit. Due to the class only meeting three times and with no class for an entire four-day span between Wednesday and the next Monday, I needed to plan creatively. For example, no long-term labs could be run during this time since students would not be in class everyday to collect data. Students were still expected to complete reading and homework assignments that came directly from their textbook. I did not want to fill class time with notes and homework. Instead, I used class time to discuss and implement supplemental material and activities designed during my research. Throughout the course we went on three fieldtrips: Rabbit River Watershed study, Kalamazoo Wastewater Treatment Plant, and the Wolf Lake Fish Hatchery.

An outline of what I planned and completed is described below. The outline shows the topics covered, labs performed and activities completed within the water ecology unit. The new topics, activities, and labs are indicated with an asterisk.

Week 1

Topics:
- surface and ground water
- watershed and aquifers
- desalinization
- water conservation
- Great Lakes exotic species
- Great Lakes Water and the Economy*

Activities:
- pretest*
- Pond Water Lab*
- Great Lakes Invaders Concept Map
- Fishing Trip Assignment*
- internet lab research

Week 2

Topics:
- Water Quality
- Rabbit River Watershed Project*
- Macroinvertebrates*

Activities:
- Fishing Trip Presentations*
- Macroinvertebrate PowerPoint presentation*
- Rabbit River Fieldtrip*
- Quiz: Surface and Groundwater

Week 3

Topics:
- freshwater pollution
- point and nonpoint pollution
- wastewater treatment plants
- bioaccumulation
- artificial eutrophication
- thermal pollution
- Kalamazoo Wastewater Treatment Plant*
- calculating parts per million in organisms*

Activities:
- East Lansing Wastewater Treatment Plant Power Point Presentation*
- Kalamazoo Wastewater Treatment Plant Tour*
- Wolf Lake Fish Hatchery Tour*
- Dragonfly Pond Activity*
- The Lighter Side Activity*
- Quiz: Freshwater pollution

Week 4

Topics: ocean pollution
Exxon Valdez oil spill
MARPOL
territorial sea and exclusive economic zone
Water Careers*

Activities: Duckweed Lab*
Water Career Research*
Quiz: Ocean Pollution

Week 5

Topics: Review for Water Quality Test

Activities: posttest*
Water Career Presentations*
Saltwater Potato Lab

To begin the unit on water ecology unit, every student was given a pretest (Appendix B). The pretest consisted of an objective portion, which included true and false questions and short answer questions addressing the water quality, freshwater pollution, and ocean pollution material. The pretest also included a subjective portion, which asked short answer and essay questions over the additional material presented describing artificial eutrophication, bioaccumulation, and water-related careers. The students were not given grades that reflected their score on the pretest but rather a participation grade for completing the pretest to the best of their ability.

After the pretest, I wanted to engage my students in the complexity of water ecology. Students were given the question, "What does this jar of pond water contain?". They needed to use inquiry to answer this question. Most students if given a jar of pond or river water and asked what it contains would just say "a bunch of gross stuff" or "nothing, I can't see anything". I wanted to show my students that there is much more to water and to keeping it healthy than what meets the eye. The first activity was a simple Pond Water Lab (Appendix C1) where students made slides from different depths pond water in a jar and analyzed it for biodiversity. Students worked in partners to complete this activity. Students were given Pond Water Guidebooks and handouts with pictures of possible microscopic organisms. They found an enormous variety of organisms in the pond water. All students were successful at locating a variety of organisms. They were completely surprised at the diverse morphology of the organisms found within a small sample. Their assessment was to draw and color six different species found, attempt to correctly label the organism and include the correct magnification. A discussion was lead to again answer the question, "What does this jar of pond water contain?" and I encouraged them to think about the purpose of these organisms along with the effects of water pollution to these organisms and ultimately the entire environment.

The next two days included an activity (Appendix C2) on exotic species in the Great Lakes. Students were given a short article from the Kalamazoo Gazette on various exotic species in the Great Lakes. They read the article and we discussed the information as a class and looked at preserved examples of some exotic species and photographs of the others. Students were instructed on the purpose and correct method of designing a concept map. Extra points were given in this authentic assessment for including linking words for every connection and for showing how two ideas are related by cross-linking terms or ideas. These concept maps were then displayed for the class and we briefly discussed each one. The class also watched a short video entitled, Great

Lakes Unwelcome Visitors which summarizes the problem of exotic species within the Great Lakes.

I introduced the research project entitled; *Great Lakes Fishing Trip* (Appendix C3) and a corresponding article (Appendix D1). This activity asked students to look at the Great Lakes region from an environmental science focus. By researching the economic impact that fishing has on the area, students will see another reason to maintain healthy water sources. Students were placed into groups of three with each group given the task of planning and budgeting a fishing trip within the Great Lakes region. Some groups were told to charter a boat, eat every meal out, and stay in a hotel. Others were told to plan to camp, bring their own fishing gear, rent a fishing boat, and cook all meals at the campground. Still others were told to stay in their RV and bring their own fishing boat. All groups were given different locations around the Great Lakes and were presented with the problem of calculating the cost of the trip. Students had to find the price of all of their equipment including fishing tackle, fishing boat, RV in order to calculate one tenth of the price into the total cost. Groups had to locate the destination on a map, plot out their driving route and calculate the mileage to determine the cost of gas. Students chartering or renting a boat had to locate a charter or rental service at their destination and call them to get a price. Groups also had to find prices for the lodging and calculate the cost of meals. Finally, each group was provided with an amount in pounds of fish caught on the trip and calculated per pound the cost of
the fish in regards to the trip cost. Then they compared this cost to the current per pound cost in several grocery stores. I found that my students were very excited about this activity. They really used their imagination in planning their trip and enjoyed actually

calling the different business to get prices. The cost per pound of the fish caught really surprised them and they could see how important sport fishing is to the Great Lakes economy. They were asked to list as many jobs that depend someway on the production of the goods and services for sport fishing. Groups gave a ten-minute presentation on their research, trip, and calculated outcomes. Extra points were given for using a visual aid in their presentation.

Next, I took two days and introduced the concept of using a macroinvertebrate study as a means of determining the health of a river. I explained the purpose of the Rabbit River Watershed Project and told them the data they produced would be passed on to the DEQ for further analysis. The macroinvertebrate keys used to identify the samples collected were explained and I presented a macroinvertebrate Power Point presentation which was provided by the Allegan Math and Science Center. Students observed the macroinvertebrate collection I had gathered the previous summer during research so to see up close they samples they were to collect. Finally, I gave them handouts that contained pictures of samples collected form various fictional streams. Students were asked to identify them based on the information presented and by using the macro-invertebrate key provided. Next, the class went to two different sites and collected the required data. Since the forms and information were required for the DEQ, the lab (Appendix C4) was not altered in anyway. Diane Hornebrook of the Allegan Conservation District and Amy Oliver of the Allegan Math and Science Center met us at the two sites. The class was divided into three groups and told to collect the entire data for each site.

The third week was dedicated primarily to the topic of freshwater pollution. Students were presented with a Power Point Presentation® that gave them a virtual tour through the East Lansing Wastewater Treatment Plant. This presentation was provided by two fellow researchers Kari Simon and Angela Clark. This presentation was given after the students had been assigned the book reading over wastewater treatment plants. Students were asked to make a map describing the treatment of wastewater through a treatment plant for assessment. The next day the class went on a fieldtrip to the Kalamazoo Wastewater Treatment Plant. This allowed them to make comparisons between the processes they have learned about. One of the questions they asked at the plant was, "What is the strangest item every recovered from the plant?" and the answer was a large safe that had been stolen! During the same day students toured the Wolf Lake Fish Hatchery in Kalamazoo and watched a video on the preservation and importance of fishing in Michigan. This tour wrapped up the importance of healthy waterways to the economy of Michigan that the students had earlier investigated in the Fishing Trip Assignment.

The week continued with students using the information learned regarding freshwater pollution to solve a real-life problem. The activity Dragonfly Pond (Appendix C5) asked students to design a community around a body of water. Students were given cutouts that illustrated various businesses and industries that were important components of the community. They had to situate the different components around Dragonfly Pond based on the land use effects of the business. Students had to make a plausible decision based on what they knew about freshwater pollution. I chose to do this activity near the end of the freshwater portion to allow my students to exhibit what they have learned and it was treated as an authentic assessment piece of this portion of the unit. Finally, the class looked at the concept of bioaccumulation specifically within the Great Lakes by completing the mini activity *Contaminants in Great Lakes Fishes* (Appendix C6). Students were given the problem of determining if the different regional fish were suitable for consumption by the U.S. Food and Drug Administration. Students need to calculate the part per million of contaminants in the fish.

The fourth week was dedicated to setting up the *Duckweed's Favorite Food Lab* (Appendix C7), discussing the problem of ocean pollution and investigating water careers. Students began the week by setting up the *Duckweed's Favorite Food Lab* which analyzes the growth rate of duckweed in varying nitrogen, phosphorus, and potassium levels. Students were given the task of determining the preferable nutrient source for duckweed. Students set up petri dishes with different fertilizers and tracked the population growth of the duckweed over time. Once this lab was set up it only required about 5 minutes everyday for the students to count the duckweed fronds. One day was spent looking at the effect of salt water on organisms by completing the *Potato and Saltwater Lab* (Appendix C8). Students bored corks of potato and recorded the mass, length, width, and texture of the pieces. These potato corks were soaked over night in tap water, salt water, and distilled water. Students then measured the mass, length, width, and texture of the pieces again and noted any changes. Last, in groups of 3 or 4 students completed the *Water You Want to Be?* (Appendix C9) and used magazines to list as many water-related careers as they could. Students individually chose one water-related career and developed a poster to illustrate the important aspects of that career. Students had to locate one person in that field and interview them.

