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Big Fish In A Small Pond: Using Authentic
Assessment In A Teaching Unit On Pond Fisheries Management

presented by

Eric W. Buhr

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BIG FISH IN A SMALL POND: USING AUTHENTIC ASSESSMENT IN A TEACHING UNIT ON POND FISHERIES MANAGEMENT

By

Eric W. Buhr

A THESIS

Submitted to
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ABSTRACT

BIG FISH IN A SMALL POND: USING AUTHENTIC ASSESSMENT IN A TEACHING UNIT ON POND FISHERIES MANAGEMENT

By

Eric W. Buhr

The study of fisheries resources in a high school environmental science course poses many challenges to the educational professional. While many students are familiar with fish through personal experiences of recreational angling, some lack those experiences entirely. Of those that have fished, scientific knowledge concerning the environmental factors that contribute to the success of a fish species' survival in various aquatic environments is often limited. Students may know how they can catch a fish from a body of water, but cannot identify the major components of fish habitat, life cycles or differences among individual species. This thesis unit addresses these problems in student knowledge and understanding of fisheries resources by providing opportunities to closely study a small pond and its fish population.

Students worked in cooperative groups to explore various pond habitats. They captured, measured, determined age and growth rates of fish and assessed the overall population of a small recreational fishing pond in their local school district. Assuming the role of a team of pond fishery consultants, they presented the results of their findings in a report to the pond's owners and all students learn that there is a great deal more affecting the survival of a fish population in a pond than they have previously considered.

This thesis is dedicated to my students, past, present and future, who challenge me to continue my educational growth with their ever-present and always appreciated questions about the wondrous world we live in.

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TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

In my nine years of experience as a high school science teacher, I have witnessed a great change in the way I approach teaching the life sciences. Fresh out of Michigan State University with Bachelor's degree in hand, I knew what I had been taught about biology: cells, taxonomic classification, genetics, ecology, botany and more content knowledge than I could possibly ever use up in one game of Trivial Pursuit! What I hadn't learned very well, I soon found out, was how to make all this something that fourteen- to eighteen-year-old high school students cared about learning for themselves. I had a lot of answers, but couldn't get my students to ask the right questions!

As I gained more experience and listened to veteran teachers describe their approaches to classroom instruction, I began to realize that what I had been taught about science, while exciting to me, was not very attractive to most of my students. I found that I really needed to make science tangible for my students, to get their hands on it, to have it make sense in their everyday experience. The Environmental and Behavioral Biology coursework at Kellogg Biological Station was a turning point in my science teaching career. That summer I found a new perspective that was absent from all the content-based teaching that I had done. I found ecology to be the common denominator that I could relate to any student's experience and weave into it most other concepts from the life sciences. In the six years since my teaching has changed, I believe, for the better. I engage my students in more real-world problems and examples of biology concepts, and show them that biology class doesn't end with the bell, but is part of every breath they take.

Statement of Problem and Rationale for Study

One of the elective courses that I have taught since coming to Fowler High School is Environmental Conservation, a yearlong science elective course. Historically, this course covered agriculture and natural resources topics and was considered a "blow-off" for serious students and a way for less serious students to pass a second required science credit. With my arrival, the class changed quickly in its reputation, but because of my unfamiliarity with the content, was originally text-driven. In my second year I began looking for alternative materials to the text because of its difficult reading level and lack of connection to the students' real world experience. In the third year the text was a seldom-used resource that gave the students something to read for supporting information beyond the videos, articles and news clippings that dominated the class materials.

After a one-year hiatus due to scheduling conflicts, the class really began to change in the 1993-1994 school year. This was a reflection of the Environmental and Behavioral Biology coursework at Kellogg Biological Station (KBS) in the summer of 1992 that had already had an impact on my approach to teaching the sophomore biology class. I used many of the ideas and materials from KBS to bolster the units that I had been developing during the second and third years of the Environmental Conservation course. A unit on groundwater was expanded to include the new groundwater model and porosity/permeability labs; a unit on solid waste issues was expanded to use labs on composting and landfill biodegradation; and a fisheries unit that started in the second year began to take shape as part of a larger Great Lakes ecology unit.

During the 1994-1995 school year I expanded the fisheries unit to teach it for the last seven weeks of the school year, following a unit on Great Lakes water quality. The unit included the topics of fish species identification, external anatomy, bioaccumulation, Michigan fisheries history and angling techniques and regulations. I did my best to relate these topics to concepts of ecology like habitat and population dynamics, but didn't include any laboratory activities. Student interest was piqued when I took the class on a unit's end fishing trip to a local pond.

In the biology class during the 1995-1996 school year I began teaching a freshwater ecology unit that included water quality and aquatic macroinvertebrate survey work at a nearby stream. This large-scale lab activity had great benefits for my students and I have continued it each year since. The experience with that unit encouraged me to do more fieldwork with aquatic systems and I began thinking about how to change other units, such as the one on water quality, to include similar exercises.

As I pondered a topic to use for my thesis I considered making significant changes in one of the units from Environmental Conservation because I have greater flexibility with the curriculum than I do in Biology. I wanted to choose a unit where I could improve my effectiveness in teaching principles of ecology as well as specific content of a related discipline such as fisheries or wildlife. I wanted to do a better job of teaching for understanding and involve students in new types of hands-on learning activities.

After the fishing trip in the spring of 1997 I realized that the fisheries unit was the one that could be most improved by changing the focus of the content and instructional methods. I recognized that this unit lacked the involvement of the students in seeing and understanding how ponds and their fish populations are part of a complex ecology. I still wanted to focus on the fish and fishing because the students signing up for the class definitely looked forward to that part of the class and it is connected to their common experience.

The pond that we had fished the previous two years would continue to be our study location and the owners, Claude and Cecile Feldpausch, were happy to accommodate a more extensive survey of the pond and its fish population. They were pleased that I wanted to engage the students in a serious scientific investigation, and anticipated the results of our work as an opportunity to increase their own knowledge as well.

This unit should go further than its previous forms to educate students and to increase their motivation to show and tell others what they have learned. The knowledge that they will gain should be more experiential and have attached to it memories of fun times spent with classmates working in a familiar and enjoyable setting. It is likely that they may someday revisit the pond with others that may listen to their story about doing science and learning about pond fisheries management. This cascade effect can lead to an even greater impact on how people view our environment and their place in it.

Review of Written Materials

In the development of this unit I reviewed a great deal of literature to find suitable and grade appropriate information and activities to use with my students. Having no specific textbook for this course, I looked for information on pond ecology in our biology class textbook, Silver Burdett's Biology, and found it terribly insufficient. Review of Project WET and Project WILD materials provided some ideas for student activities to illustrate concepts but were not helpful in providing good "hands on" labs. Popular press articles from magazines such as In-Fisherman and Field and Stream on pond fishing and concepts related to limnology were helpful resources to use as student readings because of their appropriate reading level and graphics.

Most helpful to me was the Michigan State University Cooperative Extension Service publication Managing Michigan Ponds for Sport Fishing, which by far turned out to be the best source of scientific information and was suitable for student use as a text as well. I also used the Golden Guide book Pond Life as a student text because of its simple explanation of limnology concepts and excellent overview of the various pond organisms that we might encounter. Another Michigan State University Cooperative Extension Service publication, Determining the Age of Fish, proved very helpful to my own understanding and for use as student materials. Additional materials used included the Michigan Department of Natural Resources 1998 Michigan Fishing Guide and Michigan Department of Community Health's 1998 Fish Consumption Advisory.

Science Concepts Taught

This unit sought to teach students some of the concepts of scientific fisheries management that are specific to small ponds. Basic principles of limnology were presented with regard to the classification of the four basic pond habitats and the identification of various organisms such as plants, macroinvertebrates and vertebrates found there. Fisheries science concepts pertaining to fish anatomy and species taxonomy were covered, as well as the field study and laboratory techniques of population sampling, scale sample collection and examination to find fish age and back-calculate growth. Additionally the unit addressed the concept of bioaccumulation of contaminants in fish tissues and the advisories issued for fish consumption. The topics of soil structure, groundwater, and nutrient cycling that had been previously covered in this course and the biology course that I also teach were revisited as necessary to reinforce the pond fisheries management concepts being taught.

The primary objective in determining the appropriate science content for the unit was to include material that would be intellectually challenging but not impossible for students to comprehend. The field and classroom laboratory activities needed to be designed so that they required a minimal amount of specialized equipment and were relevant to the students. Most importantly the science content had to give them some practical knowledge that they could apply in their personal lives as they use ponds or other aquatic ecosystems for recreational or other purposes.

The planning, construction and use of small ponds as recreational fisheries in Michigan is more complex than many people realize. Students, whose parents own or who have otherwise used such ponds for fishing, often overlook or ignore the complex ecological relationships that exist within the ponds' communities of fish, plants, macroinvertebrates and plankton. The pond's ecology determines whether or not it is deemed successful by its human caretakers. Most students who go fishing want to catch big fish and lots of them, but fail to understand the necessary conditions in a pond that allow this to occur.

Southern Michigan ponds are best suited for warmwater fish species of the sunfish family such as bass and panfish like bluegill, pumpkinseed and redear sunfish because of their limitations in size, depth, and summertime water temperatures. The types of fish that are often stocked and the manner in which they are harvested are seldom done with regard to sound scientific management. For successful recreational fishing a sound plan of construction, stocking, maintenance and harvest must be employed to prevent the abundance of small stunted fish in species such as bass and bluegill that will result from an improperly managed pond.

Ponds should be constructed and maintained to reduce the influx of nutrients from overland runoff, and should be deep enough to retard the growth of aquatic plants and provide enough water to avoid winter die-off under the snow-covered ice. Selective stocking should be done to choose combinations of suitable fish such as minnows and largemouth bass, or hybrid sunfish with or without largemouth bass, that will provide the angling opportunities desired but also maintain a healthy predator-prey relationship in the pond. Monitoring the condition of the fish can be accomplished by taking length and weight measurements and age may be determined by observing the scales and counting annular growth rings in a manner similar to tree aging. This information is vital in determining management decisions on how many fish to remove and of what species and size to keep a healthy population balance.

Management of Michigan ponds and those in other northern states is fundamentally different from those in southern states. My initial survey of pond management materials on the Internet and through written text was heavily weighted to southern pond management. In fact, the major impetus for this project, an In-Fisherman article by Steve Quinn with Dr. Hal Schramm of Mississippi gave a totally different picture of pond fisheries management than what I later learned about Michigan ponds. Our ponds don't compare with southern ponds in terms of fish growth rates, stocking plans and harvest guidelines. Michigan ponds may allow the harvest of three pounds of bluegill for each pound of bass, while in the south that ratio is ten to one! Additionally, southern ponds often need added lime and organic matter to increase the fertility of the water, whereas Michigan ponds would eutrophy quickly if those practices were employed. My review of scientific literature for this project taught me a great deal about ponds but also reinforced my belief that one of the fundamental laws in science is that everything is relative!

Pedagogical Literature Review

Student assessment in science that does not incorporate the methods of doing science cannot give a complete view of what students have learned. "Science is an active process that involves physical skills, imagination, and creativity to tackle the ill-defined problems and events of the real world" (Hein 1991). To assess science learning without considering these elements is to look past a large part of what makes scientists successful in the real world. In my own science education I know that I was assessed more on what content I knew, as determined by multiple choice tests. My early teaching reflected my belief that this was how I would identify the best science students. Teaching as I had been taught has been a difficult thing to overcome, although my teacher training in Constructivist methods gave me an advantage in looking for new ways to find out what students know about science and adapt my teaching accordingly.

Student achievement in science may be assessed in five different ways: observation, verbal questions, written records, drawings and products (Hein 1991). I have used observation to assess skills in laboratory settings, posed questions to evoke verbal responses and written records in my assessment of students in my science classes.

Students loved to hate my open-ended "essay questions" in both pre-test and post-test scenarios in the past. Additionally, I have had students produce drawings to illustrate science concepts in a variety of content areas. The product form of assessment is something that I have used less frequently for end-of-unit assessment because of the time that it takes for students to produce such items.

When considering how to best change my teaching practices in this unit, I felt it was necessary to try a new approach to assessment. I wanted students to develop a product at the end of the unit that would reflect their science learning from the concepts and content that I taught. For the past three years I have attended in-service presentations and read many articles on authentic assessment, the use of reports, models, guides, pamphlets and other such student created materials to replace the paper and pencil tests normally used at the end of a teaching unit. While I have incorporated some of those strategies into many of my teaching units, I found them lacking in the fisheries resources unit. This was primarily due to a lack of hands on material from which students could develop a worthwhile product.

For an assessment to be authentic it must involve performance rather than drills. "A test of many items (a drill) is not a test of knowledge in use" (Wiggins 1992). The "hands on" doing of science must be placed in a context that has meaning beyond the boundaries of the classroom. The challenge for the development of the authentic assessment task is that it be meaningful, challenging, and engage the students in higher order thinking skills. I have not done this in this unit previously but believe that I have a suitable plan for successfully implementing such an assessment.

As the idea for the content change in the unit evolved to incorporate a pond life survey and fish population study, I found a happy marriage between that material and an authentic assessment method called *Analyze* and Apply™ that I had learned about through a district in-service presentation. The theme of the *Analyze* and Apply™ method is to team students in cooperative groups to achieve a goal that would be commonly expected of them in the world of work. *Analyze* and Apply™ has been used successfully in core curriculum applications, with vocational education, alternative education programs and elsewhere in schools. Students assume the role of professionals in a specified field related to the content area and then must gather, analyze, and apply the information that they have learned to design a product that will be presented to or reviewed by someone other than the student or teacher. This product may be a report, video documentary, brochure, or even an actual manufactured product, depending on the subject matter being used.

Authentic assessment occurs most naturally and lastingly when it is in a meaningful context (Brooks and Brooks 1993). The product that student groups create is truly authentic in that it has merit in the adult world, it provides for progressive steps allowing revision, achievement standards are known, and students associate greater value to the task (Schaftenaar 1994). This authenticity is important for the students to realize that they are being assessed on what they know and that they must provide the answers rather than making a choice from a list of possible responses. The students' group skills are also reflected in the final product in terms of meeting deadlines, quality control, and creative problem solving. The *Analyze* and Apply™ method, therefore, assesses a number of things that have conceptual as well as practical implications.

The *Analyze* and Apply™ method utilizes a workplace situation to direct the focus of the group to its goal of designing and completing their product. In this unit the students will assume the role of pond fisheries management consultants and their workplace situation was to prepare an assessment of the fish populations in Claude and Cecile Feldpausch's farm pond. This scenario required that the students not only survey the attributes of the pond, but also work closely with the Feldpausches to learn about the pond's history and purposes, and what they desired as a goal for the pond's fish resources. This closely mirrors the workplace setting that an actual consultant would encounter in the course of their employment. The project is therefore a meaningful and challenging one, making it a credible task for the students (Herman 1992).

The connection to the world of work is a practical and essential part of today's education. Preparing students for success in life after graduation requires that they are competent in five basic areas. They must be able to demonstrate their skill in managing or using resources, interpersonal skills, information, systems, and technology (Brock 1991). Each of these areas is addressed within the workplace scenario in this unit as the students schedule time and assign tasks (resources); work cooperatively as a team (interpersonal skills); collect and report information in a variety of ways (information); recognize their role in context of those around them (systems); and utilize microfiche projectors, calculators and computers for collection of data and production of their final report (technology).

The project that students engaged in at the end of the unit required them to perform all five of these tasks. Most important among them was their work in cooperative teams. I have used cooperative groups in this class and others in a variety of ways. I have used the Jigsaw method (Slavin 1986) in a Biology unit on the nitrogen cycle. In this situation, individual students learn different information about the parts of the nitrogen cycle to become their group's experts in specific areas that they later teach to their teammates. I have also used the Jigsaw II method in which all students learn the same material on plant classification, then perform a task as a group. In addition I have utilized the Think-Pair Share method, spontaneous group discussions and team products in units on energy and waste management in this course (Kagan 1985).

The difference between my previous use of cooperative learning methods and this unit's group report is the scope and size of the final product. This unit utilized a team product method where each member contributes a part to the group's final report. I had not used team strategies to produce such a large report in any of my classes and I expected some unique challenges in scheduling, team assignments and scoring.

Classroom Demographics

Fowler High School is a rural Class D school with an enrollment of 182 students during the 1997-1998 school year. The district is found in northwest Clinton County, approximately thirty miles northwest of Lansing. The student population is predominantly white of German ancestry, with only two students in the high school recognized as minority students.

The 1997-1998 Environmental Conservation class at Fowler High School consists of ten sophomore students including three girls and seven boys. These students chose the class as one of their two sophomore elective courses, and they earned a third science credit for successful completion of the full year course. All the students took the required sophomore biology course that I also teach. Environmental Conservation was offered during the final class period of the day, and all students had me for Biology class earlier in the day. All of the students had or were taking a full year of high school algebra, and five of them have completed a second year of algebra and were taking geometry.

Of the class members, one individual was classified as a minority student; none were considered to have any learning disabilities. Overall grade point averages for the group range from 2.46 to 3.74 on a 4.0 scale, with a mean of 3.17. Seven of the ten were consistent honor roll students (3.0 or better marking period grade point average). All students in the class participated in at least one extracurricular athletic activity at the junior varsity or varsity level and several held part time jobs. Overall this group of students was motivated to learn and highly involved in school and extracurricular activities.

IMPLEMENTATION OF THE UNIT

Unit Objectives

The unit is divided into four distinct parts: fish anatomy and species identification, pond ecology, pond fisheries management principles, and the group reports project. Objectives that the lecture, activities and labs were designed to teach are:

Part One: Michigan Fish Species and External Anatomy. Upon completion of this section, students will be able to:

- Identify 20 species of Michigan sport fish.
- Identify the various external features of fish such as fins, mouth, etc.

Part Two: Pond Ecology. Upon completion of this section, students will be able to:

- Identify limnology as the study of lake and pond ecology.
- Compare and contrast lakes and ponds.
- Identify characteristics of a properly constructed farm pond.
- Identify sources of various chemical nutrients in the aquatic environment.
- Describe chemical and physical characteristics of water that affect aquatic organisms.
- Describe the effect of sediment runoff on pond ecosystems.
- Identify the four habitat components of ponds and list organisms commonly found in each.
- Construct a common pond food chain.
- Describe factors affecting the rate of eutrophication in a pond.

Part Three: Principles of Pond Fisheries Management. Upon completion of this section, students will be able to:

- Identify reasons why people have ponds on their property.
- Define stunting, describe its cause and identify fish species that are prone to it.
- Identify suitable fish species or combinations of species for stocking a pond in southern Michigan.
- Estimate the size of a pond's fish population by use of a mark and recapture survey.
- Determine the age of a fish from scale analysis.
- Back-calculate the growth of a fish based on scale analysis.
- Identify reasons and methods for control of aquatic vegetation.
- Identify bioaccumulation and describe how a fish's niche influences the risks associated with consuming it.
- Identify ways to reduce risk of contaminant exposure when consuming fish.

Part Four: Group Reports Project. Upon completion of this section, students will have demonstrated their abilities to:

- Schedule their time appropriately and assign tasks fairly.
- Work cooperatively as a team.
- Collect and report information in a variety of ways.
- Recognize their role in context of those around them.
- Utilize technology for collection of data and production of their final report.

- Apply their knowledge and understanding of the science concepts and content information learned in the unit.
- Develop a product that has importance beyond the limits of the class.

Unit Outline

The unit was planned to be the last taught for the 1997-1998 school year. Our previous units on groundwater and water resources, in place for the last three years, flowed quite nicely into the study of aquatic ecosystems. Content on Great Lakes geography and fisheries history was omitted to provide ample time for the new unit's implementation. The following is an outline of the unit as it was presented this spring. New activities are denoted by an asterisk (*):

Week One: April 13^{th} –17^{th}. Part One: Michigan Fish Species and Fish Anatomy.

Free-writing Assignment: "Fish Story" (Appendix A-1)
Pre-test: "Name Those Fish" (Appendix B-1)
Lecture Presentation: Identifying Michigan Fish Species
Video Presentation: Wild America: "Fascinating Fishes"
Lecture Presentation: Basic Fish Anatomy
Review Game: "Goin' Fishin' in Michigan"*
Post-test: Fish Species and Anatomy (Appendix B-2)

Week Two: April 20^{th}—April 24^{th}. Part Two: Pond Ecology.

Pre-test: Pond Ecology (Appendix B-3)*
Activity: "The Pond as a Puzzle" (Appendix A-3)*
Lecture Presentation: The Pond Environment. (Appendix A-4, A-5)*
Activity: Pond Life Drawing (Appendix A-6)*
Mural Construction: Pond Habitats and Organisms*

Week Three: April 27^{th}—May 1^{st}.

Field Work: Survey Pond Habitats and Organisms*
Lab Observations: Identification of Collected Specimens*
Post-test: Pond Life (Appendix B-4)*

Week Four: May 4th—8th. Part Three: Principles of Pond Fisheries Management.

Free-writing Activity: "I want a pond because…" (Appendix A-7)*
Activity: Pond Goals Brainstorm (Appendix A-9)*
Lecture Presentation: Pond Construction*
Interview: Pond Owners Claude and Cecile Feldpausch*
Pre-test: Principles of Pond Fisheries Management (Appendix B-5)*
Field Work: Fish Capture and Marking *
Lab Activity: "How Many Fish in the Pond?" (Appendix C-1)*
Lab Activity: "How Old Is That Fish?" (Appendix C-2)*
Lecture Presentation: Pond Fish Stocking and Management Strategies*

Week Five: May 11th—15th.

Field Work: Recapture Fish*
Lab Activity: "Fillet Yo' Fish!" and Fish Fry
Lab Activity: "How Big Was That Fish When…?" (Appendix C-3)*
Project Work: Designation of Teams, Roles and Report Requirements (Appendix A-10, A-11, A-12)*

Week Six: May 18th—May 22nd. Part Four: Group Project.

Project Work: Peer Review of First Draft (selected portions). (Appendix A-13)*
Project Work: Revise First Draft.
Video Presentation: Michigan At Risk: "The Not-So-Great Lakes"
Reading and Discussion: Bioaccumulation and the Michigan Fish Consumption Advisory (Appendix A-14, A-15)

Week Seven: May 26th—29th

Project Work: First draft (entire report) scored (Appendix A-13)
Project Work: Revision and Final Draft Due

Week Eight: Final Exam Week

Project Work: Report Evaluations
Meeting with Mr. Claude Feldpausch for Discussion*
Post-test: Pond Fisheries Resources Unit (Appendix B-6)*

Audio-Visual Aids

The videos that I have used in the past that I incorporated into this unit included a Marty Stouffer Productions Wild America episode entitled “Fascinating Fishes”. This video, presented during week one, showed a wide variety of fish species common to the United States and was useful for showing the types of fish that are both common and uncommon in our state. Many of the students were able to recognize the fish species shown. They were assigned to list as many of the thirty-three species identified in the video as they could while it played. This has been an effective audio-visual aid for the fisheries unit, but I would like to find something more specific to Michigan fish species only.

The second video presentation, “The Not So Great Lakes” was on Great Lakes fish contamination from the Michigan at Risk series. I showed it during week six. This video, now several years old, addressed the controversy over Michigan’s Fish Consumption Advisory and contains some powerful visual images of the Great Lakes, their fish, and our state’s “Yes, Michigan!” ad campaign. This video provided a ready source of discussion regarding the safety of eating the fish that students catch. It would be helpful to find an updated version of this video for the purposes of the statistical information presented, but it was very effective as it stands.

Teaching Techniques

The unit began with a writing activity that I have used each year to generate student interest and connect the unit to their real world experiences. This activity, “My Fish Story” (Appendix A-1), required students to write a descriptive account of any experience that they have had with Michigan fish. All the students had a story to tell and after they read their responses I probed for more information about the species, physical traits, locations, methods, etc., that the students either omitted or didn't consider when writing their accounts.

My approach to teaching the first part of the unit on species identification differed from previous years in that I used only the Michigan Fishing Guide for this portion of the unit. In previous years I used the guide and other sources to compile a list of about thirty common Michigan species. I chose to stay within the guide to maintain consistency and keep one source that the students all had ready access to, as each had been given a copy for their use. The guide provides color pictures and identifying characteristics of the major Michigan sport fish that students are required to learn.

For the lecture presentation of this part of the unit I made new graphics pages on fish anatomy for student use in labeling the various external structures that were used in the notes. My research on fisheries taxonomy and sampling techniques increased my level of knowledge and preparedness for these lecture presentations. All of these approaches made for a smoother and more efficient delivery of content and simplified the student handouts that had been used in former years.

The review sheet (Appendix A-2) was like those used in previous years but specific to the twenty species selected from the fishing guide. Additionally, I constructed a review game that used cut out pictures of the fish species that were attached to fish-shaped cards bearing a paper clip. Student teams "fished" the cards from a bucket with a magnet "lure" on the end of a fishing pole's line and were awarded points for correct identification.

To introduce the second part of the unit I used an activity called "The Pond As A Puzzle" (Appendix A-3) to survey student prior knowledge and engage them in a group discussion about some of the living things found in ponds. I have utilized activities like this in other science classes but this is the first use of the pond puzzle for this unit.

Due to the length of the lecture presentation for this part of the unit I produced the Pond Ecology Note Outline (Appendix A-4) for student use. To reinforce the pond life material taught in the lecture presentation, students were given a review worksheet (Appendix A-5) and verbal instructions to produce a pond drawing that identified the four habitats of the pond and a minimum of three organisms that could be found in each (Appendix A-6). They were allowed to use their notes and Pond Life guides to assist them. After reviewing these drawings I allowed students time for revision before giving them credit for completing the assignment.

As a follow-up assignment, I wrote the names of thirty common Michigan pond organisms identified in the Pond Life guide on index cards. Each student randomly chose three organisms and drew pictures on pieces of copy paper that were later attached to a large sheet labeled with the pond habitats, forming a mural for the classroom wall. This project was a deviation from my normal routine because I have never been very enthusiastic about such large-scale "arts and crafts" projects, preferring instead to have individual students produce drawings for their own use. The drawing completed prior to the construction of the mural allowed me to assess students' understanding and provide each of them with a reference. The mural served as a class focal point on the pond life content area and displayed to students in other classes what we were doing in this unit, and provided an informative display for our interview with the pond's owners, Claude and Cecile Feldpausch.

The invitation to the Feldpausches to collaborate on the project as "clients" in need of a pond assessment was a new approach for me also, borne of the *Analyze* and Apply^{TM} format. I also sought the help of additional professionals in the field, namely Dr. Don Garling of the Michigan State University Fisheries Department, a local excavator specializing in ponds and a pond fish-stocking specialist. None of these people were able to visit my classroom because of scheduling conflicts, but were valuable contacts when I had specific questions. This is the first time in teaching this subject matter that I have sought such outside help.

The free-writing assignment about ponds (Appendix A-7) was designed to bring student attention to the presentation on pond construction and goals. The follow-up review questions (Appendix A-8) reinforced the material learned from lecture and provided students with a strong background from which they could brainstorm questions (Appendix A-9) to ask the Feldpausches in their interview. I gave these questions to the Feldpausches prior to their visit so that they could be prepared to address the issues the students wanted to know about. This method was very helpful in eliminating the silence that often dominates a guest's visit to the classroom.

The use of large groups in the authentic assessment report is also a change in my teaching approach. In the past three years I incorporated more authentic assessment tools into the curriculum, particularly writing, but have never done it with more than two students working together. My previous experience with lab groups and lab reports did not enthuse me enough to try large groups for written reports because of time abuses that

I had witnessed. The sheer size of the report and time I was allowing for its completion made me optimistic that students would be more motivated to use the time they had wisely and utilize the expertise of their peers.

Assignment of the students to their respective groups could have been done by a variety of methods for this project. I chose to assign students to one of two groups according to past performance in the class based on their cumulative grade point averages. In this manner, teams were balanced by assigning high, average and low performing students among the groups so that their average performance was equal. In addition to grades I considered skills in the various areas of art, computing, and writing so that teams would be balanced with student specialists in those areas. The first group chose the name "Perch" and the second chose the name "Crappie" to identify their groups. Plaques in the shapes of those fish were later awarded to the participants in the respective groups.

The team members worked together on the lab activities for estimating fish population, finding fish age and back-calculating growth. They also determined the roles of the individuals within the group and responsibility for various parts of the project (Appendix A-10). Those students identified as having the "Primary" role for each section of the report were the head writers of those sections. "Assistants" were designated to provide help and support and to be the first person providing peer review. The "Peer Reviewer" was another group member who would be responsible for reading and scoring the work before it was handed in.

During class periods designated for project work, "primary" writers collaborated with their "assistants" and writers from the other group to work cooperatively on their reports. Students constructed graphs using computer spreadsheet programs and analyzed the information contained in them. Others searched Internet sources for graphics that they could place in their reports. All used word processing programs to type the text of their report, and some drew pictures and maps of the pond and its inhabitants.

This group work was guided with performance standards in the form of guidelines (Appendix A-11) that were distributed to all group members and through conversations with team leaders. A list of deadlines (Appendix A-12) that I felt would be appropriate yet challenging was also given to each student. Providing these instruments of responsibility and quality control was necessary for directing the group activity and keeping students informed of the expectations for their performance.

A very important aspect of the group report involved the use of performance standards or quality controls that the students helped to develop. The specific criteria were developed into a rubric for the project (Appendix A-13) based upon what the students and I discussed as appropriate and necessary to be included in the written product. The students were familiar with how to construct and use them through previous experience in my classroom. Peer reviewers read student work and gave feedback based upon how it measured up to the criteria established in the rubric ahead of time. In this unit we utilized the peer review system during writing and construction of the group report as well as at other times during class work.

I had to make some special considerations for selecting the groups so that they would be balanced in ability. There was also a great deal of thought put into designing the project roles so that all students would be capable of completing the assigned tasks.