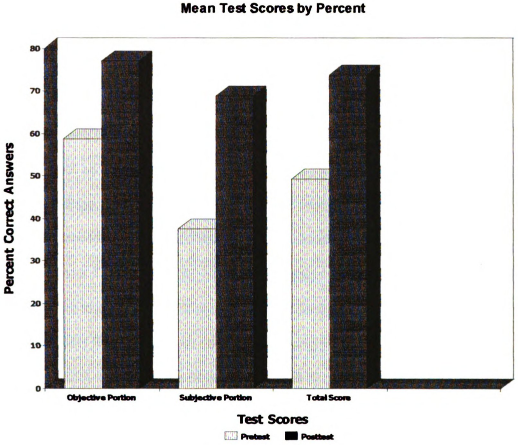
My class really enjoyed doing this project. They researched first on the Internet and then did their interviews. Some students simply contacted people via the Internet (for example the underwater photographer) others completed a phone interview (for example the underwater archeologist). Their posters were due the day after the water unit test and they briefly described their researched career. This activity was a nice way to finish the unit. Students had a chance to work independently and be as creative as they wanted.

Several types of assessments were given throughout the water ecology unit. Besides the authentic assessments, including the Great Lakes Invaders concept map, wastewater treatment plant drawing, and the Dragonfly Pond activity, an assessment in the form of a formal quiz was given after each section in the textbook (Appendix C10). The final assessment used to evaluate the students' learning was the Water Unit posttest. This assessment had the same questions as the pretest but I added more questions to the test so I could also use their scores in their marking period grade. I decided to use the same test so I could directly compare pre-unit questions to the post-unit questions. The students did not know the same test questions would appear on the posttest.

EVALUATION

All of the students were given the same pretest and posttest which contained a set of objective true and false questions. The objective set contained questions that covered the water ecology terms and concepts. After comparing the objective portion of the pretest and posttest, I determined that the students did show a significant improvement in their knowledge and understanding of water ecology (Figure 1).

Figure 1



Of the 18 students in the class, 17 students signed the consent forms opting to participate in the study. The class average for this portion of the pretest was 9.24 or 58.8%. The class average for the posttest was 12.35 or 77.2%. A paired t-test was performed to focus on the difference between the paired data. This type of comparison eliminates the variation that exists when performing a simple t-test. The statistical analysis shows that with 17 data points, the mean difference is 2.47 and the T-statistic is 5.99. Within 16 degrees of freedom, the distribution of probability is 99.5% sure that the difference between the pretest and posttest scores is significant. The statistical analysis supports the idea that students increased their knowledge of water ecology significantly.

The pretest and posttest also contained a set of short answer subjective questions. The subjective set asked the students to apply their knowledge and solve problems related to water ecology. The subjective portion of the posttest indicated a noticeable increase when compared to the pretest (Figure 1). The class average correct for this portion of the pretest was 6.411 or 37.7%. The class average for the posttest was 11.7 or 68.9%. The statistical analysis shows that with 17 data points, the mean difference is 5.29 and the T-statistic is 9.93. Within 16 degrees of freedom, the distribution of probability is 99.5% sure that the difference between the pretest and posttest scores is significant. While the posttest subjective average is not as high as I would like, this tends to be the more difficult part of any test and an obvious area that I need to work with my students on improving in the future. It is valuable to note that all students improved to some degree on the subjective portion of the posttest.

It was obvious that students improved when their written answers on the pretest were compared to the written answers on their posttest. One student improved greatly when asked, "Describe as best you can where the water in your home comes from." The student's pretest answer was, "The water from my home comes from a water place that gets its water from a nearby water source." The same student showed impressive improvement when asked to answer the same question on the posttest. The student's posttest answer was, " The water from my home is city water, water is taken from either a river, pond, lake, or groundwater and taken through a screen to get rid of plants, fish, etc. Then, alum is added to form sticky flocks that help collect impurities. Chlorine is added to kill microorganisms. The alum impurities settle and are taken out, then it is taken to my home." While this student did not completely answer the question correctly, definite improvement was made in the posttest. Another student showed improvement on the subjective portion of the posttest. When asked, "do you think the water you drink at home is pure or polluted? Explain you answer." the student's initial response was simple and did not elaborate. The student replied, "The water I drink at home is pure because it has been filtered being city water from the water plant that it comes from." This answer illustrates that students will often believe what they hear until they further investigate the subject. The same student replied to the identical posttest question, "yes, city water goes through a very good purifying process. In fact, city water is checked by the government more than bottled water is. Considering all they do to purify the water (see question 1) I am sure my water is safe and pure."

In comparing the overall, both the objective and subjective portions, pretest and posttest scores, it is obvious that the students improved their knowledge of water ecology. I feel strongly that this is due to the modified activities and labs that were used in the unit. The statistical analysis does support this within a 99.5% confidence. The overall average pretest score was a 16.29 or 49.36%, while the overall average posttest score was a 24.06 or 73.9% (Figure 1). The paired t-test statistics show that the T-statistic is 13.27 with a mean difference of 7.76 and is significant within 16 degrees of freedom. It is important to note that prior to the unit only 3 of the students passed the pretest with the highest score being a 70%. After the unit, all students were successfully in passing the posttest with the highest score being a 91% and the lowest being 64%.

I received several positive and informal responses from the students. Students allowed their creativity to be expressed in many of the research activities. Due to their excitement to share, many students volunteered to give their presentations. Several students commented positively on the fieldtrips. I observed them genuinely listening to the tour guides and asking relevant questions.

DISCUSSION AND CONCLUSION

The paired t-test does support the idea that using relevant ecology activities including inquiry and authentic assessment increases the learning of students with the overall T-statistic equal to 13.27 within 16 degrees of freedom. The students tests scores show an obvious increase in the comprehension of the students after completing the water ecology unit. By developing and implementing this unit, I have come to several conclusions regarding its future use in the classroom.

While having a class of lower achieving students has its problems, there are some benefits as well. These students really appreciated the fieldtrips. These students are not often provided with these opportunities and showed genuine interest during the trips. In the future I would like to make the three fieldtrips I implemented standard activities for the course. However I can see a problem with this goal due to the recent budget cuts our school district has faced resulting in the cancellation of all fieldtrips.

I did find that overall the unit ran very smoothly. I credit this to all of the time spent in preparation for this unit. I knew exactly what my lesson plans were and what projects and activities I was implementing ahead of time. I found that being prepared for an entire 5-week unit allowed time to work with students on their projects for the class. It would be of great benefit to all teachers if they could find the time to prepare for each unit as well as I did for the water ecology unit.

One struggle I had in preparing and implementing this unit was knowing what to leave in and what to cut out of the unit. As an ecology teacher, I find that there are so many labs and activities that would benefit the students' learning process. Since this class is only a one-semester course, time is always a critical factor in determining which activities to use. I found that I had developed more new and revised labs and activities and had to leave some of the prepared lessons out. It would be no problem to teach a one-semester course just on water ecology.

Another struggle I had in preparing this unit was determining when and how much of the different teaching styles I should use. As was stated in the literature review, a teacher cannot use one type of teaching method exclusively in their classroom. Sometimes it was difficult to know when to use the inquiry and problem solving methods and when the students really need some traditional instruction to get the fundamental concepts of the topic. I did not want to overuse any one type of method. Knowing the appropriate timing of using a teaching method comes with experience, having taught the unit once I would make some changes. First, I would provide brief notes exclusively at the beginning of a new section. This gives the students the background knowledge they need to successfully complete the tasks related to the material. Although lecturing is important, I used concise fill-in style note for this particular class. I found that when notes were needed this worked well because the typical ecology student can easily lose focus if the material is not presented in a simple style.

Although I am pleased with the outcomes of this unit, there are some changes I would make in the future. First, I would implement more problem-solving activities. The subjective assessment percentages were not as high as I expected and I think this is due to two reasons. One was being the writing level of the students. Many of these students can not effectively express themselves in writing. To help them improve; I would implement more writing activities and assignments to provide them with practice. To do this effectively I would need to supply immediate feedback on these assignments. Also, I think that these students need more practice in answering subjective type questions. As was stated in the literature review, so much is objectively asked of students that teachers need to make a conscience effort to implement more subjective type questions so the students understand what is being asked of them.

Second, I would monitor the class partners and groups more closely. I often allow the students to choose their partners and group members, which often leads to the same people working together throughout the semester. I believe that if I make a deliberate effort to mix up the students they would learn much more from working with new people. Not only will they teach each other more effectively, but the wasted time in class that happens when friends work together would be reduced.

One of most valuable responses that I received were the verbal comments that I received from my students. They genuinely enjoyed getting out of the classroom and getting their hands dirty in the stream monitoring lab and fieldtrip. The class really enjoyed the trip to the Rabbit River. My students connected with the need to correctly collect and report these data. This was obvious by their fairly meticulous methods of data collection. I think that they felt that the data being collected were not just simply for the purpose of doing a lab but for the analysis of the watershed. I noticed that some students whom I wouldn't think would enjoy the macroinvertebrate collecting had no trouble getting in the river and collecting a variety of insect larva. I provided them with an extra credit opportunity by challenging each group to find an example of a Hellgrammite. Unfortunately no one was that lucky. While they researched the Internet and media center for several of the activities, I observed many groups really working together and being creative developing their presentations. They enjoyed emailing people to obtain information on their water career of choice. Many students would give me daily updates on their email conversations and would ask when they could check their email again for responses. Several groups added to their presentations by either bringing in props and/or dressing the part. It was the overall enthusiasm that I often observed that made the most difference for me and the implementation of this unit. The increased test scores were an added pleasant achievement for my students.