The rubric used to score the subsections of the reports was similar in length and form to those I have used in other classes. The compiled subsections resulted in an overall document much longer than any other rubric that I have used.

The two parts of the unit that really remained unchanged from last year were the handouts on bioaccumulation (Appendix A-14) and the Michigan Fish Advisory (Appendix A-15). I do feel that these topics would be more appropriately addressed with the pond ecology part of the unit in the future. Their importance was diminished due to interference from the report work that had started the week before.

The tremendous amount of lab activity time changed my teaching strategies a great deal also. Finding or constructing the necessary equipment such as measuring boards, microfiche projectors and computers for graphing made life more hectic. I found my organizational methods improving so that I could get things done when needed and avoid delays. Scheduling field trips and consulting with other staff members to coordinate student pullouts at the busiest time of the year put an additional stress on my class preparation time. Fortunately some flexibility in the schedule during the last two weeks of school allowed for all of our trips to go as needed. Scheduling class activities around early releases for athletics and other activities made things more interesting. The loss of power on May 31st and resulting two days off of school made for a more difficult end to the unit than anticipated but the cooperation I got from nearly all the students made things a little easier in completing the materials.

Laboratory Activities: Implementation and Reflection

As the planning for the unit progressed, it became necessary for me to narrow my focus on what laboratory experiences I wanted to incorporate. I initially planned to include work on water chemistry using the Hach Surface Waters test kits that we have available through our Clinton County Soil Conservation District. That may have worked had I not lost the opportunity the previous fall to introduce their use during our biology class unit on stream ecology, but to include them in the time available for this unit was not feasible. I also hoped to do some specific taxonomic classification of aquatic plants, but it became evident that my schedule was going to be very full simply getting the fish survey done, which was most important. I plan to revise my biology unit to include the aquatic plant information so that the students will have that material prior to our pond survey. We did use class time for a basic identification of some of the plant and invertebrate specimens that we collected during our first pond visit, but this was not what I considered a lab investigation as much as an observation.

The lab investigations that became the primary objective of the unit were those that specifically studied the pond's fish population. "How Many Fish in the Pond?" (Appendix C-1) is the lab investigation that served as the mark and recapture survey and was developed to engage students in estimating the number of fish that inhabit the pond. On our first visit to the pond for the survey we caught as many fish as possible with recreational angling methods, recorded their species, length, location where caught, took a scale sample and clipped their pelvic fin to mark them. On the second visit we fished with the same methods and in the same locations, again taking data on all fish caught and looking for recaptures of marked fish. We then applied the formula below to our data to develop a population estimate for each species in the pond.

$$\text{TOTAL POPULATION} = \frac{\begin{array}{c}\text{TOTAL MARKED}\\ \text{FIRST CAPTURE}\end{array} \times \begin{array}{c}\text{TOTAL CAUGHT}\\ \text{SECOND CAPTURE}\end{array}}{\text{TOTAL RECAPTURES}}$$

When previewing the lab exercise, we discussed the various types of fish that were likely to be found in the pond and what each species used as its food source. This reinforced the concept of food webs and the various habitats that we discussed the week before. Having visited the pond and observed the various macroinvertebrates, plant life, and even some fish, some students speculated on how many fish the pond might support. Some students who had fished the pond in previous years on their own had estimates on the size of fish that could be found but could not give an estimate of population size.

This lab was extremely effective at getting the students to do some real scientific investigation. All were highly motivated to capture the fish and took part in the measuring and sampling of fish that others captured. Our initial capture was quite small due to weather conditions that kept the fish inactive and students confined to a limited area of the pond bank. We caught a variety of fish species and sizes and only four students were shut out from catching at least one fish. I took the opportunity to give some personal instruction on fishing techniques to help some of the less experienced students find success, and the "pros" get even better.

On our next visit to take the second fish sample weather conditions were perfect and all students had success at capturing fish. Unfortunately we had no recaptures in the second fish sample and were therefore unable to calculate a population estimate. This apparent failure provided an excellent discussion about sampling techniques and the variables that we were not able to control such as weather, fish mood, learned behaviors, and seasonal migrations. Overall the lab was a failure from the standpoint of generating a population estimate but was a success by getting all students involved and giving us an opportunity to discuss the process of improving scientific investigations.

Next year I intend to make some improvements. I would like to obtain a larger representative sample of the fish in the pond, including younger year classes. I will investigate the possibility of constructing fish traps and using seines. Dr. Don Garling and other teachers who saw a cause for concern with regard to student safety dissuaded me from using these methods. I believe that it will be of benefit to sample the younger fish that we did not catch with sport tackle and to get a larger sample in a similar period of time.

The next new lab investigation was "How Old is That Fish?" (Appendix C-2). In this investigation the students took the scale samples that they had collected from the captured fish and placed them on a microfiche projector to observe the growth rings evident in the scale's structure. The rings, or circuli, are laid down throughout the year as a fish grows but as metabolism slows in the winter months the distance between adjacent rings decreases and leads to the appearance of an annulus, which is used to calculate the fish's age.

The annuli are sometimes difficult to determine due to irregular growth rates, spawning changes, and age factors. Students engaged in the lab were observing, hypothesizing, and discussing their points of view regarding the appearance, or lack thereof, of the annuli in each scale. For the most part, the students did an admirable job of determining the age of the fish and were thoroughly engaged by the activity. Further study of the back-calculated growth revealed some apparent misinterpretations of fish age (or nonsensical growth rates) and these scale samples were later re-evaluated.

Once again the amount of individual work and group interaction was impressive as the student teams worked to age the fish. Even students who rarely speak up in a group setting were voicing opinions about fish age! Their efforts to prove and disprove ideas were a welcome change from the previous unit's lack of debate. I felt this lab was one of the most effective in terms of scientific observation and problem solving.

To improve this lab I will try to acquire an additional microfiche projector to speed along the process of scale viewing. The students did a good job with the two projectors we had available but if we increase the number of fish sampled we will need to meet or beat the time we spent analyzing them this year. Additionally I will look into the using a spreadsheet program to facilitate quicker back-calculation of growth that may be less prone to errors. I will also have the students use metric units to do their measuring rather than inches as we had some problems with fractions, decimals and significant digits. I had felt that the use of inches would be easier from a size recognition standpoint but the little bit of confusion at the measuring board would have been minimized with the quicker calculations later on.

The lab activity "Fillet Yo' Fish" was based on my own expertise in filleting fish and was used as a practical application of fish dissection. We kept a number of the larger bluegill and bass that we caught on the second sampling trip and brought them back to the classroom. Nearly all of the students who wished to had the opportunity to fillet a fish with a guiding hand (mine) to help them. This practical knowledge was especially appreciated by the students that fish regularly, only one of whom had already tried their hand at the skill on their own.

Another truly "hands on" activity, this lab allowed the students the opportunity to see and feel the musculoskeletal anatomy of the fish and prepare some tasty fillets for our class fish fry! Several took the additional time to observe the internal anatomy of the fish and saw the gills, heart, digestive tract and reproductive structures, effectively performing an impromptu dissection that I had previously decided against providing the class time for. Additionally the activity served as a segue to our discussion of preparation techniques used to reduce exposure to contaminants in fish that is being consumed.

The lab investigation "How Big Was That Fish When…?" (Appendix C-3) was a follow-up to the age determination lab. This lab utilized the ratio between current scale length and overall size to determine the length of a fish at a previous age, because fish typically have scales that are in proportion to their body size. That is, the longer the fish of a given species the larger its scale will be relative to a shorter fish of the same species. This ratio can be used to calculate the fish's length at a prior age according to its scale length at that age through the following formula:

$$\text{TOTAL LENGTH AT AGE X} = \frac{\text{TOTAL LENGTH}}{\text{SCALE LENGTH}} \times \text{SCALE LENGTH AT AGE X}$$

All of these laboratory activities are new to this teaching unit with the exception of the fish filleting. This is a modification in that we kept fish from the pond and all students had an opportunity to try their skills. In the past I brought a fish or two in to demonstrate this and one or two students could try if they wished. The change made it possible for all to get involved and get their hands on a fish, then eat it fresh from the fryer if they wished!

Assessment of Student Work

I chose to assess student work (Appendix A) in a variety of ways. Some assignments were scored on a credit/no credit system such as daily homework assignments. This is a common method that I have used for many years. Lab activities were scored on preparation and participation, and follow-up questions were scored as homework assignments. I also used pre-tests and post-tests for the lecture material, as well as incorporating many questions as part of beginning and end of class period reviews of the materials covered that day.

Assessment of the group project differed from that of any other part of the unit. I observed student activity, gave full, partial or no credit for meeting deadlines on time, and used the scoring rubric (Appendix A-13) that we set up in class to provide final assessment on the project. These methods allowed students to have a clear understanding of their grade, they knew how much they would be penalized for not meeting a deadline, and they knew that their final draft—their best work—would receive the bulk of their grade for the project. I have found these methods helpful in other units because they make students accountable for completing the work in a timely manner, avoid procrastination, and develop a product superior to those done the night before a deadline.

The rubric (Appendix A-13) was designed for use by both the students and me as a list of criteria that the project required. In some cases the criteria were met but quality was not up to standards expected of a student at this level. In discussions with students about these standards, some tend to be more lenient but we agreed on a basic set of expectations. The rubric for assessing the project was given to the students during their work on it as a guide for appropriate completion of the assignment.

EVALUATION

Pre-tests and Post-tests

Student pre-tests (Appendices B-1, B-3, and B-5) were given at the beginning of each of the first three parts of the unit and took the form of written responses to either oral or written questions. I have used pre-tests extensively in the past as a means of assessing prior knowledge so that I can adjust my teaching strategies to meet the needs of the students. I graded all pre-tests on a credit/no credit system. Responses to the pre-tests showed a wide range in student prior knowledge. I expected students to be knowledgeable about some topics that we had previously covered such as water quality and trophic level relationships, and less familiar with specific content on pond species and fisheries management techniques.

Post-tests (Appendices B-2, B-4, and B-6) were given following completion of each section of the unit and the responses were graded as a quiz or test. Students were typically concerned about their performances on these assessments and prepared for them. The overall message from the post-tests was consistent with student grades throughout the year, ranging from 68 to 96 percent. The students did seem to respond more fully to the open-ended questions as the unit moved along. I reviewed the post-tests and compared them to pre-tests to assess student learning.

The first pre-test (Appendix B-1) began the section on fish species and anatomy and was designed to survey students' prior knowledge of Michigan fish and anatomy. I have used this type of pre-test over the past five years and found that even those students who do a great deal of fishing are hard pressed to correctly identify six or seven species in this activity, and few can correctly identify more than four anatomical terms.

Correct responses ranged from six to twenty three species, with a class average of fifteen different Michigan species. Some lists included local names such as "speck" for crappie and "steelhead" for rainbow trout, and others had generic names like "trout" and "salmon" which were not counted because they pertained to no particular species. When prompted, some students added to their lists the specific names of trout and salmon that they had omitted, and remembered other species that they had not previously considered, such as smelt.

The question about fish anatomy showed a very rudimentary knowledge among students. Nearly all included identifications for the mouth, anus, eye, "tail" fin and "top" fin. Two students used the term "dorsal" to correctly identify that fin, and two also drew in gills. No names were given for additional fins, and only three of ten students even drew any of those on their diagram. These results did not surprise me a great deal, as fish anatomy is not presently a topic that we cover in the biology curriculum.

The corresponding post-test (Appendix B-2) followed lecture, a review sheet (Appendix A-2) and review game that challenged students to identify pictures of the twenty Michigan fish species they had learned. Identification of fish species was tremendously improved, with five of ten students correctly identifying all twenty sportfish that we surveyed from the Michigan Fishing Guide. Two of the five that weren't perfect scores missed a species or two due to misnaming the fish (e.g.- "poppyseed" instead of "pumpkinseed"), and two others mixed up the lake trout and the lake trout/brook trout hybrid, the splake—always a difficult identification!

On the anatomy portion of the post-test, five of ten students got perfect scores on fifteen identifications of fish parts on an overhead diagram with no help from a word list.

Three of the remaining five lost partial credit for incomplete or misspelled answers, and only one student missed more than one point in this section. Overall, the post-test scores averaged 28.5/30.

I attribute a lot of the students' success to the alterations I made on the focus of the material. The prior use of specialized reports on one species that were presented by the students as lecture notes was very time consuming and did not lead to overall understanding. I felt that the lecture notes, review sheet and game were better than the methods used in previous years as scores were higher for a shorter expenditure of class time.

The second pre-test on pond ecology showed some continuing difficulties that some of the students were having with content related to ponds. Topics such as water chemistry, eutrophication, and food chains had been covered in the biology class and in previous units in this class. This pre-test indicated that retention of that information was not complete. The responses to these questions were a signal to make changes in those units to improve student understanding of the concepts addressed again here. Some of the students did score very well on those questions and I was pleased with their performance.

On the pre-test (Appendix B-3), not one student in the class identified "limnology" as the study of ponds (#1): this was not unexpected. Eight of ten students could differentiate lakes and ponds (#2), with most citing physical comparisons of size and depth. Only two of ten students answered correctly on the question concerning pond construction (#3) and those students identified depth and water supply characteristics. Incorrect answers focused on fish to be stocked and purposes for building.

Only one student answered the nutrient question (#4) correctly in its entirety. Five students gave correct responses to four or more of the seven items, one identified a single nutrient's source, and three missed all items. This was disappointing because the students had learned this content in biology in the first semester and I had hoped that students would transfer the information between the two units.

Nobody identified the surface film as the correct response for question #5, although we had covered that in the water unit that preceded this one. In question #6, three students correctly identified lower density as the reason ice forms at the surface of the water. In question #7, eight of ten said that water temperature would change with a change in air temperature and four of those correctly stated that there would be a time lag for that change.

In question #8 on sediment runoff, eight students identified the correlation to increased nutrients that we had covered in a prior unit. One included the concept of turbidity by stating that the water would become "murky". The question on life in different pond habitats (#9) garnered eight correct responses, with two students not responding to the item about "open water". On question #10, six of ten students constructed appropriate food chain diagrams while two others had only the direction of arrows incorrect. Nine students, indicative of their previous experience with this topic, answered the final question (#11) on eutrophication correctly.

I expected to see a better score on the nutrient question (#4), but I feel that the students brought with them a lot of prior knowledge of the concepts of limnology from their studies in the ecology unit in biology class and previous units in this class. My primary focus for instruction, based on the results of the pre-test, will be to teach students the pond habitats and acquaint them with the organisms common to them, and to reinforce the concepts previously learned from those other related units.

Results from the post-test (Appendix B-4) showed marked improvement in student understanding in nearly all concept areas. Eight of ten students identified the term "limnology" and six provided the appropriate definition (#1). Nine students correctly contrasted lakes and ponds (#2), and seven identified proper pond construction characteristics (#3). More impressive were the results of the nutrient question (#4), where eight students had six or seven correct responses to the seven items, and the remaining two students answered four of seven items correctly.