In conclusion, I am very pleased with the progress my students made through this unit. I feel that the time devoted to developing and implementing the new and modified activities greatly enhanced the water ecology unit for my students. I plan to use many of the same activities again next year in the ecology class for example; Pond Water Lab, Fishing Trip assignment, Rabbit River Fieldtrip, Kalamazoo Wastewater Treatment Plant Tour and the Water Career activity. I especially feel pleased with the feedback that was provided by my students on a daily basis. I could easily tell that they appreciated the extra effort I made in making their experience a richer one. They seemed to find humor in my dependence on them in obtaining my Masters degree. I truly feel that they knew we were all working together, giving 110% to this unit.

APPENDIX A

Parent/Student Consent Form

Date: August 21, 2002
To: Parents/Guardians/Students
From: Ms. Eichbauer
Re: Collection of Data for Master's Thesis

For the past 3 summers I have been working on my Master's Degree at Michigan State University. This past summer I worked on redesigning the Water Quality Unit in the Ecology class that I teach in the fall semester. I have developed a new water pollution lab, tested new water quality labs, and gathered activities that I feel will enhance the students' understanding. This unit we will begin in October and will take 4-5 weeks to complete.

An important requirement for obtaining the Master's degree is to write and submit a thesis explaining this work and its implementation into the curriculum. To accomplish this task, I will be collecting data from pre- and post- tests, surveys on the students' reflections and opinions, student interviews, as well as pulling essay and short answer questions from the labs, homework, and assessments. With your permission, I would like to use this data in my research thesis. At no time will the students' names be attached to or within the thesis paper. Your privacy will be protected to the maximum extent allowable by law.

The requirements for the course will remain the same for all students whether their work is used in my thesis or not. At any time throughout the course, you may request that your student's work not be included in the data analysis. There is no penalty for not giving consent or for revoking consent in the future.

Please complete the lower portion, insert and seal the envelope provided and return this letter to me by August 30, 2002. Envelopes will not be opened until semester grades are complete. Thank you for your time. If you have any questions or concerns regarding your rights as a study participant, or are dissatisfied at any time with any aspect of this study, you may contact-anonymously, if you wish- Ashir Kumar, M.D., Chair of the University Committee on Research Involving Human Subject (UCRIHS) by phone 517-355-2180, by fax 517-432-4503, e-mail , or regular mail 202 Olds Hall, East Lansing, MI 48824. Please contact me if you have any questions or concerns 673-7002 ext. 5129 (voicemail) or 6612 (classroom).

Sincerely,

Ms. Cynthia Eichbauer

________, I voluntarily agree to participate in this study. Ms. Eichbauer will not use my name and any student information will remain confidential.

________, I do not agree to participate in this study. There is no penalty for choosing to withhold my data.

Student Name (print) ____

Student Signature ____________________________________Date: ________

Parent/Guardian Signature _______________________________Date: ________

Appendix B

Pre-Assessment/Post-Assessment
Water Ecology

True or False

1. Water is considered a renewable resource.	T	F
2. Our everyday water comes exclusively from groundwater.	T	F
3. The area of land from which groundwater originates is called the watershed.	T	F
4. The largest domestic use of water in the home is by washing and bathing.	T	F
5. Alum is added to water to form sticky flocks that help collect impurities.	T	F
6. Point pollution originates from several sources and is difficult to control and regulate.	T	F
7. Sludge from water treatment plants is safe to use as a fertilizer.	T	F
8. Most chemicals that can bioaccumulate are fat-soluble.	T	F
9. Eutrophication can happen naturally just at a slower pace.	T	F
10. Chlorine is added to water to deter bacterial growth.	T	F
11. Fertilizers can cause eutrophication of a pond or lake.	T	F
12. Accidental oil spills account for 75% of oil pollution.	T	F
13. By building dams, conflict between countries that share a river is reduced.	T	F
14. Warm water holds more oxygen than cold water.	T	F
15. Plastic bags, pop rings, and balloons are examples of water pollution.	T	F
16. A city's water supply originates from a nearby river.	T	F

Short Answer. (use complete sentences where applicable)

1. Describe as best you can where the water in your home comes from.

2. Do you think the water you drink at home is pure or polluted? Explain your answer.

3. List and describe 2 ways to desalinize seawater.

4. Calculate the parts per million of contaminants in the following fish:

a. Perch	weight	= 1.8 kg
	P	= .004g
b. Whitefish	weight	= 3.1 kg
	P	= .064g

5. List and explain the problems caused by 2 exotic species of Michigan.

6. Identify the following macroinvertebrates:

a)____________________ b) ____________________ c) __________________

7. Make a list of the jobs that depend on someway on the production of the goods and services for sport fishing.

8. How can artificial eutrophication be prevented in natural water bodies?

9. Where do PCBs turn up in fish and other animals?

10. **Describe the path of the bioaccumulation of the pesticide DDT as it originates in surface water runoff and ends in the body of Bald Eagles. Describe the concentration levels and the effects of DDT.**

APPENDIX C

STUDENT ACTIVITIES

APPENDIX C1 - POND WATER LAB

Problem: What does a jar of pond water contain?

Part I: Wet Mount Preparation

Materials:	clean dry slide	cover slip
	dropper	water

Instructions:
1. Using a clean dry slide, place one drop of water on the center of the slide.
2. Carefully pick up the cover slip and place one of the four sides on the edge of the drop of water. (this is to make a complete seal)
3. After obtaining a complete seal, slowly lower the cover slip down onto the slide.
4. Practice this a few times or until you feel comfortable doing this task.

Part II: Letter "e" Slide Preparation

Materials:	clean dry slide	cover slip
	dropper	water
	small "e"	

Instructions:
1. Make a wet mount slide of the letter "e".
2. Focus your slide sample on your microscope.
3. Draw what you see on the lowest power and record the total magnification.
4. Draw what you see on the highest power and record the total magnification.

__________ total magnification

__________ total magnification

1. Which way does the letter "e" appear to move when you move the slide to the right?

Part III: Pond Water Slide Preparation

Materials: clean dry slide, cover slip, dropper, pond water

Instructions:

1. Prepare a wet mount of pond water and observe it under low power.
2. Focus the slide under low power and then adjust to the next power.
3. Draw and color six different organisms that you observed.
4. Record the total magnification
5. Using the provided protozoa key, record the name of the organism.

(Hint: If some organisms are moving too fast for you to clearly see, place a piece of stretched out cotton on the microscope slide, then put your water sample directly on the cotton and place the cover slip on top of it.)

total magnification

name

total magnification

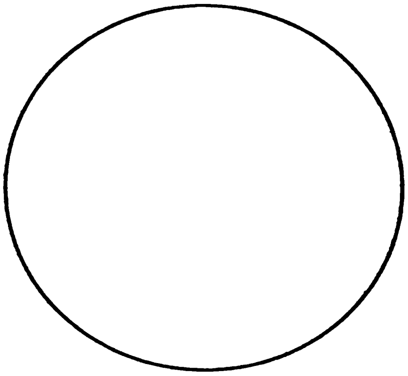
name

total magnification

name

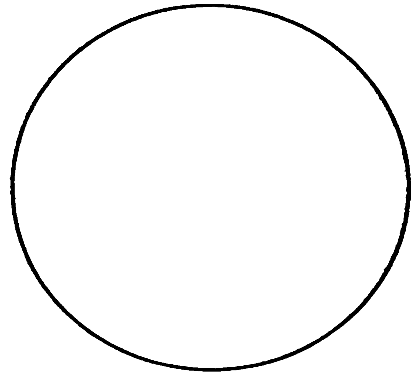
total magnification

name



____
total magnification

____
name



____
total magnification

____
name

<u>Questions:</u> Answer the following in complete sentences by using the Pond Life Guidebooks.

1. If one of your microorganisms were said to be autotrophic what would this mean? Give an example of an autotrophic organism found in a forest ecosystem.

2. What are the three ways in which protozoa are capable of moving?

3. In a jar of pond water, where are you most likely to find the greatest diversity of microorganisms?

4. How can so many different microorganisms live in the same habitat?

5. Explain how the microscopic community fits into the pond ecosystem.

APPENDIX C2 - GREAT LAKES INVADERS CONCEPT MAP

Problem: To create a concept map that summarizes the article, *Great Lakes Invaders.*

Directions: With a partner your job is to create a concept map on the provided poster board that summarizes the article you just read on exotic species in the Great Lakes. Make sure your concept map is well thought out, organized and neat. You should include linking words for each pair of connected concepts. Additional points will be given for showing more complex relationships between concepts or cross links.

APPENDIX C3-GREAT LAKES FISHING TRIP

Introduction:

The term fishery refers to a complex relationship of the fish population, the environment, and the people using the fish and the environment. Some types of fishery include: sport fishery, commercial fishery, tribal fishery, and supplemental fishery. The Great Lakes Region is fortunate to have an adequate environment and technology to support several types of fishery. The different types of fisheries found in Michigan benefits the state in several ways: economically, culturally, socially, ecologically, and through dietary means. In fact, the Great Lakes regional economy is impacted by $2.3 to 4.3 billion per year.

Materials:

Role and destination cards (1 card for each group)
One WORKSHEET FOR PLANNING A SPORTFISHING TRIP per group
Masking tape
Newsprint
Markers
A road map for Michigan
The life of Lakes map/posters
Fish, boating, and outdoor magazines and catalogs
Overheads: Fisheries Science and Management, Sport-fishing In the Great Lakes: Where It Occurs, Sport-fishing in the Great Lakes: What Species Anglers Prefer, Commercial Fisheries in the Great Lakes

Procedure:

1) Obtain and read a role and destination card from the teacher.
2) You should calculate the costs of traveling to your intended fishing site and all other costs you will have for the trip.
3) Using a Michigan Road Map calculate the distance it is from Allegan to your destination. Use the instructions on the role and destination card to calculate the transportation costs.
4) Brainstorm a list of goods that you will need for the fishing trip and write these materials on the paper provided. This list may include things like: clothing, food, tackle and transportation.
5) Brainstorm a list of services that are needed for your trip to be successful: lodging (camping fees, hotel/motel rates, boat rental or charter.
6) Brainstorm a list of optional items that you would like one your trip: special gear, special snack food, or entertainment).
7) Agree in your group upon the items you will keep on the list and then transfer these lists to the group worksheet.
8) Research the cost of these items via magazines, catalogs, Internet, or phone calls to get an accurate expected price for each item or service.
9) Add up all of these expenses and record the sum.

10) Refer to your role and destination card to find out how many pounds of salmon were caught on the trip. Calculate the cost per pound of fish caught.
11) Call a local supermarket and find out how much a pound of frozen of fresh salmon costs. Find out where the market fish was caught.
12) Compare the cost of your fish from the trip to the cost of the fish purchased in the market.
13) Be ready to give a 10-minute presentation on the description and cost of your trip.

Analysis:

1) Would you prefer to pay the market price for salmon or catch it yourself? Why?

2) What are the benefits to you, and society as a whole, of paying the higher price
for the salmon you caught?

3) What are the benefits to you, and society as a whole, of paying the price of the fish available in the market?

4) In the late 1980's, sport anglers began to catch fewer and fewer salmon from Lake Michigan. The populations of salmon had declined seriously, probably due to a disease called bacterial kidney disease (BKD). What happens to the communities when the population of a sport fish declines?

5) Make a list and of the jobs that depend on someway on the production of the goods and services for sport fishing.

6) Make a list of the jobs that are generated by the *commercial* fishing industry.

7) How does the difference between the lists explain the difference in cost between fish caught by a commercial fisher and fish caught by a sport angler?

8) How is it possible that a small number of commercial fishers can produce large quantities of fish more cheaply than a large number of sport anglers? Why do commercial fishers still have a much smaller overall impact on the economy of the Great Lakes region?

WORKSHEET FOR PLANNING A SPORTFISHING TRIP

Materials Needed		Services Needed		Optional Goods & Services	
Item	Cost	Item	Cost	Item	Cost
	Subtotal:		Subtotal:		Subtotal:

Fish Species:

____

Grand total of costs: $______________

Pounds of fish caught: ____________lbs.

From:

____

Cost per pound of fish: $ ____________

Cost per pound of fish at store:$__________

Destination and Role Card: **Campers/Boat Renters**

You are a family of four planning to go on a sport-fishing trip. You are going to a campground near __________________ where you will spend the weekend. Your vehicle gets 20 miles per gallon of gasoline used. You will camp in a tent, and will rent a fishing boat for two days. You own your own fishing tackle. Include one tenth of the costs of your tent, sleeping bags and other camping equipment. Also add one tenth of the costs of your fishing tackle. Your costs for boat rental will be $35.00 per day (including gas). You will catch enough salmon to weigh five pounds when cleaned (dressed).

Miles to destination	__________________	(a)
Miles per gallon of gasoline	__________________	(b)
Gallons of gasoline used: (a/b)	__________________	(c)
Current price per gallon of gas	$__________________	(d)
Transportation costs: (cXd)	$__________________	

--------------------------------cut--

Destination and Role Card: **Hotel/Charter Boat Users**

You are a family of four planning to go on a sport-fishing trip. You are going to a coastal community called ____________________ where you will spend a weekend. You will stay in a hotel or motel and rent the service of a charter boat for two days. Your vehicle gets 20 miles per gallon of gasoline used. Estimate your charter boat costs at $75.00 per person per day. You will catch ten pounds of salmon, dressed.

Miles to destination	__________________	(a)
Miles per gallon of gasoline	__________________	(b)
Gallons of gasoline used: (a/b)	__________________	(c)
Current price per gallon of gas	$__________________	(d)
Transportation costs: (cXd)	$__________________	

--------------------------------cut--

Destination and Role Card: **Recreational Vehicle (RV)/Boat Owners**

You are a family of four planning to go on a sport-fishing trip. You are going to a fishing spot near ________________ where you will spend the weekend. You will sleep in your Recreational Vehicle (RV) and use your own boat. Your vehicle gets 10 miles per gallon of gasoline used. Include in the costs one-tenth of the cost of your recreational vehicle and boat. Also add one tenth of the cost of your fishing tackle. You will catch five pounds of lake trout, dressed.

Great Lakes Fishing Trip
Teacher Notes

Objective:
The students will be able to 1) name several jobs that relate directly or indirectly to Great Lakes fisheries 2) plan a sport-fishing trip and make a budget for the trip's cost 3) identify and discuss the relative benefits to themselves and society of catching fish on a sport-fishing trip and of buying Great Lakes fish in the market 4) suggest reasons why many people prefer to catch their own fish.

Time:
1 day to introduce activity and have students make their lists
1-2 days for research and assembling the presentations
1 day for presentations

Teacher Preparation:
1) Make the needed copies of Destination and Role Cards and overheads for introduction.
2) Ask students for their definition of the term "fisheries". Let them discuss this briefly. Show the overheads and emphasize the term fishery refers to fish species, people catching fish and the environment.
3) Ask the students to choose a destination for their fishing trip.
4) Explain that they will be planning a fishing trip for three different types of vacations. One group will play the role of CAMPERS/BOAT RENTERS, another will be HOTEL/CHARTER BOAT USERS, and another group will be RECREATIONAL VEHICLE/BOAT OWNERS. Divide the class into groups of 2-3 people.
5) Let the groups randomly pick what role they will be investigating.
6) Tell the students they can begin their lists and brainstorming activities.

Resources:

Dann, Shari L., The Life of the Lakes, Michigan Sea Grant, Michigan State University.

Appendix C4-Volunteer Stream Survey Form

Section 1: General Information

Stream Name: ______________________________ Site Number: ____________

Location: ______________________________ County: ____________________

Township/City: __________________________ Sec: _____ T: _____ R: _____

Date: __________ Time: _________ Investigators: ________________________

Section 2: Weather Conditions

2.1 ( ) Sunny ( ) Partly Cloudy ( ) Cloudy ( ) Rain

2.2 Any Precipitation In the Last 5 Days: ( ) Yes ( ) No
If Yes, approximate amount: __________

2.3 Air Temperature (F) (C): _________ Water Temperature (F) (C): _________

Section 3: Stream Habitat

3.1 Average Stream Width (ft): (1. ______ + 2. ______ + 3. ______) ÷ 3 = ________
3.2 Average Stream Depth (ft): (1. ______ + 2. ______ + 3. ______) ÷ 3 = ________

3.3 Surface Water Velocity (ft/sec):
distance (ft): ________ distance (ft): ________ distance (ft): ________
time (sec): ________ time (sec): ________ time (sec): ________
(Trial 1 velocity: _____ + Trial 2 velocity: _____ + Trial 3 velocity: _____) ÷3 _____

3.4 Estimate Flow (width X depth X velocity): ______________ cfs

3.5 Has the Stream Been Channelized? ( ) Yes ( ) No

3.6 Water Clarity/Coloration (describe): ____________ Water Odor (describe): ________

3.7 Trash In Stream/ Along Banks? ( ) Yes ( ) No
Trash/Debris In Trees Above Stream? ( ) Yes ( ) No

3.8 <u>Substrate</u> (report relative % of each. Leave blank if absent.)
_______ Clay
_______ Silt
_______ Sand
_______ Gravel (.25-2")
_______ Cobble (2-10")
_______ Boulder (>10")

3.9 <u>Obvious siltation</u>?
( ) Yes
( ) No

3.10 <u>Substrate Embeddedness</u>
( ) Completely (100%)
( ) Mostly (75%)
( ) Halfway (50%)
( ) Little/None (0-25%)

3.11 Riparian Vegetation
(Report relative % of each.
Leave blank if absent)
_______ Trees
_______ Shrubs
_______ Herbaceous Plants
_______ Grass
_______Bare
Other (please describe):
____

3.12 Stream Shading
( ) 75-100%
( ) 50-74%
( ) 25-49%
( ) 0-24%

3.13 Bank Erosion
( ) Extensive
( ) Moderate
( ) Little/None

Estimate Width of Riparian Vegetation __________ ft.