The next two questions saw similar improvement, with seven students correctly stating that ice has lower density and therefore floats (#5), and ten identified the change in water temperature with air temperature, five specifying a time lag for that to occur (#6). Nine of ten students identified the increase in turbidity and lack of sunlight penetration correctly in the following question (#7) and added that nutrient levels would increase.

The question on pond habitats (#8) had a good result as four of ten students gave correct definitions for all four zones. Incorrect responses to these items included switching "littoral" and "limnetic" identifications, and one student who did not write any definitions at all. Every student was able to identify organisms that inhabited the different areas. On the food chain question (#10) only three completely correct answers were given. Five students drew the arrows backwards, and two failed to include plants as part of the food chain. The work we did with this concept should have resulted in a better showing than this! The final question on eutrophication was again answered well as nine students correctly identified it and causes for its occurrence.

This portion of the unit used and depended on the greatest amount of prior knowledge from other related science units that the students had learned and the results show an overall improvement compared to the pre-test. I believe that the time I devote to aquatic ecology in the biology class is well spent not only for its importance to the connection to other units in that course, but in this class as well. I really believe that the students made the connection from the two different classes and some of their comments indicated that they were very familiar with the material.

Results of the pre-test for the third section of the unit on pond fisheries management (Appendix B-5) were mixed. The first three questions were answered correctly by six of the ten students, and two others missed only one part of the multiple response items (#2, #3). The remaining students provided partially correct responses to each item. I attribute the success with these items to the relationship of this subject matter to the pond ecology topics of nutrients and dissolved oxygen that we discussed in detail in the previous two weeks while studying pond ecology. I was glad to see that the students were applying that information in a related but new situation.

The pre-test showed that most students were unfamiliar with the principles of pond fish management. I truly didn't expect any student to be well versed in this material, but hoped that some of the anglers would know something. Only two students correctly identified stunting (#5) and how to determine a fish's age by scale analysis (#7). These students had conversations with me last fall in which we discussed what we would be doing at the pond in this unit. Some interesting answers to these questions included the football definition of stunting as a tactic for fish feeding, and taking measurements of length, weight, and looking at teeth to determine fish age. Three species not to be stocked in ponds (#6) included carp, catfish and suckers, most likely because students who go fishing view them as undesirable fish to eat.

"Small fish" were cited as food for bass (#4) but no specific type was identified. One student attempted to answer question #8 by suggesting that the fish be tagged and measured, then you could catch it later and find out how much it grew. Not exactly an answer to that question as it was worded, was it? However, three students did recognize that they could make a population estimate by taking a sample of the population and extrapolating it to the larger group (#9). This showed me that they had retained some of the information on sampling that we had discussed in our unit on wildlife management last fall, though none remembered mark and recapture as the method of choice. Other responses to this question inferred total fish counts by netting or draining the pond, counting fish caught by people or killing off the entire population.

The post-test (Appendix B-6) that followed the presentation of the materials on pond fisheries management principles was delayed in its delivery due to conflicts with the project deadlines and the power outage caused by the storms of May 31st. Students were given the test as a take-home "final" that they were asked to answer without notes or assigned information to aid them. Eight of the ten students returned the test and reviewing them lead me to believe that my request was honored, as none of the responses seemed to be "from the book". The test did include information from previous post-tests that I wished to re-test, but I will only consider the new information tested at this time.

Question #2 regarding stunting was answered correctly by all eight of the students with regard to the species involved, but only six gave a correct definition and gave appropriate management recommendations to reduce it effects. Only three students correctly named minnows as the appropriate fish for stocking with bass (#3) while four named bluegills—exactly what was advised against in the previous question. The remaining student named perch, but also named them previously as a fish that can be stunted, citing body conformation as being more suitable for bass prey.

All eight students identified means of controlling aquatic vegetation (#4), while one inappropriately used "pesticide" instead of "herbicide". Only one student correctly identified the term "bioaccumulation" (#6) with six students giving no response at all. Only two named correct examples of contaminants, while five named nutrients that could be considered water contaminants associated with eutrophication. All eight, however, correctly named at least one method of reducing contaminants from fish consumed (#7), and six named two different ways. The two that missed this cited "thoroughly cooking" the fish.

Only two of eight answered question #8 correctly about fish to avoid stocking. Six of eight named two correct species, with "catfish" being a choice on all of those. Catfish was never presented as an answer to this question, but I believe it was chosen due to the pond owner's disdain for his neighbor's addition of them to the pond, or that the students confused them with carp. Other incorrect answers included "trout" and "salmon" which are irrelevant to the study of warmwater ponds and I assume were guesses.

The next four questions pertained to the lab activities. Question #9 asked students to diagram a scale, and produced mixed results. All eight students correctly identified the focus, three labeled concentric circuli, but none showed tightly grouped circuli labeled annuli, although one called them "rings". The lack of vocabulary carried over into the following question (#10), where seven students described how to count "rings" or "dark bands", but none used the appropriate vocabulary terms. One student gave no answer to this question. I was somewhat surprised that even the high achieving student had little recall of the vocabulary terms from this lab as they were well versed in them during the course of study and I frequently heard them being used.

Question #11 dealt with the mark and recapture lab. Four of eight students gave correct responses and also included the correct formula for estimating population size. Two of eight gave a vague answer to the question without any formula, and two gave no response. The final question (#12) on back-calculation of growth was answered correctly by seven of the students, with five of them giving the correct formula for the calculation. I expected this level of response because of the amount of practice that the students had within their groups back-calculating the age of five or more fish.

The next question (#13) dealt with average sizes of bass and bluegill in Michigan ponds and their approximate ages. Five of eight students correctly identified the bluegill ages while none identified the bass ages. Two students provided no response, and those that missed the question overestimated the ages, especially on the bass. I believe that these results are related to the amount of work that was done in aging bluegills of the size in the question while we caught few bass of that size. Finally, all students answered the question on reasons for constructing a pond correctly, with most responses including "fishing" and "aesthetics".

This final post-test, while given at a highly disrupted time, showed me that students learned a great deal from the last portion of the unit and especially the lab activities. The pre-test results showed very little prior knowledge regarding the fisheries science techniques that were going to be covered, but the post-test reveals that a large percentage of the group learned how to perform these methods and capably described them, in spite of not using the technical vocabulary. I am very pleased with how far the students came during this unit and am pleased to have incorporated the new activities that significantly enhanced their learning.

Authentic Assessment

The reports produced by the two student groups that encompassed all the material that the students learned from this unit was evaluated in a variety of ways. Designated assistants and peer reviewers performed preliminary evaluation of student writing using the rubric (Appendix A-13) as a guide. I also assessed the drafts of the various report components. Although students had copies of the rubric and other oral guidelines, as well as printed deadlines (Appendix A-12) some did not bother to follow them in the initial phases of the project. These stated standards and criteria were of benefit to several of the students and their work was of better quality at an earlier stage than that of those who ignored that information. Some students ignored the process of peer review, which was detrimental to the quality of their work, while those students that utilized the peer review process had higher quality work.

My overall assessment of the team projects was favorable. The writing process requiring revision of the various sections was beneficial to producing a cohesive end report. The students had some difficulty in the final stages as they put the pieces together, trying to make them read as a continuous document and avoiding repetitious sections. The finished product was something that the teams could be proud of and our pond hosts were very interested in reading.

The group reports scoring rubrics are found in Appendices B-7 and B-8. The groups were given a numerical score for each section based upon how well the material compared to the requirements and standards. The individual components of each section were marked with a "+" to indicate appropriate completion or a "-" to show where there were deficiencies that resulted in a lower score being awarded.

The groups varied in their overall performance on the report. Group Crappie had a strong performance on the introduction (Part 1) but lacked life history information on three of the pond's fish species in the aquatic life survey (Part 2). Their population survey (Part 3) did not provide the expected information on the mark and recapture sampling method nor discussion of the results and recommendations for improvement. The age and growth survey (Part 4) lacked description of the scale sampling and analysis methods but had some discussion of results. The population and growth analyses (Part 5) were sufficient except for discussion of environmental factors affecting growth rates. The management recommendations (Part 6) lacked a clear understanding of all the factors affecting the pond's fish population and was the most incomplete part of the report

The Perch Group scored better overall due to a more thorough performance in all areas. A well done introduction (Part 1) earned a perfect score and only the omission of the information on crappies and scientific names of the fish species prevented a perfect score in the aquatic life survey (Part 2). The population survey (Part 3) was the group's weakest section, as it failed to discuss the results of the survey or how to improve it, and had an incomplete form of the formula used to calculate population size. The age and growth survey (Part 4) was well done except for thorough discussion of the results, and the population and growth analysis (Part 5) lacked thorough discussion of environmental factors influencing growth. Management recommendations (Part 6) were much better for this group, with only two minor points omitted.

The final scores were added to others from the entire report writing process to give the group's overall grade on the project. Group Crappie earned an overall score of 84/100 and group Perch earned an overall score of 92/100. These scores reflected meeting deadlines on time, improvement throughout the revision process and appropriate use of class time. The grades were assigned as the semester exam grade, which accounted for 20% of the semester grade.

Some specific details of the projects were disappointing. I had encouraged the groups to collect various pictures of the organisms they found in the pond and display them in the report. Some group members found excellent electronic sources for these pictures but did not make the effort to incorporate them into their report. The independent artwork of the students, while appropriate, did not convey the professional quality that I was expecting. Next year I will have students take photographs of the organisms they encounter and create a scrapbook of sorts.

Another aspect of the report that I found disappointing was the vague interpretation of the data collected on the fish populations and their growth rates. A lot of effort went into the processing and graphical display of this information, but I think students ran out of time and energy when it came time to do the real analytical work.

Focusing on this portion of the report with a class discussion or group brainstorming activity may have helped to stimulate more interest. I had numerous discussions with the team members responsible for these sections and felt that they could have done a better job of determining reasons for different growth rates of the fish of different age classes. This made it difficult for the students to give any reliable recommendations about management of the fish population in the pond.

I believe that the data analysis and recommendations portion of the report were the most difficult for students, yet the most critical to the pond study. I also believe that the students' specialization in a particular area of the report lead to isolation. I intend to revise this assessment tool next year to involve students more fully in the entire project by having each of them construct the individual sections of the report after each portion is completed in the unit schedule. "Editor" assignments will then be given at the time of final report construction, and the chosen student will then construct that part of the report from all the team members' prepared documents.

Student Interviews

Student interviews were conducted on June 19th, a little over two weeks after the class last met. All students were invited to participate in the interview and questionnaire process to give their feed back on the unit's strengths and weaknesses, and to take a follow-up test to see what they had retained since school dismissed three weeks ago. Six students, including four males and two females, accepted the invitation to participate. The students included a fairly even distribution of high, average and low achieving students from the two project groups.

The students were given a list of follow-up questions (Appendix D-1) very much like the post-test that they had taken at the end of the unit. The responses to these questions were scored and compared to the equivalent questions on the unit post-test to evaluate the students' retention of the concepts taught during the unit. The data from these tests was analyzed for statistical purposes.

The students also completed a questionnaire (Appendix D-2) about their perceptions of the unit's activities. The first part of the questionnaire asked the students to answer "Yes" or "No" to a series of questions relating to the topics in the unit as they knew or understood them before the unit, and then respond to the same questions again as they now knew or understood them after the unit's conclusion.

The next section of the questionnaire asked the students to rank the different activities with regard to presentation, their knowledge, motivation, and enjoyment of the material. Most important was the last section in which I asked students to list what they most liked and disliked about the unit. All agreed that the opportunity to fish was the best part, and some also acknowledged that working with the Feldpausches was enjoyable. They did not like the labs on age determination and back-calculation of growth, which was the real science in the unit.

Analysis

Analysis was performed on the unit post-test (Appendix B-6) and student interview questions (Appendix D-1) for the six students that were present in both groups. Two students who failed to turn in the final unit test did not participate in the interview and two others who did turn in a final test were unable to attend the interview, so their scores were not considered.

Student scores for the corresponding unit post-test and student interview questions are summarized in Table 1:

TABLE 1

Comparison of Student Scores: Unit Post-test and Interview Questions

	Unit Post–test	Interview Questions
Number of Students (n)	6	6
Points Possible	37	37
Mean Score	25.7	27.8
Range	20.5 – 30.5	24.0 – 32.5
Standard Deviation	$\pm$ 3.4	$\pm$ 3.0
Standard Error	$\pm$ 1.4	$\pm$ 1.2

Note: The same students comprised both groups in this comparison.

Overall scores on the post-test were lower than typical grade averages for the students surveyed. I attributed this to the disruptions in our schedule that occurred when the post-test was given and the resulting lack of student preparation. Scores on the follow-up questions were better in the case of two students. One who was considered to be lower achieving but showed the greatest interest in the unit earned the highest score of 32.5/37.

The data was used to perform a statistical "t" test to compare the scores from the two test instruments. In the "t" test, the standard difference of the mean was calculated to be 1.8, the "t" value that resulted from the overall calculation was 1.2. At ten degrees of freedom, this result shows that the two scores are most likely in the same population, so the null hypothesis "There will be no difference between student scores on the unit post-test and the follow-up questions" can be accepted with high probability of being correct.

Examination of the individual responses on the follow-up questions shows that students retained a great deal of the knowledge that was part of the lab experiences. Most were able to explain back-calculation of growth and provided the equation with their response. The mark and recapture question showed similar recall, but fewer properly identified the equation used. The use of scale observation in aging was named correctly by all, although none made use of the specific vocabulary terms in their explanation.

Other responses of positive note included the identification of anatomical characteristics of fish. Students were still strong in their abilities to identify those structures that had been on the unit post-test. Also impressive was the recognition of contaminant reduction methods in fish prepared for consumption, and pond construction characteristics.

On the negative side, the concept of bluegill stunting was not fully grasped by all students. They could identify stunting and its cause, but did not connect this to the fact that bluegills and similar panfish should not be stocked in a pond with bass, but rather minnows should. They still held onto the misconception that bass, being predators of bluegills, can control their population successfully and avoid stunting. Additionally they listed weed control as a means of preventing this condition, when it is not a complete control. Many students missed the point that bluegills should not be stocked in a pond, with or without bass. Instead, minnows should be provided as prey for bass and bluegill/sunfish hybrids should be stocked if that type of fish is desired.

The results from part one of the questionnaire (Appendix D-2) showed an increase in student perception of their knowledge and abilities after the unit. The results are summarized in Table 2.

TABLE 2

Student Interview Responses to Questionnaire: Part One

Topic	Before Unit		After Unit	
	#YES	#NO	#YES	#NO
ID 15 fish species?	3	3	6	0
Photo ID of 15 species?	2	4	5	1
Name 4 pond habitats?	0	6	6	0
Estimate fish population?	1	5	5	1
Determine age?	0	6	6	0
Back-calculate growth?	0	6	5	1
Predator-prey interactions?	2	4	6	0
Stocking species/methods?	0	6	6	0
Filleted a fish?	2	4	4	2
Advisory/preparation?	2	4	6	0

Most noteworthy in the data is the reversal of student familiarity with the topics of habitats, population estimation, age determination, back-calculation of growth, and contaminants. The students acknowledged that these are topics that they knew little of before but are much more comfortable with now. I note, however, some potential error here as all students believed that they could identify proper species and methods for stocking new ponds, but some of the students were incorrect in their responses to the corresponding follow-up questions. Their self-perceptions, apparently, are somewhat optimistic in this category! Overall, however, I see that the unit has caused a significant change in awareness of these topics.