3.14 Stream Habitat (Check all that are present)
( ) Riffles
( ) Runs
( ) Pools
( ) Eddies

3.15 Woody Debris
( ) Abundant
( ) Common
( ) Rare
( ) None

3.16 Dams Present: ( ) Yes ( ) No
If Yes: ( )Man-made ( ) Beaver

3.17 Aquatic Plants: ( ) Periphyton ( ) Filamentous Algae ( ) Macrophytes
Are any of these plants very abundant? ( ) Yes ( ) No

3.18 Surrounding Land Use: (Rank relative abundance 1 most common, etc. Leave blank if absent.)

Woodland: _____________ Wetland: ____________ Open Field: _________ (grassland/meadow)

Farmland: ______________ Residential: __________ Commercial: ________

Other (please describe):
____

3.19 Does the Road Ditch Discharge Directly To the Stream At the Crossing?
( ) Yes ( ) No

3.20 Any Obvious Pollution Sources: ( ) Yes ( ) No
If Yes, Please Describe:

Other Observations:

Please Attach Photos to Survey Form (downstream, upstream, and others of interest)

Single Site Watershed Survey Data Sheet (page 2)

Date: Site Number:

Upstream Side/Downstream Side

POTENTIAL SOURCES (severity: S-slight, M - moderate, H - high)

Crop Related Sources	S	M	H	Land Disposal	S	M	H
Grazing Related Sources	S	M	H	On-site Wastewater Systems	S	M	H
Intensive Animal Feeding Operations	S	M	H	Silviculture (Forestry NPS)	S	M	H
Highway/Road/Bridge Maintenance and Runoff (Transportation NPS)	S	M	H	Resource Extraction (Mining NPS)	S	M	H
Channelization	S	M	H	Recreational/TourISm Activities (general)	S	M	H
Dredging	S	M	H	·Golf Courses	S	M	H
Removal of Riparian Vegetation	S	M	H	·Marinas/Recr. Boating (water releases)	S	M	H
Bank and Shoreline Erosion/ Modification/Destruction	S	M	H	·Marinas/Recr. Boating (bank or shoreline	S	M	H
Flow Regulation/Modification (hydrology)	S	M	H	Debris in Water	S	M	H
Upstream Impoundment	S	M	H	Industrial Point Source	S	M	H
Construction: Highway/Road/ Bridge/Culvert	S	M	H	Municipal Point Source	S	M	H
Construction: Land Development	S	M	H	Natural Sources	S	M	H
Urban Runoff (Residential/Urban NPS)	S	M	H	Source(s) Unknown	S	M	H

Site Summary Information

Survey Direction	N/A	U/S	D/S
Site Similarity	?	Y	N
Overall Site Ranking	L	M	H
Site Follow Up Rank	L	M	H

Comments:

Section 4: Benthic Macroinvertebrates

4.1 Spend approximately 30 minutes collecting invertebrates, then identify and fill out the sheet below.

4.2 Try to sample from all of the habitats listed below.
Check the types of habitats and substrates from which invertebrates were collected.

______ Riffles	______ Runs	_______ Pools
______ Cobbles	______ Margins	_______ Undercut Banks/Over-hanging Vegetation
______ Aquatic Plants	______ Leaf Packs	_______ Submerged Wood

______ Other (Please Describe) ____

4.3 Use letter codes R and C (Rare = 1-10 and Common = 11 or more) to record the approximate numbers of organisms in each taxa found in the stream reach.

Group1 Sensitive	**Group 2** Somewhat Sensitive	**Group 3** Tolerant
_____ Coleoptara (Adult Beetle)	_____ Amphipoda (Scuds)	______ Diptera (Midge larvae
_____ Coleoptera (Water penny)	_____ Coleoptera (Beetle larvae)	______ Diptera (Other)
_____ Diptera (Black Fly larvae)	_____ Decapoda (Crayfish)	______ Gastropoda (Pouch snails)
_____ Ephemeroptera (Mayfly nymphs)	_____ Diptera (Crane Fly larvae)	______ Hemiptera (True Bugs)
_____ Gastropoda (Gilled Snails)	_____ Megaloptera (Alderfly larvae)	______ Hirudina (Leeches)
_____ Megaloptera (Hellgrammites)	_____ Odonata (Damselfly nymphs)	______ Isopoda (Sowbugs)
_____ Plecoptera (Stonefly nymphs)	_____ Odonata (Dragonfly nymphs)	______ Oligochaeta (Aquatic worms)
_____ Trichoptera (Caddisfly larvae)	_____ Pelecypoda (Clams)	

Group1	**Group 2**	**Group 3**
_____# of R's X 5.0 = ________	_____# of R's X 3.0 = ________	_____# of R's X 1.1 = ________
_____ # of C's X 5.3 = ________	_____ # of C's X 3.2 = ________	_____ # of C's X 1.0 = ________
Group 1 Total =________	Group 2 Total =________	Group 3 Total =________

Total Stream Quality Score (sum of totals for Groups 1-3) = ______________

_________ Excellent (>48)   _________ Good (34-48)   _________ Fair (19-33)   __________ Poor (<19)

4.4 During the sampling and evaluation, did you observe any fish or wildlife?   ( ) Yes   ( ) No
If yes, please describe (if possible):

DRAGONFLY POND

Introduction:

Each use of the land either negatively or positively affects the environment. Each land is an illustration of its importance to humans. Some people feel that the land and its resources are there for the use and sometimes overuse. Others feel that the land and environments should be protected from alteration. Finally, some people believe that a balance of land use and land protection should be instilled.

At the center of the land use decisions is the idea of growth. The goal is for an environment to be used and yet still show growth or even stability. Growth of an ecosystem is dependent on limiting factors such as: food, water, shelter space and available mates. If an ecosystem can be used by humans and still grow by not altering any limiting factors significantly then it still maintains the ability to self regenerate. The ability to self regulate is what allows all biotic factors to live together. It is important to realize that all life forms must be maintained since they are all interconnected. Humans have the ability to alter these limiting factors and upset the ecosystem. For example, people can build dams to create power, water can be captured for irrigation, and wetlands can be drained for homes and buildings. All of these activities affect wildlife habitat.

Wetlands are often viewed as useless but they are important nurseries for fish and birds, they are homes for a variety of animals, they assist in controlling flooding, and help in cleaning the environment. Unfortunately, wetlands are delicate and can be easily degraded by human influence.

Materials:

Scissors	Glue
Paper	(1) set of land use cutouts
(1) Dragonfly Pond cutout	(1) large piece of paper (18" X 24")

Procedure:

1. Your group is responsible for arranging the pattern of land use around the Dragonfly Pond. Your goal is to do the best you can to preserve the health of this beautiful aquatic area while keeping in mind the assigned interest group you are to represent.

2. Create a pros and cons list for each land use card.

3. Cut out the land use pieces and the Dragonfly Pond. **All** the pieces must fit on the large (18" X 24") paper which will represent your group's map You may cut **only** the park and farmland pieces smaller but must be used. Parts may touch but may **not** overlap. Hint: Only begin gluing when you all have agreed on the location of the pieces.

4. Each group should turn in the final arrangement and the pros and cons list.

5. Once you have completed the placement of your pieces, on lined paper as a group come up with a list of pros and cons of each required land use.

6. Turn in for class discussion.

Name: ___________________________________ Date: ___________ Hour: _______

Dragonfly Pond Discussion Questions

1. If you could discard one land use card, which would it be? Explain why you chose that one.

2. List some possible benefits of discarding the chosen card from above. List some possible problems with discarding this card.

3. If you could enlarge one land use card, which would it be? Explain why you chose that one.

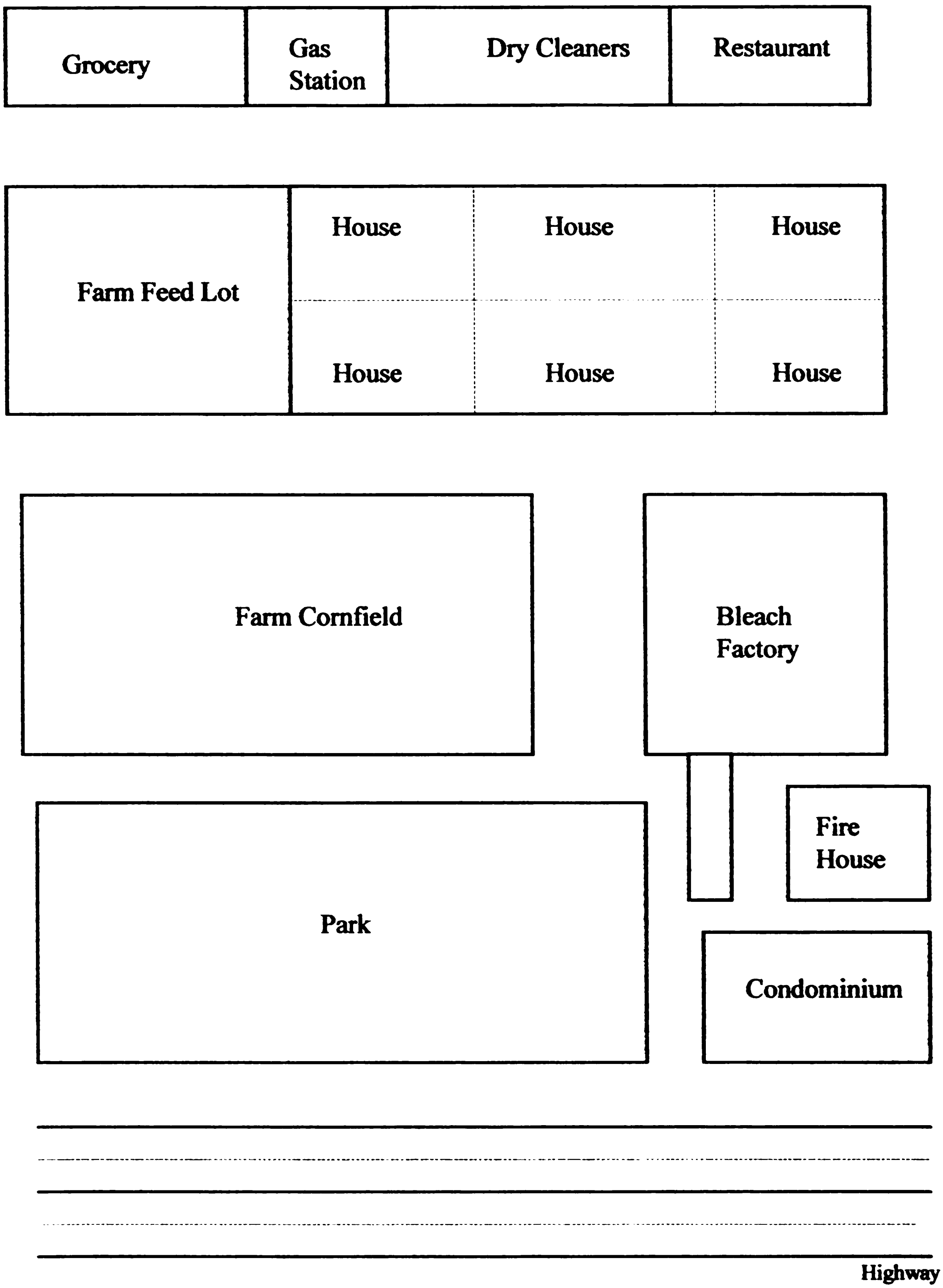
4. List some possible benefits of enlarging the chosen card from above. List some possible problems with enlarging this card.
5. Imagine that downriver from the land uses and Dragonfly Pond are other aquatic systems (refer to drawing).
    a) If we are looking a specifically the bleach factory effluent, what effect will this possible have on these other aquatic systems?

    b) How should it be treated? Where should it be treated? By whom?

    c) Where will it go? With what effects?

6. What could the people who are actually in charge of the various land uses do in their practices to minimize the damage to Dragonfly Pond?

7. Create a list of things you could personally do to begin to reduce the potentially damaging effects of your own lifestyles on the "downstream" habitats. (at least 5)


Grocery
Gas Station
Dry Cleaners
Restaurant
Farm Feed Lot
House
House
House
House
House
House
Farm Cornfield
Bleach Factory
Fire House
Park
Condominium
Highway

Dragonfly Pond
Teacher Notes

Objectives:

Students will be able to: 1) evaluate the effects of different kinds of land use on wetland habitats: and 2) discuss and evaluate lifestyle changes to minimize damaging effects on wetlands.

Methods:

Students create a collage of human land-use activities around an image of a pond.

Time:

1 class period to complete group activity
20 minutes to discuss homework assignment the next day

Background:

The major purpose of this activity is to encourage students to wrestle with these land and water-use concerns. In this simulation, students use the "Dragonfly Pond" as a microcosm of environmental concerns involved in management decisions. They struggle with the arrangement of overlapping and conflicting land uses in an effort to preserve a wetlands habitat. When the students reach some kind of agreement about the local issues, the activity shifts to how what they have done affects other dragonfly ponds downstream. The activity ends with consideration of the idea that the planet is, in fact, a single "Dragonfly Pond."

Teacher Procedure:

1. Prepare copies of the two cutout sheets ahead of time. Explain the activity.

2. Divide the class into groups of three or four individuals with each group representing one of the interest groups:

   - Residents – want to live in the area
   - Farmers – want to use the land to raise food and livestock
   - Business interests – want to use the land for commerce and economic growth
   - Gas station owners – want to make a living in servicing and repairing cars
   - Parks department personnel – want people to have a place for recreation
   - Highway department personnel – want to maintain access in the area
   - Bleach factory representatives – want to preserve jobs and commerce

3. Pass out the land use materials and large (18" X 24") paper to serve as the base.
4. Hang the final arrangements on the board and have a spokesperson explain the diagram and the groups reasoning.
5. Have all groups turn in diagrams and pros/cons list. Assign Dragonfly questions for individual homework.

Resources:

Western Regional Environmental Education Council, pages 143-148, 1987.

Contaminants In Great Lakes Fishes

Introduction:
Biomagnification is the process by which contaminants, which breakdown slowly, accumulate in the tissues of animals increasing through the food chain. If these contaminants are fat-soluble (for example DDT and PCBs) they will remain in the tissues of the animal and not be passed through the organism. When a predator consumes that animal, it receives and stores all of the contaminants within the prey. The amount of contaminants is compounded (or biomagnifies) as the predator feeds on many prey. In fact, humans (being a top predator) can have contaminant concentrations that are 1million times greater than the water concentration. Some researchers believe that high enough levels of these contaminants can affect birth weight and childhood development.

Materials:

Per group:

- 8 iodine crystals
- screw-top vial-77cc
- water – 30 cc
- vegetable oil - 30cc

One PARTS PER MILLION: VERY SMALL FRACTIONS WORKSHEET per person

Part A:

Procedure:

1) Place the iodine crystals in the vial.
2) Pour in 30 cc of water. Screw the lid back on.
3) Shake the vial vigorously in an effort to dissolve the crystals.
4) After a few minutes of shaking, observe any change in color of the water and whether the crystals have dissolved.
5) Unscrew the lid and pour 33 cc of vegetable oil into the vial . Screw the lid back on.
6) Shake the vial again.
7) After a few minutes, hold the vial still and observe changes in the color of the water, oil and amount of solid crystal present.

Analysis:

1) What happened to the iodine, when it was mixed with water?

2) What happened to the iodine and water when the oil was added?

3) In which substance is iodine more soluble, water or oil?

4) What type of bodily substance does the oil represent? The water?

5) Where do you think PCBs turn up in fish and other animals?

6) Why can't they be "washed out" by blood or urine?

7) How are anglers told about contaminants in fishes they are trying to catch?

8) Suppose you want to cook a fish, which may have tiny traces of PCBs. What would be the best way to prepare it?

Part B:

**PARTS PER MILLION:
VERY SMALL FRACTIONS WORKSHEET**

Contaminants are chemicals, which are found at undesirable levels in organisms or the environment. Scientists and people who make policies measure levels of contaminants in units called "parts per million." In fact, these amounts are so tiny that scientists have trouble measuring them. Special expensive equipment is used to measure parts per million.

Unfortunately, there are contaminants within the bodies of some plants and animals in the Great Lakes. However, the amounts are very small. The amounts are usually expressed as parts per million, or ppm for short.

For example, a scientist might say that a Coho salmon has 8 parts per million of PCBs, a contaminant found in the Great Lakes. This would mean that if you divided the fish's weight into a million parts, 8 of those parts would be made up of PCBs.

How much is a part per million? One part per million would be like one drop of chocolate in 64 quarts of milk.

The U.S. Food and Drug Administration sets limits on the amount of contaminants that can be in a food product to be sold. For Great Lakes fish, they have decided that level is 2 parts per million of PCBs. Therefore, fish over the "safety limit" of 2 ppm of PCBs cannot be sold for interstate trade. Most states have similar limits for sales within their boundaries.

When the governments sets a level for a contaminant in you food, it does not mean that eating something at that level will kill or harm you. It just means that it could eventually be damaging to eat this food if you ate a lot of it over time. Usually, the "safety limit" is much, much lower than the actual amounts, which might be harmful

Many of our foods have some level of contaminants. For instance, most bacon and ham contains small amounts of chemicals, which kill bacteria and preserve the pork.

It is hard to avoid harmful substances; they are all around. Many potentially harmful substances are around because they are "good" for something else. PCBs are useful chemicals that, in the past, were used in making electrical equipment. Pesticides may increase a farmer's crop by killing insects that eat the crops. As you can imagine, solving the problems of contaminants in our air, food, and water is going to be a complex task.

Now Try This...

You can figure out parts per million with a simple formula:

Weight of fish: =F
Weight of PCBs in fish: =P make sure F & P are in the same units
Parts per million of P in F =X

The formula for figuring out X is:

$$X = (P / F) \times 1{,}000{,}000$$

So let's take a look at a whitefish that a commercial fisher has caught. The fish weighs 3 kg. The government lab found .009 g of PCBs in the fish. Is the fish over 2 ppm? Let's use the formula to find out.

First, change the weight of the fish to grams, just like the weight of the PCBs.
Since 1 kg is 1000g, then 3 kg = 3 x 1000 = 3000 g.

Then, X = (.009 g/3000 g) x 1,000,000 = 3 parts per million

No, the whitefish is not under the 2ppm limit, and cannot be sold.

Some other fish came in with the catch. Calculate the ppm of contaminants in each fish.

1. Whitefish — Wt. = 2.5 kg; P = .007 g
2. Yellow Perch — Wt. = .5 kg; P = .005 g
3. Sucker — Wt. = 1.5 kg; P = .003 g

Some sport anglers come in with more fish. Calculate the ppm of contaminants in these fish.

4. Coho salmon — Wt. = 6.5 kg; P = 0.052 g

5. Lake trout — Wt. = 7.0 kg
P = 0.066 g

Analysis:

1) Trout and salmon have more fat in their bodies than fishes like whitefish, perch, and smelt. Why might the amount of body fat have something to do with parts per million of PCBs in a fish?

2) Why might it be difficult to determine the level of PCBs in humans?