In part two of the questionnaire, students gave their opinions in the form of numerical ratings of different aspects of the unit. A rating of "1" meant that they strongly disagreed with the statement, a rating of "5" meant they strongly agreed. Results are summarized in Table 3.

Students rated the presentation of the habitat, population and age determination topics highly, while the presentation for the back-calculation of growth activity was lowest of all. Students rated themselves most comfortable with their knowledge of species, and habitats, least comfortable with age and growth determination. Motivation was highest for the topics of species and habitats, but waned on the lab activities of population survey and growth, and really hit bottom in the aging lab. This was likely due to the repetitive and mundane nature of those activities. It was no surprise that the enjoyment ratings followed a very similar pattern!

TABLE 3
Student Interview Responses to Questionnaire: Part Two

Summary of mean numerical ratings where 1 = strongly disagree and 5 = strongly agree with statement presented in questionnaire.

	TOPIC				
CATEGORY	Species	Habitats	Population Survey	Scale Aging	Back-Calculate Growth
Presentation	3.8	4.2	4.0	4.0	3.3
Comfort with Knowledge	4.2	4.2	3.8	3.5	3.5
Motivation	3.7	3.7	3.5	2.8	3.5
Enjoyment	4.6	4.1	3.8	3.0	3.3

These data held few surprises, but reinforced much of what I had witnessed during the unit. The tedium of reading scale samples and back-calculating growth was not an enjoyable part of the unit for students, but was essential to the fisheries science concepts that were so important to its success. I think they got a better understanding of the other side of fisheries management—away from the pond, that is! I think the low enjoyment scores for those two items was indicative of the prolonged nature of the activity, because early responses that the students made during initial stages of the labs were more favorable. I was surprised to see such high marks for enjoyment of the species portion of the unit. I didn't expect it to be their favorite part of the whole unit!

The ratings for the group report were very favorable as well. Students felt that the assessment was well constructed in regard to workload and having learned the necessary information to write the report, and recommended keeping it in the future. Some disliked the deadlines and made less use of the peer review than I expected. Most looked at the report as slightly more significant because of the Feldpausches involvement. I would like to have seen higher marks in that category.

Subjective Evidence

During the course of this unit I took the opportunity to listen even more carefully than I usually do to the comments that my students made regarding the classroom presentations, lab activities, field work, and project completion. Some of their comments provided constructive criticism for improving the unit in the future. Many reinforced my feelings that I was giving them an opportunity to learn and do things they hadn't considered or tried to do before and were glad to have the new knowledge and experience. I made note of a few of these comments because they came from students not known for giving such responses or showing much interest in commenting on class activities.

One of the comments that I took most to heart was from a disgruntled student who could not manage to catch a fish on our first sampling trip. The student had little fishing experience and had been too self-conscious to request any help, even from his teammate who was relatively experienced. The comment I overheard between the two partners referred to my not teaching the fish how to bite! I looked at this as constructive criticism because I consciously left out portions from the previous unit that focused on fishing techniques and improving the angling skills of students. I do plan to find a way to put those back into this unit in the future, if only as a brief demonstration on our first pond visit.

Other constructive comments related to lecture presentations that ran a bit long, particularly the pond life lecture. My improvement in that presentation will be to reduce the student writing required on the note outline to make the burden a bit easier, more streamlined, and improve their attention and opportunity to ask and answer questions. One student actually asked if a lecture could include more information on bioaccumulation and fish consumption. Again, this was something that had previously been included but was reduced to fit the time available.

I was most pleased with the comments I heard students make in their conversations with classmates both in and out of the class setting. While many had complaints about the tedious nature of the aging and back calculating of growth, they often mentioned how interesting it was to see the difference in the scales and they speculated among themselves about what causes different growth rates. Some even said they would start saving scale samples from large fish they caught on their own because they were curious how old they were. Conversations with other friends relayed their interest in the field work and excitement for getting out and doing something different.

My pond owner hosts also made some comments about the students' project work, their ability to ask and answer questions and their intense interest in the project. Some students apparently were doing "extra credit" work by going fishing at the pond outside of school hours because they really got hooked on the experience. The owners were more than happy to oblige their request for access and said the kids stopped to tell them what they caught and observed while fishing.

DISCUSSION AND CONCLUSIONS

“Keepers”—Effective Aspects of the Unit

My reflection on the materials that I used in the teaching of this unit has lead me to some conclusions about what I should keep, revise or completely throw away. Review of the data from student evaluations has reinforced some of my initial feelings about the effectiveness of certain activities and caused concern over what I originally viewed as worthwhile materials.

The definite “keepers” are the lab activities that were designed specifically for this new unit—the mark/recapture lab, the age determination lab and related back-calculation of growth lab. These specific activities were very valuable in generating student interest because of their “hands on” nature in working with the fish. Their science concepts involving sampling and working with scale samples improved observation and reasoning skills. Math skills such as measuring and calculating were necessary for their completion. The part of the final group report assessing the pond’s fish population relied heavily on the data collected and conclusions drawn from its analysis. Most important was the student recognition and understanding of fisheries management as a science that relied on some fairly simple activities and basic principles.

These activities were also, unfortunately, the ones that the students came to dislike because of their repetitive nature and use of math skills and graphing. They are the real science that the whole unit is based on, and they provide a valuable lesson for those who think that the life of a fisheries biologist is all about fishing.

"How Many Fish In The Pond?", the mark/recapture lab, although a failure in terms of reaching a conclusive population estimate, did provide a platform for teaching sampling methods and scientific research methods. The considerable discussion that it raised regarding bias and control of variables was beneficial to the students. In the future I will do more to address these issues by having the student teams produce a lab protocol for effective sampling and avoiding bias. An apparently effective discussion in class the day before our first sampling trip was not applied in the very blustery weather that made fishing half of the pond's shoreline very difficult for even the experienced anglers in the group.

The lab activity "How Old Is That Fish?" was extremely valuable for purposes of observation, student discussion and analytical work of determining age and population data. Students openly discussed their ideas about fish ages, disagreed and pointed out errors or other points of view within their group settings. Some scales required very careful examination and some errors were still made which, when found later while graphing back-calculated growths, lead to more than one "I told you so!" among group members.

The lab, "How Old Was That Fish When…?", was very worthwhile in getting students to use math skills. Students found some of this activity to be mundane, but realized the necessity of completing it. One student suggested setting up a spreadsheet program for the number crunching, but stopped short of volunteering. (Extra credit notwithstanding!) This is an area to improve next year to illustrate the usefulness of the computer to data processing in the science field. The results of this lab also allowed the students to compare the age and growth of fish they caught to the average sizes that have been found to exist in Michigan ponds. This helped to reinforce some of their ideas about age and size and gave some of the students who needed to be "right" a guide for their work.

The non-investigative lab activity "Fillet Yo' Fish!" was well worth the time spent teaching the art of filleting fish and the results were well received at lunch the next day. This was another of those "guide on the side" situations where I was much happier with the outcome than in previous years of demonstrating but not teaching. I was especially pleased with the eagerness of the students, especially the girls, to try this activity. The benefits of this practical learning will probably last far longer than any other information they learned!

I was much more pleased with the outcome of the fish species identification section of this unit than I have been in past years. I feel that the students were much better prepared in a shorter period of time. The change from a report and lengthy note format to a simpler sight recognition/basic life history was appropriate for this section of the unit. I will improve this in the future with some additional life history specific to those fish that students will be catching in the pond.

In the past I have not done a great deal with the "arts and crafts" aspects of science teaching. I was very pleased, however, that I took the time to have the students construct the pond habitat mural and draw representative organisms. I will adjust my schedule and expectations in the future in response to the observations that I made in this year's unit. The value of this activity was evident when one of the students correctly identified a mayfly larva during a biology field trip and told their astonished friends, "Oh, I had to draw one of those in Conservation."

Some of the aspects of the group project that I especially liked were the cooperation and positive attitudes that the students exhibited when deciding on roles, assignments, and actually working on the materials in class. The class time was well spent in preparing the materials that were assigned and the students worked well together on meeting deadlines and sharing their knowledge of computer software and subject matter. I felt that I was being consulted only when they had a truly difficult problem that they were unable to resolve within their group or with the help of other classmates. This was one of the most rewarding facets of the unit—that the students were capable of independent work in which relied on what they had learned before and were applying in a new task. It was really authentic assessment!

"Throwbacks"—Things Needing Improvement

While I really tried to pare down my lecture materials and streamline the note-taking process, I was not fully successful in doing that. For example, I believe I can improve by weaving information about pond life into the mural activity in a way that will break up the lecture and make more effective use of class time for that project. If I covered one or two habitats per day and then went to the mural construction it would work much better for both my students and me.

In the future I will also try to finish all the lecture presentations prior to students beginning work on their project. The material on bioaccumulation was presented at a time when the students were preoccupied with meeting the project deadlines and could not, or would not, devote their attention to it. The practical message regarding fish preparation probably stood because of the reinforcement from the filleting lab. This information is important but did not seem to fit well in the pond fisheries material presented earlier.

Students did not learn the principles of pond fisheries management as well as I had hoped. This I attributed to the students' preoccupation with the ongoing lab activities and preparation of group project materials while I was teaching that portion of the unit. In the future I will eliminate the interference with the lab activities and complete this material before engaging in the group work.

There are two aspects of the group project that need some adjustment in the future. While I was satisfied with the students in determining their roles, I was not satisfied that the "assistant" and "peer reviewers" for each section of the project were fully utilized. Students signed off on the portions of the report that they were assigned to, but I was suspicious that some of them may have failed to really read the information for quality control.

The other concern that I had was with the specialization of each student to a small section of the subject matter. This is perhaps more of a philosophical point, but I have my doubts that this project assessed each student's knowledge of all the information. Rather, each was expert at a smaller part of the whole and had some knowledge of the entire project. It is, however, paralleled by the world of work that it was designed to imitate. The size of the project is too large for individual students or pairs of students to accomplish under the time restrictions in place, yet the degree of specialization leads to some dumfounded looks when asking the wrong people some content specific questions. Next year I will try having all students prepare smaller versions of the report components as we progress through the unit, then have groups compile them at the end.

This problem may be lessened if the timing of the group project could be changed to facilitate better completion of all the content materials before breaking up into group work. The student focus on the project would be delayed until after all previous information had been learned. This may be more easily done in the future if I delay the determination of groups and roles until after all labs and other content is completed. In this manner the student should not see material as unimportant to their specific role with in the group.

Overall Evaluation and Conclusion

In conclusion, I am very pleased with the outcome of this teaching unit for what it gave my students. They learned a great deal about ponds as fisheries and ecosystems and the methods of doing science. My students fully appreciated the opportunity to get out of the classroom or, when in the classroom, to be doing more self-motivated and hands on work. Their group experiences were positive overall and allowed them to work with those they knew well and those that they didn't.

The collaboration with our pond hosts was a very beneficial arrangement for all of us as the students got to create a piece of work for a different audience. This collaboration helped answer some of their questions about the pond and stimulated others. I believe that the students were more motivated to produce a work that they were proud of because there was really more at stake than just a grade. They had their out-of-school pride on the line as well, dealing with a local couple who knew most of them or their families. This aspect of authentic assessment and the *Analyze* and Apply™ format is what struck me as being the most rewarding part of this entire teaching experience.

Another rewarding aspect of the unit was the gusto with which the students approached the lab activities. I have used limited field studies before but these studies generated the most motivation. I believe that this is due in large part to the familiarity with fishing that my students brought with them to the classroom, and their comfort with learning more about what interested them. At times during the unit I got the feeling that some of the students actually looked forward to coming to class, and I can't say that happens very often! I am very glad to have undertaken this project this year. Developing this unit has given me a new perspective on teaching that I had been too busy to really think about. This infusion of enthusiasm for teaching students who have found something they want to learn gives me increased motivation to break away from some of my other trusty (rusty?) units and incorporate new activities and approaches to assessment that I have not used in the past nine years.

APPENDIX A

STUDENT HANDOUTS

A-1

Name ___________________

ENVIRONMENTAL CONSERVATION
FISHERIES RESOURCES UNIT
WEEK ONE: MICHIGAN FISH SPECIES
FREE-WRITING ASSIGNMENT: "MY FISH STORY"

At some time in your past you have had some experience with a Michigan fish species. You may have been fishing, at the beach, or in a restaurant, but you must have some firsthand knowledge of a Michigan fish. In a minimum of two paragraphs, relate your experience with a Michigan fish species. Be sure to provide as much detail as possible such as the setting, reaction, and others that were with you. Also describe the shape, color and other characteristics of the fish. This is your chance to tell that "fish story" that everyone has especially the true angler!

Name ____________________

ENVIRONMENTAL CONSERVATION
FISHERIES RESOURCES UNIT
WEEK ONE: MICHIGAN FISH SPECIES
"NAME THAT FISH" REVIEW

Use your Michigan Fishing Guide to identify each of the fish species described below:

____________ 1. Sunfish that has red or scarlet spot and turquoise or yellow bands on operculum.

____________ 2. Native trout with well forked tail and spotted back.

____________ 3. Trout with spotted, forked tail, usually has a pink streak along lateral surface.

____________ 4. Perch family member with dark blotches on a gold background, very reflective eyes and a white tip on the bottom of the caudal fin.

____________ 5. Sunfish with red eye, dark blotches on a golden background and six anal fin spines.

____________ 6. Pike family member scales on the upper half of the cheek and operculum, dark spots or bars on a light background.

____________ 7. Smaller relative of the walleye having 6-8 dark bands on a greenish-yellow background, orange pelvic and anal fins.

____________ 8. Catfish with forked caudal fin, upper jaw extending beyond lower jaw, grayish to golden brown color

____________ 9. Native trout with square tail, wormy marks on back and black and white edges on caudal, anal, pelvic and pectoral fins.

____________10. Salmon with dark mouth and gums, large spots over upper body and entire tail.

____________11. Sunfish with pointed pectoral fin, dark spot on posterior portion of dorsal fin, black flap on a blue-colored operculum.

____________12. Trout with orange or red spots, yellowish abdomen, brownish back, upper jaw extends beyond rear of eye.

____________13. Sunfish with 7+ dorsal fin spines, dark spots on a light green background, locally known as a "speck".

____________14. Salmon with dark mouth and whitish gums, small spots on upper part of caudal fin.

____________15. Largest sunfish family member, has dark horizontal band, upper jaw extends beyond rear of eye.

____________16. Musky relative having yellowish spots on a green background, fully scaled cheek and operculum, rounded caudal fin.

____________17. Catfish with square caudal fin, lower jaw extends beyond upper jaw, dark brown color.

____________18. Large sunfish family member with dark vertical bars on sides, upper jaw does not extend beyond back of eye.