3) Do you know any chemicals that have been banned or restricted by governments? Are those substances still in the environment?

4) In Lake Ontario, a chemical called Mirex got into the fish at levels which the government thought were unsafe for people to eat. The state of New York made it illegal to possess a fish from Lake Ontario, even if you caught it yourself. In Michigan, on the other hand, the government knew that salmon and lake trout had high levels of PCBs, also a harmful substance. The state of Michigan did not make it illegal to possess these fish. What they did instead was to put advisories in information people received with their sport-fishing licenses. These advisories asked people not to eat more than two Great Lakes fish meals per week and asked women of childbearing age and small children not to eat any at all. Which method of protecting people is better? Why? Does the government have the right to control what you eat?

Contaminants In Great Lakes Fishes
Teacher Notes

Objectives:
The students will be able to 1) explain the term solubility 2) explain how and why contaminants end up in fat tissues of some fish 3) suggest how to reduce the intake of contaminants when eating Great Lakes fish 4) calculate parts per million concentrations, given the weight of the organism and the weight of substance found in the organism 5) explain the role that governments play in protecting citizens from exposure to contaminants and 6) critique an article about contaminants in Great Lakes fishes.

Time:
Part A – 20 minutes
Part B – 30 minutes

Materials:
Teacher Prep:
1) Ask: What happens to a teaspoon of sugar when you mix it into a glass of water? What would happen to a pat of butter if you mix it into a glass of water? Explain that the two substances illustrate the concept of solubility. Solubility is the ability on one substance to become evenly distributed in another substance.

2) Have the students complete Part A.

3) Explain that Part B will show them how people talk about contaminants and that they will learn about the math behind the term "parts per million"(ppm).

4) Read the Part Per Million Worksheet and go over the practice problem.

5) Have the students answer the questions for homework.

Resources:

Dann, Shari L., The Life of the Lakes, Michigan Sea Grant, Michigan State University.

APPENDIX C7 - Duckweed's Favorite Food

Introduction:

Duckweed (*Lemna minor*) is a small aquatic plant, which floats on the surface of ponds, lakes and streams individually or in large mats. *Lemna minor* has one rootlet hanging from the underside from which it absorbs vital nutrients like nitrogen, phosphorus, and potassium. There are about 25 different species of these small flowering plants, which are feed on by waterfowl. Reproduction often takes place by a division of the plant body. A duckweed plant has a leaf-like structure called a frond. During reproduction, the mother frond can give rise to two or three daughter fronds. As the daughter fronds increase in number the plant separates into individual plants. When the correct abiotic factors are present, duckweed can reproduce within 24 hours. In this experiment we will be trying to identify the optimal nutrient concentrations for duckweed. Various solutions of fertilizers will be used. The fertilizer solutions will be identified by their standard N-P-K (nitrogen-phosphorus-potassium) concentrations. All other factors will be kept constant for the various solutions.

H_o (null hypothesis) –

H_1 (your hypothesis)-

Identifying and Counting Fronds:

Materials:

- Clean petri dishes with lids (8)
- Duckweed plants (10 fronds/jar)
- Magnifying glass
- Stirring rod
- Nutrient solutions-
  - Distilled water
  - Pond water
  - 15-30-15 fertilizer solution
  - 10-60-10 fertilizer solution
  - 6-12-0 fertilizer solution
  - 30-10-10 fertilizer solution
  - 6-10-10 fertilizer solution
  - 12-0-0 fertilizer solution

Procedure:

1. Study the duckweed using a magnifying glass and draw and label a mother frond and daughter frond(s) in the space provided.

2. Label each beaker with the following information: YOUR NAME, PARTNER'S NAME, AND ASSIGNED SOLUTION.

3. Add 75ml of each solution to the appropriate beaker.

4. Using a clean glass-stirring rod, lift several clusters of the Duckweed from the stock bucket and float them off into the jar. ***Yellow or white fronds are dead. Do Not include them.***

5. Place the beaker on a white surface and using a magnifying glass carefully count the number of fronds in the culture. Refer to the diagram on the front side to correctly count the number of fronds. ***Do not count any dead fronds that may be in your beaker.*** Add or remove clusters, parts of clusters or individual fronds until 10 fronds are present to start your culture. Record your counts as made on the Data Table #1 under today's date. Place the jars under plant growth lights or near a window, as directed by the instructor.

6. Properly title Data Table #1 in the space provided above the table.

7. Count the number of fronds in each culture and record the counts under the proper data using the Data Table #1. Make counts every two days for about a week, then every two to three days for another week or as you are instructed. ***Disregard dead fronds in all counts.*** Be sure to count little, new fronds (buds) as well as the larger, older fronds. Use the magnifying glass when counting. Check the sides of the beaker for fronds or clusters that may be sticking there.

8. Properly title Data Table #2 in the space provided above the table.

9. At the conclusion of the experiment, use Data Table #2 to record the average number of fronds for each of the different solutions.

Results:

Data Table #1

Date											
Day #											
Number of Fronds Present											
Distilled Water											
Pond Water											
15-30-15 Solution											
10-60-10 Solution											
6-12-0 Solution											
30-10-10 Solution											
6-10-10 Solution											
12-0-0 Solution											

Data Table #2

____

Date											
Day #											
Class Average Number of Fronds Present											
Distilled Water											
Pond Water											
15-30-15 Solution											
10-60-10 Solution											
6-12-0 Solution											
30-10-10 Solution											
6-10-10 Solution											
12-0-0 Solution											

Analysis and Discussion Questions

1. Can you accept or reject your null hypothesis? Why? (Give specific reasons – use data)

2. Can you accept or reject your own hypothesis? Why? (Give specific reasons – use data)

3. Compare and contrast pond water as a nutrient medium with stronger nutrient solutions.

4. Which solution showed the optimal nutrient concentrations for duckweed reproduction? Explain.

5. Which solution showed the worse nutrient concentrations for duckweed reproduction? Explain.

6. Did your data show similar trends when compared to the class average data collected? Explain.

7. **What could be some possible sources of error that you had no control over? (name at least 2)**

Duckweed's Favorite Food
Teacher Notes

Objective:
Students will be able to 1) identify duckweed 2) observe the effects of various fertilizers on the duckweed population and 3) understand the importance of nitrogen, phosphorus, and potassium to plant growth and development.

Time:
1 day to set up
5 minutes each day for 10 days to monitor growth

Teacher Procedure:

1) To prepare solutions: mix 1 gram of fertilizer with 100 ml of distilled water.
2) Stir mixture to dissolve most of the granular fertilizer.
3) Filter out any particles by pouring the solution through a funnel lined with filter paper.

Resources:
"Growth of a population of organisms: Lesser Duckweed *Lemna Minor L.*", obtained lab from science teacher at a conference.

Reid, George K., Pond Life, Golden Press, New York, 1987.

APPENDIX C8 - POTATO AND SALTWATER LAB

Question - Why is saltwater not suitable for drinking?

Water is a valuable and necessary resource. If changes are not made in the ways we use it, soon water may become a nonrenewable resource. If that should happen, we may need to look at alternative places other than our freshwater supply to meet our needs. In this investigation, we will demonstrate why it is not possible to use saltwater for drinking before using the desalinization process.

Materials:			
	potato	beakers (3)	tap water
	scale	ruler	saltwater
	stirring rod	distilled water	

Procedure:

1. Cut a potato into three equal pieces. Determine and record the mass of each piece. Measure and record the length, width, and thickness in metric units. Record the texture. (can you bend it? is it soft?)

2. Then label and prepare three beakers as follows: In beaker 1, dissolve 10 g of salt into 250ml of tap water. Into beaker 2, place 250 ml of tap water. Into beaker 3, place 250 ml of distilled water.

3. **Only after determining the mass and dimensions!** Place one potato piece into each beaker. Let stand for 24 hours.

4. The following day, observe and record the texture of each piece of potato.

5. Blot dry with a paper towel. Measure the dimensions and record on the data table. Determine the mass of each potato once again.

6. Calculate the difference in mass and record. Include the appropriate +/- sign.
   (mass after soaking - mass before soaking = mass difference)

7. Calculate the percent change in mass.
   (mass difference / mass before soaking X 100)

8. Clean up lab station and return any materials.

Answer the following questions on a separate sheet of paper and in complete sentences.

1. What happened to each piece of potato as it soaked overnight? Why?
   (describe texture, dimension, and mass changes)

2. What would happen if people used saltwater as drinking water?

3. What process must saltwater be put through before using it as a drinking source?

4. What two ways can this be accomplished? Describe them.

5. What is the main reason for not using processed saltwater?

6. How can we solve the possible approaching water crisis?

Each person needs to turn in and staple in the following order:

title page
data table (neat and professional with a title and appropriate units)
questions #1-6

APPENDIX C9 - **Water You Want to Be?**

Scavenger Hunt
Teacher Notes

Objectives:
The students will be able to 1) identify the need for and diversity of careers related to water habitats, 2) list several types of water-related careers and 3) state that people with water-related careers work with habitats, biotic factors, abiotic factors, and people in the community.

Materials:
Outdoor and environmental magazines and catalogs
Markers
Posterboard

Time:
30 minutes

Procedure:

1. Divide the class into groups of 3 or 4. Give each group several magazines and catalogs, a piece of posterboard and some markers.
2. Tell the group that they will have 10-15 minutes to go on a scavenger hunt. Their job is to use the magazines, catalogs and background information to list as many water-related careers as they can. Have each group write their list on the paper.
3. After the time is over, have each group share their list.