____________19. Salmon with torpedo-shaped body, black "X" marks on upper body, and upper jaw extending to rear of eye.

____________20. Hybrid trout with slightly forked tail and wormy marks on back.

Name ____________________

ENVIRONMENTAL CONSERVATION
FISHERIES RESOURCES UNIT
WEEK TWO: POND ECOLOGY
GROUP ACTIVITY: THE POND AS A PUZZLE

With your classmates, construct the puzzle that you have on the table in front of you. Recognize that some of the pieces have been purposely removed. When you have constructed the puzzle, sketch the missing pieces on a sheet of copy paper and then draw in the missing information using your knowledge of what should or might be there, and the clues provided on the adjoining pieces. Color these drawings to the best of your abilities, then ask me for the missing pieces and answer the questions that follow:

1. How did your drawings compare to what was on the puzzle piece?

2. What information did you use to draw the missing pictures?

3. What information did you miss when trying to draw the pictures that could have helped you do a better job?

4. Name as many of the pond organisms as you can, including the plants and insects!

Name ___________________

ENVIRONMENTAL CONSERVATION
FISHERIES RESOURCES UNIT
WEEK TWO: POND LIFE
NOTE OUTLINE

1. LIMNOLOGY

2. LAKE OR POND?

   A. POND CHARACTERISTICS:

      *
      *
      *
      *
      *
      *

   B. LAKE CHARACTERISTICS:

      *
      *
      *
      *

3. TYPES OF NATURAL PONDS:
   A.
   B.
   C.
   D.

4. FARM POND CHARACTERISTICS:

   A.

   B.

   C.

5. **CHEMICALS FOUND IN POND WATER:**

- **OXYGEN -**
- **CARBON DIOXIDE -**
- **NITROGEN -**
- **PHOSPHATES -**
- **CHLORIDES -**
- **AMMONIA -**
- **NITRATES -**

6. **PROPERTIES OF WATER:**

A. **COHESION –**

B. **DENSITY –**

C. **HEAT CAPACITY –**

D. **TRANSPARENCY –**

E. **DISSOLVED GASES**

1. **OXYGEN –**

2. **CARBON DIOXIDE –**

F. **DISSOLVED MINERALS –**

G. **STRATIFICATION –**

7. POND HABITATS

A. SURFACE FILM

1. PLANTS

2. ANIMALS

B. LIMNETIC ZONE

1. PLANTS

2. ANIMALS

3. BACTERIA

C. BENTHIC ZONE

1. ANIMALS

2. BACTERIA

D. LITTORAL ZONE

1. PLANTS

A. EMERGENT PLANTS

B. FLOATING-LEAFED

C. SUBMERSED

2. ANIMALS

8. FOOD CHAINS AND WEBS

A. TROPHIC LEVELS

1. PRODUCERS

2. HERBIVORES

3. CARNIVORES

B. INTERACTIONS

1. FOOD CHAINS

2. FOOD WEBS

Name ________________

ENVIRONMENTAL CONSERVATION
FISHERIES RESOURCES UNIT
WEEK TWO: POND LIFE
NOTE REVIEW

1. What is limnology?

2. Name three differences between ponds and lakes:

   *

   *

   *

3. Name 3 characteristics of a properly constructed farm pond:

   *

   *

   *

4. Give the chemical symbols and name the source(s) of each of the following chemical nutrients or compounds in pond water:

   - Oxygen
   - Carbon dioxide
   - Nitrogen
   - Phosphates
   - Chlorides
   - Ammonia
   - Nitrates

5. What organisms depend upon the surface film of a pond for their livelihood?

6. At what temperature does water have its greatest density? How does this compare to the density of ice?

7. How does the ability of water to hold heat compare to air?

8. What is turbidity? How does it affect plant growth in a pond?

9. Identify the following parts of a pond and list examples of organisms that reside there:

    - littoral zone
    - limnetic zone
    - benthic zone

10. Identify each of the following members of a pond food web:

    - phytoplankton
    - zooplankton
    - emergent plants
    - floating leaf plants
    - submersed plants
    - herbivores
    - carnivores
    - decomposers

11. What is eutrophication? Identify three causes of eutrophication:

Name ____________________

ENVIRONMENTAL CONSERVATION
FISHERIES RESOURCES UNIT
WEEK TWO: POND LIFE
POND LIFE DRAWING

From the information about pond habitats that you learned from the lecture presentation, draw your artistic interpretation of a pond and label the following parts:

Surface film, littoral zone, limnetic zone, benthic zone

For each habitat, draw and label 3 organisms that can be found there (plants, animals, fungi, bacteria, etc.). Use your notes, review worksheet and Pond Life guide to help you.

Please color the drawing to make it appear as realistic as possible.

A-7

Name ________________

ENVIRONMENTAL CONSERVATION
FISHERIES RESOURCES UNIT
WEEK FOUR: POND MANAGEMENT PRINCIPLES
FREE-WRITING ASSIGNMENT
"I WANT A POND BECAUSE..."

Many people buy property in Michigan each year that has a pond on it or they construct ponds on land that they own. Ponds mean many different things to these people and their reasons for buying property with them or constructing them will vary. In this assignment you are to express your opinions on what a pond means to you in a minimum of two paragraphs. Include the types of activities that you enjoy that are associated with ponds. If there is no way that you would ever own a pond, identify the aspects of them that are so revolting and explain why they do not appeal to you.

A-8

Name ___________________

ENVIRONMENTAL CONSERVATION
FISHERIES RESOURCES UNIT
WEEK FOUR: POND MANAGEMENT PRINCIPLES
REVIEW QUESTIONS: WHY HAVE A POND?

1. Name six purposes that people have for ponds:

   *
   *
   *
   *
   *
   *

2. Can a pond especially managed for one purpose be expected to function well for other purposes? Explain.

3. What may doom a pond to failure from its beginning?

4. How do pond management professionals determine the "success" of a pond?

5. Name 4 reasons NOT to have a pond:

   *
   *
   *
   *

6. Name 3 differences between natural and artificial ponds in Michigan:

   *
   *
   *

Name _______________

ENVIRONMENTAL CONSERVATION
FISHERIES RESOURCES UNIT
WEEK FOUR: POND MANAGEMENT PRINCIPLES
"MR. AND MRS. FELDPAUSCH, WHY DID YOU BUILD THIS POND?"
QUESTIONNAIRE BRAINSTORM

With your partner, brainstorm a list of possible questions to ask the pond's owners, Mr. and Mrs. Claude Feldpausch. Questions should address the following topics:

- Purpose(s) of the pond
- Goals for the pond in light of the chosen purpose(s)
- Planning for construction
- Construction process
- Maintenance
- "Success"(Satisfaction) with the pond

Name ________________

ENVIRONMENTAL CONSERVATION
GROUP REPORT ASSIGNMENT LIST

Below is a list of the various components that are required to be in your written report on the Feldpausch's pond. Roles within the group are to be taken by each member. The roles are:

Project Leader - the person responsible for coordinating all group members' activities and having them get work in on or before posted deadlines.

Design Engineer – the person who handles the arrangement and visual presentation of the report including diagrams, art work, and page layout.

Editor – the person who proofreads copy and checks the individual sections for their accuracy and completeness.

Graphics Specialist – the person who handles the construction and printing of the informational graphs and charts.

Technical Advisor – the person who serves as the group's resident limnologist. They know the specific information on ponds, fish and fish management.

Within the report there are several components that need to be addressed. While some of these are very specific to the roles above, others require the integration or coordination of two or more specialties. Please designate which group member will have the primary responsibility for each of the following report components, who will assist them, and who will be responsible for peer review.

The report's components, described in "Pond Report Guidelines", are

Introduction

Aquatic Life Survey

Fish Population Survey Report

Age and Growth Survey Report

Pond Population and Growth Analysis

Management Recommendations

Group Name ________________

ENVIRONMENTAL CONSERVATION
POND FISHERIES MANAGEMENT
GROUP REPORT ASSIGNMENT LIST

Role Assignments: Please identify the group member who will assume each role.

Project Leader ______________________________

Design Engineer ______________________________

Editor ______________________________

Graphics Specialist ______________________________

Technical Advisor ______________________________

Please identify the group members responsible for each of the following report components:

	Primary	Assistant	Peer Reviewer
Introduction	__________	__________	__________
Aquatic Life Survey	__________	__________	__________
Fish Population Survey Report	__________	__________	__________
Age and Growth Survey Report	__________	__________	__________
Pond Population and Growth Analysis	__________	__________	__________
Management Recommendations	__________	__________	__________

Each group member should keep a copy of this form in their notebook, and a separate one should be handed in.

A-11

ENVIRONMENTAL CONSERVATION
POND FISH MANAGEMENT
GROUP REPORT PROJECT GUIDELINES

One of the main reasons for our work on pond fisheries management is for you to become more familiar with pond ecosystems and the role that fish play within them. Additionally, we have been concerned with the purposes that people have for constructing and maintaining ponds for recreational fishing. The goal of this unit is for you to be able to assess a pond's fish population and other environmental factors and consider how the pond can be managed to best meet the purposes of its owners. Your group members are therefore considered to be a team of fisheries biologists who act as consultants to private pond owners. Pond owners call you to help them assess the quality of their pond, the fish populations in it, and seek your input on how best to improve or maintain their pond as a recreational fishery. The final project for this unit is a report that you and your teammates produce to tell the Feldpausches what you found out about their pond, the fish in it, and how they are doing in meeting their fisheries goals.

This report must include the following information:

Introduction – describe the pond's location, age, shape, depth, etc.

Aquatic Life Survey – identify and describe the various living things that you observed in the pond, including plants, invertebrates and fish. This portion will be extensive, as it will include information on the various fish species found there. Be sure to identify and describe the 4 pond habitats and tell which location you found the organisms in.

Fish Population Survey Report – this section shows the results of our mark and recapture survey of the pond population. Include a discussion of how the marking process was done and how the population estimate is arrived at. You will also need graphs of the population sizes of each species from the estimates.

Age and Growth Survey Report – this section includes your assessment of the age of the fish sampled and how they grew over their lifetime. This section will require graphs of the fishes' growth over their lifetime for all fish sampled of each species caught.

Pond Population and Growth Analysis – this section should compare the results of your surveys to those expected or typically seen in Michigan ponds in our area. Describe how the fish are growing and what environmental conditions may be contributing (positively or negatively) to their growth.

Management Recommendations – make suggestions about how the pond could be maintained or better managed to meet the owners' objectives.

Your report must typed in double-spaced 12-point text using default margins. You must have a title page including all group members, and a table of contents page. All tables and graphs must be done on a computer spreadsheet, illustrations may be hand-drawn and colored or scanned/captured and placed within text. Two copies of the finished report must be presented in report binders.

Due date for the final draft is Thursday, May 28th, 1998 at the beginning of the class period. We will peer review them that day and they will be given to the Feldpausches the following weekend. On Monday or Tuesday evening of finals week we will meet with the Feldpausches to give an oral presentation on your reports and you will answer any questions that they may have. Wednesday's final exam period will be used to take our last trip to the pond and have our picnic.

A-12

ENVIRONMENTAL CONSERVATION
POND FISHERIES MANAGEMENT
GROUP REPORT DEADLINES

Below is a list of due dates for the various components of your pond report. These are considered to be first drafts of the various parts of the report, but the more thorough you are with them, the less revision may be necessary by the final completion date.

Age and back-calculated growth data for all fish (table form). Due Tuesday, May 19th at the beginning of the hour.

Introduction – Due Thursday, May 21st, at the beginning of the hour.

Aquatic Life Survey – Due Thursday, May 21st, at the beginning of the hour.

Fish Population Survey Report – Due Thursday, May 21st, at the end of the hour.

Age and Growth Survey Report – Due Tuesday, May 26th, at the end of the hour.

Pond Population and Growth Analysis – Due Tuesday, May 26th, at the end of the hour.

Management Recommendations – Due Tuesday, May 26th, at the end of the hour.

The final report is due Thursday, May 28th, at the beginning of the hour. This version should be revisions of previous drafts and be the next best thing to a perfect paper. We will peer review this version in class that day and the complete, presentation form of your report will be due Friday, May 29th at the end of the hour.

ENVIRONMENTAL CONSERVATION
POND FISHERIES MANAGEMENT
GROUP REPORT SCORING RUBRIC

The following is the rubric that you will use to score the various portions group report during the peer review process. Please take the time to have your assistant and peer reviewer check your work against this form! Revision is best accomplished when you have some knowledge of where you need to go!

Part One: Introduction (5 points)

Identify the pond's:

_____ location
_____ owners
_____ age
_____ construction
_____ initial stocking

Format standards

_____ 12 point, double-spaced
_____ default margins
_____ proper grammar
_____ no spelling errors
_____ grade appropriate

Part Two: Aquatic Life Survey (10 points)

Identify **and** describe:

_____ 4 pond habitats
_____ aquatic vegetation (pictures)
_____ macroinvertebrates (pictures)
_____ fish species in pond to include:

_____ largemouth bass
_____ bluegill
_____ pumpkinseed sunfish
_____ yellow perch
_____ crappie

for each fish, identify:

_____ scientific name
_____ physical description
_____ habitat preferences
_____ spawning information
_____ picture

Format standards

_____ 12 point, double-spaced
_____ default margins
_____ proper grammar
_____ no spelling errors
_____ grade appropriate

Part Three: Fish Population Survey Report (10 points)

Describe:

_____ capture methods/locations
_____ marking method
_____ population estimate (formula)
_____ discussion of results
_____ improvement of design?

Format standards

_____ 12 point, double-spaced
_____ default margins
_____ proper grammar
_____ no spelling errors
_____ grade appropriate

Graph:

_____ number and species of each fish
_____ spreadsheet/chart
_____ color
_____ title, subtitle, axes labels and legends
_____ legible font and size

Part Four: Age and Growth Survey Report (10 points)

Describe:

_____ scale sampling method
_____ aging method
_____ back-calculation of growth(formula)
_____ discussion of results

Format standards

_____ 12 point, double-spaced
_____ default margins
_____ proper grammar
_____ no spelling errors
_____ grade appropriate

Graph:

_____ age/growth for each fish by species
_____ spreadsheet/chart
_____ color
_____ title, subtitle, axes labels and legends
_____ legible font and size

Part Five: Pond Population and Growth Analysis (10 points)

Describe:

_____ Comparison of fish to standards
_____ Fish growth in pond
_____ Environmental factors influencing growth

Format standards

_____ 12 point, double-spaced
_____ default margins
_____ proper grammar
_____ no spelling errors
_____ grade appropriate

Part Six: Management Recommendations (5 points)

Discuss:	Format standards
_____ results of study	_____ 12 point, double-spaced
_____ current status of pond fish population	_____ default margins
_____ review objectives	_____ proper grammar
_____ recommendations for maintenance or improvement	_____ no spelling errors
	_____ grade appropriate

A-14

Name ___________________

ENVIRONMENTAL CONSERVATION
FISHERIES RESOURCES UNIT
WEEK SEVEN: FISH CONSUMPTION
"ARE GREAT LAKES FISH SAFE TO EAT?"