You may want to award a prize (bottle of water) to the group members that listed the most careers or had the most unique careers.

Resources:
Arms, Karen, Environmental Science, Holt, Rinehart, and Winston, Inc., Austin, TX, 1996.

Dann, Shari L., The Life of the Lakes, Michigan Sea Grant, Michigan State University.

"Water Sourcebook", Auburn University at Montgomery and Troy State University, March, 1997.

Water You Want to Be?

Introduction:

Water-related careers abound in science, industry, agriculture, recreation, federal, state, and/or local government, research, transportation, engineering, and the military. With an increasing awareness of environmental concerns, these career options can be expected to multiply. Some require no more than a high school diploma and on-the-job training; some require a Ph.D. in a very specialized area. Many of these careers will be unfamiliar to you; perhaps you will find your niche!

Procedure:

1. Research the water-related career that you have chosen including all of the information on the checklist.
2. Locate and interview a person following this career including all the information on the checklist. Include an address or phone number that the person can be reached at in the future.
3. Design a poster illustrating the highlights and requirements of the career. Describe the information to the class. Turn in the poster and the checklists (one for research and one for interview).

Water Career Checklist
Interview

1. Job Title:

2. Education for job:

3. Where is this type of education available and ho long does it take?

4. What kind of a degree, certification, or bonding is required?

5. Who employs this type of worker?

6. What is the most common geographical location for this type of job?

7. What is the average annual salary range?

8. What are the job prospects/stability of employment?

9. Describe the work that is done on this job.

10. If there is anything else you learned in your research of this job, include it below.

11. Would you be interested in this type of job? Why or why not?

Water Career Checklist
Research

1. Job Title:

2. Education for job:

3. Where is this type of education available and ho long does it take?

4. What kind of a degree, certification, or bonding is required?

5. Who employs this type of worker?

6. What is the most common geographical location for this type of job?

7. What is the average annual salary range?

8. What are the job prospects/stability of employment?

9. Describe the work that is done on this job.

10. If there is anything else you learned in your research of this job, include it below.

11. Would you be interested in this type of job? Why or why not?

Water You Want to Be?
Teacher Notes

Objectives:
The student will be able to 1) describe the great variety in water-related careers and 2) compare specific careers regarding education, training, salary, and job description.

Background Information:
Too often students have no clear career goals. Many of these water-related careers will be unfamiliar to the students. Hopefully by doing this research and listening to the reports, students will develop an interest in a water-related career.

Time:
2 class periods (one to research in media center/internet lab and one in class to design poster
out-of-class time for research and interview

Teacher Preparation:
1. Put each career from Student Sheet on Water-Related Careers on slips of paper (one for each student). Cut them apart. Put them in a container so that students can draw them out.

2. Have students contact any people in the area who are in these careers. If they are willing to be interviewed by the students, list their names and telephone numbers where they can be reached.

3. Ask students what their career goals are. Are any water-related? What does water-related mean? Ask for examples.

4. Tell students you have any expanded list and they are going to investigate these careers by randomly picking one. Students may exchange their careers as long as each student researches a different one.

Resources:
Arms, Karen, Environmental Science, Holt, Rinehart, and Winston, Inc., Austin, TX, 1996.

"Water Sourcebook", Auburn University at Montgomery and Troy State University, March, 1997.

Water-Related Careers
Teacher Sheet

Agricultural Engineer
Aquarium Director
Archaeologist
Aquatic Entomologist
Biologist
Biosolids Specialist
Boat Builder
Boater
Botanist
Bottled Water Company Employee
Chemist
Chemical Engineer
Civil Engineer
Coast Guard
College/University Professor
Commercial Fisherman
Desalination Plant Director
Diver
Docks Master
Ecologist
Environmental Attorney
Environmental Chemist
Environmental Engineer
Environmental Scientist
Farmer
Fire Fighter
Fisheries Biologist
Forester
Geographer
Geologist
Groundwater Contractor
Health Dept./Environmental Inspector
Hydraulic Engineer
Hydrologist
Ice Skater
Landscape Artist
Landscape Architect
Limnologist
Marina Owner/Operator or Employee

Marine Salvage Engineer
Marine Geophysicist
Marine Geologist
Marine Conservationist
Marine Explorer
Marine Technician
Merchant Marine
Meteorologist
Sail boater
Navy
Oceanographer
Photographer
Physical Scientist
Plant Physiologist
Plumber
Potter
Professional Tournament Fisherman
Rafting Guide
Ranger
Recreation Instructor
Science Teacher
Scuba Instructor
Scuba Diver
Ship Builder
Seaman
Snow Hydrologist
Soil Scientist
Structural Engineer
Submariner
Sunken Treasure Hunter
Tugboat Biologist
Underwater Photographer
Wastewater Treatment Engineer
Water Meter Reader
Water Level Controller
Water Resources Engineer
Water Quality Control Officer
Well Driller
Yachtsman
Zoologist

Section 5.1 Quiz
Our Water Resources

Matching:

a) Aquifer
b) Colorado River
c) Desalinization
d) Groundwater
e) Ice caps and glaciers
f) Mississippi River
g) Oceans
h) Recharge zone
i) Reservoir
j) Surface water
k) Watershed

_____ 1. Water found in lakes, rivers, and streams.

_____ 2. Area of land from which water flows into a river.

_____ 3. These hold 97% of the water on Earth.

_____ 4. This is the longest river in the United States.

_____ 5. Artificial lake created by building a dam.

_____ 6. Underground rock formations that hold water.

_____ 7. These hold 76% of all the freshwater on Earth.

_____ 8. Area of land through which water percolates to be stored as groundwater.

_____ 9. Removing salt from seawater to make fresh water.

_____10. This river only trickles by the time it reaches the deserts in Mexico.

_____11. Water that seeps down through the soil and accumulates beneath the ground.

True or False:

_____12. Water is considered a renewable resource on Earth.

_____13. Of all the water on Earth only 3% is fresh water.

_____14. Distillation and towing are two examples of desalinization.

_____15. Most of the water used in a household is due to toilet flushing.

____16. Building dams reduce conflict between countries over sharing water.

____17. Distillation removes salts by passing water through a membrane that does not allow the salts to pass through.

____18. Aluminum sulfate is added to water to form flocs, sticky globs, to, which bacteria adhere to.

Fill-In

19. Describe what is happening at each stage of the water treatment process.

20. Using complete sentences, describe two ways that you can reduce your water consumption everyday.

Section 5.2 Quiz
Freshwater Pollution

Matching:

a. Artificial eutrophication
b. Bioaccumulation
c. Nonpoint pollution
d. Pathogens
e. Point pollution
f. Sludge
g. Thermal pollution
h. Water pollution

____ 1. Results from sewage runoff or fertilizer buildup in lakes and slow moving streams.

____ 2. By product of the wastewater treatment process and maybe used as fertilizer.

____ 3. The increasing concentration of a substance as it is passed through the food chain.

____ 4. This is dangerous to aquatic environments because it causes the amount of dissolved oxygen to change.

____ 5. Examples of sources would be: septic-tank systems or municipal landfills.

____ 6. Diseasing causing agents that may be found in aquatic environments.

____ 7. Examples of sources would be: storm-water runoff from streets or highway construction and maintenance.

____ 8. The introduction of chemical, physical, or biological material into an aquatic environment causing damage to the habitat.

True or False

____ 9. The Cuyahoga River was so polluted at one time that it actually caught on fire.

____10. The fecal coliform test will determine the presence and amount of *E. coli* in the environment.

____11. DDT and PCBs are examples of toxins that are water-soluble.

____12. Warm water due to thermal pollution tends to hold more oxygen than cold water.

____13. Nitrogen is found in fertilizers and sewage.

____14. Most of the wastewater from homes is biodegradable.

____15. Phytoplankton are microscopic free-swimming animals.

____16. Stream-bottom macroinvertebrates can give some indication of the quality of the water.

Fill-In

17. Describe what is happening at each stage of the wastewater treatment process.

18. How does nutrient-rich fertilizers cause fish kills?

19. List the 5 Great Lakes.

Section 5.3 Quiz
Ocean Pollution

Matching:

a) *Exxon Valdez*
b) Helsinki Convention
c) Law of the Sea Treaty
d) Marine Mammal Protection Act
e) Marine Protection, Research, and Sanctuaries Act
f) MARPOL

____ 1. States that the laws of the coastal nations extend 22km from its coastline.
____ 2. Prohibits the release of oil or plastics into the ocean or coastal waters.
____ 3. Caused a spill of 11 million gallons of oil in Alaska in 1989.
____ 4. Prohibits any action that could harm aquatic mammals in the oceans.
____ 5. Attempts to control land-based sources of ocean pollution
____ 6. Created 15 marine refuges for marine animal species.

True or False

____ 7. Only 15 % of ocean pollution comes from the land.
____ 8. The United States is one of 134 countries that signed the Law of Sea Treaty.
____ 9. Only 5% - 15% of the oil pollution originates from oil spills.
____10. Salt water is not good for drinking because it causes our body cells to lose water.
____11. Removing all of the toxic substances refines crude oil.
____12. The international Seabed authority controls the open oceans that are not monitored by individual nations.
____13. The Public Rangelands Improvement Act of 1978 help protect the dumping of garbage into the ocean.

Short Answer:
Answer the following using complete sentences.

14. Describe how and why the oceans are polluted.

15. Describe the effects of pollution of marine wildlife.

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