1. What is meant by the term "bioaccumulation"?

2. What effect does bioaccumulation have on the people who eat fish from the Great Lakes?

3. What 3 factors is the fish consumption advisory based on?

4. Identify 3 effects of toxins on wildlife that eat fish from the Great Lakes:

5. Why are pregnant women and women who plan to have children advised not to eat certain fish from the Great Lakes?

6. What methods of preparation can you use to reduce the contaminant levels in the fish that you eat?

7. Have you eaten fish that you have caught from the Great Lakes or that was served in a restaurant (i.e. whitefish, walleye or perch)? How was it prepared? Would you consume this fish in the future after reading this article?

8. Why is the threat of contamination in fish from the Great Lakes greater than that of ocean fish? Is there a contaminant concern about fish in small inland lakes? In ponds?

Name ___________________

ENVIRONMENTAL CONSERVATION
FISHERIES RESOURCES UNIT
WEEK SEVEN: FISH CONSUMPTION
THE MICHIGAN FISH ADVISORY

1. How does the Michigan Fish Advisory compare to federal regulations regarding fish consumption?

2. When did the fish advisory program begin? How have the contaminant levels changed since then?

3. How does the cooking method used for preparing fish affect the removal of PCB's? Of Mercury? WHY?

4. Name 3 healthful benefits of fish consumption:

5. Will the chemical contaminants in fish make you immediately sick? How do they affect you?

6. Name 3 ways that you can reduce your risk of exposure to contaminants when eating Michigan fish:

7. What types of ocean fish may be hazardous for some people to eat?

8. Identify the DOS and DON'TS of fish cooking to remove contaminants:

   DO:

   DON'T

9. What general restriction is listed for consumption of fish from all inland waters of the state?

10. If you wish to eat carp, is it safer to consume them when caught from the Pine River downstream from St. Louis or the Grand River downstream from Lansing?

APPENDIX B

PRE-TESTS AND POST-TESTS

Name ____________________

ENVIRONMENTAL CONSERVATION
FISHERIES RESOURCES UNIT
WEEK ONE: MICHIGAN FISH SPECIES
PRE-TEST: "NAME THOSE FISH!

1. Write the names of all the Michigan fish species that you know of. If it is a species that you have caught before, mark it with an asterisk (*). If you aren't sure that the species is found in Michigan, mark it with a question mark (?).

2. Draw an outline diagram of a fish and label as many of its parts (different fins, mouth, eye, etc.) as you can:

B-2

Name ________________

ENVIRONMENTAL CONSERVATION
FISHERIES RESOURCES UNIT
WEEK ONE: MICHIGAN FISH SPECIES
POST-TEST: "NAME THAT FISH!"

Identify the Michigan fish species that are shown in the color photos. Be specific!

1.____________________ 11. ____________________

2.____________________ 12. ____________________

3.____________________ 13. ____________________

4.____________________ 14. ____________________

5.____________________ 15. ____________________

6.____________________ 16. ____________________

7.____________________ 17. ____________________

8.____________________ 18. ____________________

9.____________________ 19. ____________________

10.____________________ 20. ____________________

Identify the following parts of a fish's anatomy as labeled on the overhead diagram:

21. ____________________ 26. ____________________

22. ____________________ 27. ____________________

23. ____________________ 28. ____________________

24. ____________________ 29. ____________________

25. ____________________ 30. ____________________

Name ________________

ENVIRONMENTAL CONSERVATION
FISHERIES RESOURCES UNIT
WEEK TWO: POND LIFE
PRE-TEST

1. What special branch of ecology deals with the study of ponds?

2. Name two differences between ponds and lakes:

   *

   *

3. Name 3 characteristics of a properly constructed farm pond:

   *
   *
   *

4. Name the source(s) of each of the following chemical nutrients or compounds in pond water:

   - Oxygen
   - Carbon dioxide
   - Nitrogen
   - Phosphates
   - Chlorides
   - Ammonia
   - Nitrates

5. What pond feature results from the strong adhesion of water molecules to each other?

6. Why does ice form on the top of a pond in winter?

7. What happens to a pond's water temperature as the air temperature changes over the course of the day?

8. How does sediment runoff into a pond affect plant growth?

9. Identify as many living things as you can that occupy the following parts of a pond:

    - open water
    - shallow water
    - bottom

10. Give an example of a common food chain in a farm pond:

11. Describe the changes that occur in a pond over time with regard to both the physical characteristics and the living things in it:

Name ________________

ENVIRONMENTAL CONSERVATION
FISHERIES RESOURCES UNIT
WEEK TWO: POND LIFE
POST-TEST

1. What special branch of ecology deals with the study of ponds? What does it investigate?

2. Name two differences between ponds and lakes:

   *
   *

3. Name 2 characteristics of a properly constructed farm pond:

   *
   *

4. Name 1 source of each of the following chemical nutrients or compounds in pond water:

   - Oxygen
   - Carbon dioxide
   - Nitrogen
   - Phosphates
   - Chlorides
   - Ammonia
   - Nitrates

5. Describe the variation in the density of water. How does this relate to the formation of ice on the top of a pond in winter?

6. What happens to a pond's water temperature as the air temperature changes over the course of the day? Why?

7. How does sediment runoff into a pond affect turbidity? What impact may this have on plant life in the pond?

8. Identify the pond habitats below and give 2 examples of living things that occupy those parts of a pond:

- Limnetic zone

- Littoral zone

- Benthic zone

- Surface Film

9. Match the types of organisms on the left with the examples on the right:

_____ phytoplankton	A. snails, clams, insect larvae
_____ zooplankton	B. cattails, rushes, blue flag iris
_____ emergent plants	C. molds, bacteria, worms
_____ floating leaf plants	D. bass, bluegill, diving beetles
_____ submersed plants	E. water fleas, copepods, scuds, fairy shrimp
_____ herbivores	F. duckweed, yellow water lily
_____ carnivores	G. coontail(hornwort), milfoil, Elodea
_____ decomposers	H. diatoms, green algae, Cyanobacteria

10. Give an example of a food chain that you would observe in a farm pond:

11. What is eutrophication? Identify 3 changes that occur in a pond as it undergoes eutrophication:

Name________________

ENVIRONMENTAL CONSERVATION
FISHERIES RESOURCES UNIT
WEEK FIVE: PRINCIPLES OF POND FISHERIES MANAGEMENT
PRE-TEST

1. Name 3 reasons why people like to have ponds on their property:

2. Name 3 characteristics of a properly constructed farm pond:

3. Name two ways that aquatic weeds can be controlled in a pond:

4. If you want to have bass in a pond, what fish should be provided for them to feed on? Why?

5. What causes fish in a pond to become stunted? What species are especially prone to this occurring?

6. Name 3 species of fish that should not be put in Michigan ponds:

7. How can you tell how old a fish is?

8. How can you tell how much a fish has grown during each year of its life?

9. How can you estimate how many fish are in pond?

B-6

Name ________________

ENVIRONMENTAL CONSERVATION
FISHERIES RESOURCES UNIT
WEEK SEVEN: PRINCIPLES OF POND FISHERIES MANAGEMENT
POST-TEST

1. Name 2 characteristics of a well-constructed farm pond and identify how each is important to maintaining a healthy fish population:

2. What is stunting? Why does it occur? Identify 2 species commonly stocked in ponds that may become stunted, and identify 2 ways that a pond can be managed to prevent this from occurring:

3. What prey (food) fish should be stocked in a Michigan pond that you wish to stock bass in? WHY?

4. Name 2 methods by which aquatic vegetation can be controlled in a farm pond:

5. Identify and describe the 4 habitat zones of the pond and give 2 examples of organisms that can be found in each:

6. What is bioaccumulation? What chemical contaminants may be found in farm pond fish?

7. Name 2 ways that you can reduce your exposure to contaminants found in fish:

8. Name 3 species of fish that should not be stocked in Michigan ponds:

9. Diagram a fish scale labeling the focus, circuli and annuli:

10. Describe how a fish's age may be determined from a scale sample:

11. If a first capture marks and releases 100 bluegills back into a pond and a second capture collects 100 bluegills, of which 10 were previously marked, what is the estimated bluegill population in the pond?

12. Describe how a fish's growth may be back-calculated using a scale sample and a ruler.

13. Approximately how many years does it take for a bluegill in a farm pond to reach an "eating" size of 7-8 inches? For a largemouth bass to reach 12 inches?

14. Name 3 reasons why people desire to have a pond on their property:

15. Diagram a fish and label the following parts:

    operculum, anus, anal fin, caudal fin, pectoral fin, pelvic fin, dorsal fin, mouth, lateral line

Group: CRAPPIE

ENVIRONMENTAL CONSERVATION
POND FISHERIES MANAGEMENT
GROUP REPORT SCORING RUBRIC

The following is the rubric that you will use to score the various portions group report during the peer review process. Please take the time to have your assistant and peer reviewer check your work against this form! Revision is best accomplished when you have some knowledge of where you need to go!

Part One: Introduction (5 points) Score: 4

Identify the pond's:

- – location
- + owners
- + age
- + construction
- + initial stocking

Format standards

- + 12 point, double-spaced
- + default margins
- – proper grammar
- – no spelling errors
- + grade appropriate

Part Two: Aquatic Life Survey (10 points) Score: 7

Identify **and** describe:

- + 4 pond habitats
- + aquatic vegetation (pictures)
- + macroinvertebrates (pictures)
- + fish species in pond to include:
  - + largemouth bass
  - + bluegill
  - – pumpkinseed sunfish
  - – yellow perch
  - – crappie

for each fish, identify:

- + scientific name
- – physical description
- – habitat preferences
- – spawning information
- + picture

Format standards

- + 12 point, double-spaced
- + default margins
- – proper grammar
- – no spelling errors
- + grade appropriate

Part Three: Fish Population Survey Report (10 points) Score 8

Describe:

- \+ capture methods/locations
- \+ marking method
- \+ population estimate (formula)
- − discussion of results
- − improvement of design?

Format standards

- \+ 12 point, double-spaced
- \+ default margins
- − proper grammar
- − no spelling errors
- \+ grade appropriate

Graph:

- \+ number and species of each fish
- \+ spreadsheet/chart
- \+ color
- \+ title, subtitle, axes labels and legends
- \+ legible font and size

Part Four: Age and Growth Survey Report (10 points) Score 8

Describe:

- − scale sampling method
- − aging method
- − back-calculation of growth(formula)
- \+ discussion of results

Format standards

- \+ 12 point, double-spaced
- \+ default margins
- \+ proper grammar
- \+ no spelling errors
- \+ grade appropriate

Graph:

- \+ age/growth for each fish by species
- \+ spreadsheet/chart
- \+ color
- \+ title, subtitle, axes labels and legends
- \+ legible font and size

Part Five: Pond Population and Growth Analysis (10 points) Score 8

Describe:

- \+ Comparison of fish to standards
- \+ Fish growth in pond
- − Environmental factors influencing growth

Format standards

- \+ 12 point, double-spaced
- \+ default margins
- \+ proper grammar
- \+ no spelling errors
- \+ grade appropriate

Part Six: Management Recommendations (5 points) Score 3

Discuss:	Format standards
– results of study	+ 12 point, double-spaced
– current status of pond fish population	+ default margins
+ review objectives	+ proper grammar
– recommendations for maintenance or improvement	+ no spelling errors
	+ grade appropriate

TOTAL SCORE: 38 / 50

Group: PERCH

ENVIRONMENTAL CONSERVATION
POND FISHERIES MANAGEMENT
GROUP REPORT SCORING RUBRIC

The following is the rubric that you will use to score the various portions group report during the peer review process. Please take the time to have your assistant and peer reviewer check your work against this form! Revision is best accomplished when you have some knowledge of where you need to go!

Part One: Introduction (5 points) Score 5

Identify the pond's:

+ location
+ owners
+ age
+ construction
+ initial stocking

Format standards

+ 12 point, double-spaced
+ default margins
– proper grammar
+ no spelling errors
+ grade appropriate

Part Two: Aquatic Life Survey (10 points) Score 9

Identify **and** describe:

+ 4 pond habitats
+ aquatic vegetation (pictures)
+ macroinvertebrates (pictures)
+ fish species in pond to include:
  + largemouth bass
  + bluegill
  + pumpkinseed sunfish
  + yellow perch
  – crappie

for each fish, identify:

– scientific name
+ physical description
+ habitat preferences
+ spawning information
+ picture

Format standards

+ 12 point, double-spaced
+ default margins
+ proper grammar
+ no spelling errors
+ grade appropriate

Part Three: Fish Population Survey Report (10 points) Score 7

Describe:

\+ capture methods/locations
\+ marking method
— population estimate (formula)
— discussion of results
— improvement of design?

Format standards

\+ 12 point, double-spaced
\+ default margins
\+ proper grammar
\+ no spelling errors
\+ grade appropriate

Graph:

\+ number and species of each fish
\+ spreadsheet/chart
\+ color
\+ title, subtitle, axes labels and legends
\+ legible font and size

Part Four: Age and Growth Survey Report (10 points) Score 9

Describe:

\+ scale sampling method
\+ aging method
\+ back-calculation of growth(formula)
\+ discussion of results

Format standards

\+ 12 point, double-spaced
\+ default margins
\+ proper grammar
\+ no spelling errors
\+ grade appropriate

Graph:

_____ age/growth for each fish by species
_____ spreadsheet/chart
_____ color
_____ title, subtitle, axes labels and legends
_____ legible font and size

Part Five: Pond Population and Growth Analysis (10 points) Score 8

Describe:

\+ Comparison of fish to standards
\+ Fish growth in pond
— Environmental factors influencing growth

Format standards

\+ 12 point, double-spaced
\+ default margins
\+ proper grammar
\+ no spelling errors
\+ grade appropriate

Part Six: Management Recommendations (5 points) Score __4__

Discuss:		Format standards	
–	results of study	+	12 point, double-spaced
+	current status of pond fish population	+	default margins
–	review objectives	+	proper grammar
+	recommendations for maintenance or improvement	+	no spelling errors
		+	grade appropriate

TOTAL SCORE: __42__ / 50

APPENDIX C

LABORATORY ACTIVITIES

Name________________

ENVIRONMENTAL CONSERVATION
FISHERIES RESOURCES UNIT
LABORATORY INVESTIGATION
"HOW MANY FISH IN THE POND?"

You made it! The trip through the pasture was a dangerous game of cat and mouse with a Holstein bull. Thankfully he decided to stop at the electric fence that gave you such a jolt! The water stretches out before you for several hundred yards. What a beautiful pond! By all appearances, it should be loaded with fish. But how can you find out how loaded it is? How do scientists estimate the number of fish in a pond?

The populations of different fish species in a pond change on a daily basis. Reproduction, predation, and death from other environmental stresses all take their toll on the population. Certain age groups of fish, or year classes, have greater changes in their numbers than others. The young of the year (newly hatched "fry" and slightly larger "fingerlings") that are serving as a food source for many other fish, birds, mammals, reptiles, amphibians, and even some invertebrates like predaceous diving beetles, will have numbers change every day. To assess the health of a pond's fish population, it is necessary for the fisheries biologist to complete a population survey to determine the species distribution and numbers of fish in different year classes.

Various methods may be employed to find the population size of a given species in the pond. First, if the fish are stocked, the total number of fish and their age going into the pond can be known precisely. Depending upon age, length and weight may also be determined prior to release so that accurate and detailed accounts of fish growth can be determined. In a pond with an existing population fish may be sampled by various means, marked and then a follow-up sample that finds previously marked fish can lead to an estimate of overall population size. This MARK-RECAPTURE SURVEY, as it is known, is widely used in the fisheries and wildlife sciences to give population estimates for a wide variety of species. Sampling methods used to capture fish often include netting by trap nets of seine nets, electric shocking, or drawing down the pond's water level.

In this lab activity you will be sampling the fish population in Feldpausch's pond using recreational angling techniques, which will definitely influence the year class of fish that we are sampling. You will collect a scale sample from each fish caught so that we can find its age and mark the fish by clipping its pelvic fin prior to release. Next week we will take a second sample and see how many fish we can recapture, then estimate population size. For a successful capture/recapture survey of the fish population of Feldpausch's pond, we must be careful in our handling of the fish that we capture, measure, mark and release.

Fish are protected from disease-causing organisms in the aquatic environment by a layer of mucus (not slime) that covers their scales. If this mucus coat is removed during handling, it may reduce the fish's ability to resist infection by those diseases. For that purpose, do your best to

- wet your hands prior to handling a fish
- avoid dropping or dragging the fish on the ground
- wet the surfaces of your measuring boards before use

Fish exchange oxygen and carbon dioxide gas with the water through their gills. The gills are delicate structures that must remain moist to permit proper function. For that reason, do your best to

- keep the fish in the water (pond or pail) until ready to measure
- minimize time out of water for measuring process
- do not touch gills during handling
- if a fish is deeply hooked and damage to the gills may result from removal, cut the line at the fish's mouth or see me for assistance

To measure the total length of the fish, hold it flat against the horizontal board with its mouth closed and held up against the vertical board (wet boards prior to use). Pinch the tips of the caudal fin together to form a point and measure to the nearest 1/8 of an inch.

Mark the fish by clipping off the bottom edge (≤ ½") of its pelvic fin.

Release the fish by gently placing it to the water and allowing it to swim away. Avoid dropping or throwing the fish as it may stun it or cause internal damage.

REMEMBER, THE SUCCESS OF OUR SAMPLING EFFORTS RESTS ON THE SURVIVAL OF THE FISH WE CATCH AND RELEASE. BE CAREFUL!

Calculating the population size will require that you record the numbers of fish caught on our first trip, the number of fish caught on our second trip, and the number of fish that were previously marked out of those captured on our second trip. The following equation can be used to find the estimated population of each species that we catch:

$$\text{TOTAL POPULATION} = \frac{\text{TOTAL MARKED FIRST CAPTURE} \times \text{TOTAL CAUGHT SECOND CAPTURE}}{\text{TOTAL RECAPTURES}}$$

Lab Questions:

1. What was the size range of the fish that were caught in the samples?

2. What factors in our sampling techniques influenced the size of the fish that were caught?

3. Identify the species and number of fish that were marked in the first capture:

4. Identify the species, number of fish and number of recaptures in the second capture.

5. Use the formula above to estimate the population size of each species in the pond:

6. How accurate do you think these estimates are? Name 3 things we could do to improve the accuracy of our estimates:

7. What limitations are there on our ability to get a complete count on the pond's fish population? EXPLAIN!

Name ________________

ENVIRONMENTAL CONSERVATION
FISHERIES RESOURCES UNIT
LABORATORY INVESTIGATION:
"HOW OLD IS THAT FISH?"

Wow! What a monster! The pond must've dropped a foot when you pulled that big old fish out of the water! You know you've got a big one, and you know it must be old, but just how old is it? How can you determine the age of a fish?

Determining the age of fish is a very important skill for fisheries biologists to learn if they are to make accurate descriptions about the health of a pond's fish population. Finding out how old fish are and then determining how fast they grow are key to understanding the environmental factors at work in the pond system. A pond that contains many large fish of average age is more productive than one that has few fish of the same size that are much older. The faster growth of the fish indicates that they are finding better conditions for their survival. Finding the age of the fish can allow the fisheries biologist to make recommendations on fish harvest and other actions that can optimize fish production.

Fish age can be determined in a variety of ways. Knowing the exact date of hatching of stocked fish that are put into the pond is the easiest of all. Finding the age of existing populations may be done by examination of scales, ear ossicles (bones), spines from fins, or other skeletal elements. The examination of ear ossicles, spines or bones requires some difficult work with stains and microscopes. A simpler method consists of examining scales under magnification, most easily accomplished by placing the scales on a microfiche projector. YEAH, THAT'S RIGHT, YOU GET TO GO MICRO-FICHING!

Viewing the projected scale image allows you to see many concentric rings around a nearly central **focus** (the original birth scale) in the scale, much like the rings in a crosscut tree trunk. The difference between the two is that a fish scale's many rings, or **circuli**, as they are properly known, are added to the scale throughout the year, unlike the annular rings on a tree. The scale's rings become more densely packed together, however, during winter months when the fish's growth rate slows. This packed region, or **annulus**, identifies the end of a year for the fish. Fish are hatched between April and August, and thus are not by calendar a full year of age when the first annulus is created. Fisheries scientists therefore established a rule that would bring conformity to the process of determining age. Fish are considered to be the age of their last identifiable annulus, regardless of the time of year collected.

For each fish that you catch, a small scale sample must be collected and saved to be read in class using the microfiche projector. To take this sample, hold the fish firmly against the measuring board and scrape a small patch of scales from its side between the front edge of the anterior dorsal fin and the lateral line. Scrape in a tail to head direction for easiest removal. Do not collect scales from the lateral line, as there are structurally different from what we need to look at. Label the collection packet with the necessary information (date, species, length, and location) and place the scales inside.

Back in class, determine the age of each fish by examining the scale on the microfiche reader. Refer to the additional handouts to be sure that you do not have a lateral line scale (which shows an opening in the center) or a replacement scale (which shows a very large focus). Follow these guidelines to prepare and view the scale appropriately:

Place a droplet of water on the lower glass plate of the projector about three-quarters of an inch in from the edge.

Place one scale on the water droplet and close the viewing plates of the projector.

Turn the projector on and slide the plates in until you can see the scale's image.

Center the image in the projector screen. If the image is difficult to see because of air bubbles (little black circles or lines) then remove the scale and remount it in another droplet of water.

Observe the image and identify the focus, then work outward and locate the densely packed circuli that denote each annulus. On old fish this may be more difficult due to the slower and less steady growth rates and changes that occur during spawning and other times of stress.

Place a sheet of copy paper on the projector glass and then place a mark at the center of the focus. In a line from that point to the edge of the scale, place a mark at the location of each annulus and at the outer edge of the scale. Label the paper with the species and overall length. This page will be used in the next lab to calculate the fish's growth at periods in its lifetime.

Lab Questions:

1. What was the range in ages of the fish that you studied?

2. Compare length and age within species. Did fish of the same species and age have nearly identical lengths? What could cause this?

3. How difficult was it to determine annuli on older fish (>5 years)? Why?

4. How confident are you in your ability to find the age of a fish using this method?

Name ________________

ENVIRONMENTAL CONSERVATION
FISHERIES RESOURCES UNIT
LABORATORY INVESTIGATION:
"HOW BIG WAS THAT FISH WHEN...?"

You're sitting in the boat with your ol' Grandad, intently watching your rod tip for any sign of a fish biting as the old codger rambles on with another one of his stories that begins with "When I was a kid just about your size..." when suddenly the monster of the lake nearly rips the rod from your hands! After what seems like hours later, you swing the gargantuan aboard and you and Gramps spend a few excited moments admiring the fish before snapping a few pictures and taking a few scales before releasing the behemoth to fight another day.

The old fella snuffs and points at the scales you're slipping into a collection envelope. "What's that for, your trophy case?" he inquires.

"Nope," you reply. "I just want to find out how big this fish was 'when I was a kid.'"

A very important part of the analysis of the pond's fish population involves analysis of the growth rates of various fish species and the age classes within them. Fisheries scientists use a method known as **back-calculation** to determine the size of fish at various ages in its past based upon the information provided from a scale sample. The method utilizes the relationship between current scale length and current overall length of the fish to determine its length at any of its previous ages.

The ratio between the current length of the scale and overall length of the fish at its present age can be used to calculate the fish's length at a prior age according to its scale length at that age with the following formula:

$$\text{TOTAL LENGTH AT AGE X} = \frac{\text{TOTAL LENGTH}}{\text{SCALE LENGTH}} \times \text{SCALE LENGTH AT AGE X}$$

In this lab activity you will use the marked papers from the age determination lab to find the sampled fish's length at all of its previous ages. To accomplish this, follow the instructions below:

Measure the total scale length from its focus to the outside edge as marked on the page in the previous lab.

Divide the fish's total length as listed on the page by the length of the scale.

Measure the distance from the focus to each annulus as marked on the page.

For each annulus, calculate the fish's length at that age by multiplying the previous ratio of overall length /scale length and the scale length at that age.

Write the fish's length at each age in your notebook for use in constructing age and growth analysis graphs for the group project.

Lab Questions:

1. Among bluegills of the same age, how did their sizes compare at

   Age 1?

   Age 2?

   Age 3?

2. Give 2 reasons for these results:

3. Among largemouth bass of the same age, how did their sizes compare at

   Age 1?

   Age 2?

   Age 3?

4. Give 2 reasons for these results:

5. If a nine-year-old, 42.50 cm (17") largemouth bass has a projected scale length of 11.30 cm (4.5"), how long was the fish at age seven if the projected scale length is 10.60 cm (4.25")? What does this indicate about the fish's growth in the last two years?

APPENDIX D

STUDENT INTERVIEW QUESTIONS

Name ___________________

ENVIRONMENTAL CONSERVATION
FISHERIES RESOURCES UNIT
UNIT FOLLOW-UP
STUDENT INTERVIEW QUESTIONS

Please respond to each of the following questions as fully as possible:

1. How could you determine the age of a fish that you caught?

2. How could you find out how long the fish was when it was 1 year younger?

3. If bluegills are stocked in a pond, what will eventually happen to their population? Why? How can this problem be avoided?

4. If bass and bluegills are in a pond together, what size must the bass be to be effective predators of the bluegill?

5. Ideally, what prey (food) fish should be stocked in a pond with bass? Why?

6. Name 3 species of fish that are not recommended for stocking in Michigan ponds:

7. Name 2 ways that the manner in which a pond is constructed can limit the amount of aquatic plant growth in it:

8. How do fish get contaminants in their bodies?

9. Where are most of the contaminants stored in a fish's body? How can you reduce your exposure to them if you are going to eat fish?

10. Identify the difference between the benthic, littoral and limnetic zones in a pond:

11. Draw and outline diagram of a fish and label the following parts:

    operculum, anus, anal fin, caudal fin, pectoral fin, pelvic fin, dorsal fin, mouth, lateral line

12. If someone asked you to estimate the size of a fish population in their pond, explain how you would go about it:

13. List three reasons why people desire ponds on their property:

D-2

Name ________________

ENVIRONMENTAL CONSERVATION
FISHERIES RESOURCES UNIT
UNIT FOLLOW-UP
STUDENT QUESTIONNAIRE

Please respond to each of the following as honestly and thoughtfully as possible:

The following questions are about your knowledge **before** the unit was taught:

1. Could name more than 15 species of Michigan fish?	Yes	No
2. Could you identify more than 15 species of fish by their photograph?	Yes	No
3. Could you name the 4 distinct habitats of a pond and identify organisms that lived there?	Yes	No
4. Could you estimate the population size of a pond's fish population?	Yes	No
5. Could you determine the age of a fish you had caught?	Yes	No
6. Could you determine how a fish had grown over its lifetime?	Yes	No
7. Could you identify the relationships between predator and prey fish in a pond and how their populations interact?	Yes	No
8. Could you identify the proper species and methods of stocking new ponds for fishing?	Yes	No
9. Had you filleted a fish?	Yes	No
10. Were you familiar with the advisory on fish consumption and how to best prepare fish to limit your exposure to contaminants?	Yes	No

The following questions are about your knowledge **after** the unit:

11. Can you name more than 15 species of Michigan fish?	Yes	No
12. Can you identify more than 15 species of fish by their photograph?	Yes	No
13. Can you name the 4 distinct habitats of a pond and identify organisms that lived there?	Yes	No
14. Can you estimate the population size of a pond's fish population?	Yes	No
15. Can you determine the age of a fish you had caught?	Yes	No

16. Can you determine how a fish had grown over its lifetime?	Yes	No
17. Can you identify the relationships between predator and prey fish in a pond and how their populations interact?	Yes	No
18. Can you identify the proper species and methods of stocking new ponds for fishing?	Yes	No
19. Can you fillet a fish?	Yes	No
20. Are you familiar with the advisory on fish consumption and how to best prepare fish to limit your exposure to contaminants?	Yes	No

Below is a list of activities that we did during the unit. Please rate them from 1 (strongly disagree) to 5 (strongly agree) for each of the following categories:

Fish species identification using Michigan Fishing Guides

Information was presented in a way that I could easily learn _______
I learned the information well in the time spent on it _______
I was motivated to learn this material _______
I enjoyed this part of the unit and recommend keeping it _______

Pond habitats and mural construction

Information was presented in a way that I could easily learn _______
I learned the information well in the time spent on it _______
I was motivated to learn this material _______
I enjoyed this part of the unit and recommend keeping it _______

Fish population survey (mark/recapture lab)

Information was presented in a way that I could easily learn _______
I learned the information well in the time spent on it _______
I was motivated to learn this material _______
I enjoyed this part of the unit and recommend keeping _______

Determining fish age (scale reading lab)

Information was presented in a way that I could easily learn _______
I learned the information well in the time spent on it _______
I was motivated to learn this material _______
I enjoyed this part of the unit and recommend keeping it _______

Determining fish length at previous ages (back-calculated growth lab)

Information was presented in a way that I could easily learn	_______
I learned the information well in the time spent on it	_______
I was motivated to learn this material	_______
I enjoyed this part of the unit and recommend keeping it	_______

The group report

Instructions on what was required were clearly presented	_______
Workload was fairly distributed among all members by role assignment page	_______
Deadlines were fair	_______
Information needed to complete the report had been covered in class	_______
I was familiar with all information in my group's report	_______
I peer reviewed those parts that I was assistant or reviewer for	_______
I learned more about report preparation	_______
I felt the report was worth more than just a grade because the Feldpausches were getting a copy	_______
Doing the report in a group was enjoyable and it should be kept that way	_______

Please comment on what you **liked most** about this unit (less lecture, more labs, group work, working with Feldpausches, etc):

Please comment on what you liked least about this unit (report work, labs, notes, etc):

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