Catfish Planet

Educational Goals and Objectives for the Catfish Planet exhibit:

The goals of "Catfish Planet" are to introduce visitors and students to the group of fishes called catfish and present information on catfish and catfish characteristics.

The objectives of "Catfish Planet" and associated educational component are to allow visitors to experience interactive models and exhibits, observe live specimens, and to gain a better appreciation and understanding of the catfish family.

Educational Components:

This educational packet and exhibit will include nine major sections as follows.

1. Introduction to Catfish
2. Habitats and Migration
3. Anatomy
4. Defense and Camouflage
5. Diet
6. Reproduction
7. Catfish and Human Interaction
8. History
9. Catfish Activities and related Curriculum

1. Introduction to Catfish:

To most people as catfish just another fish living in ponds, rivers, and lakes of North America. What is so exciting about this particular bottom-dwelling, slow, scavenging, freshwater fish? We may think these characteristics are truth, but we could not be more wrong. Catfish are a very diverse group of fish. They are found on every continent today, and fossils of catfish have even been found in Antarctica. Catfish have over thirty families and almost 3000 described species, and they believe their may be one or two thousand more awaiting description. One out of every four freshwater fish will be a catfish, and one out of every five known fish will be a catfish.

Catfish can also live in many aquatic habitats. There are catfish in high altitude Himalayan streams and in lowland tropical rivers. There are also catfish that live in caves and some that live in the ocean.

Some catfish are among the largest freshwater fish in the world. The Wels catfish in Europe can be over 15 feet long and weigh over 700 pounds, and the giant Mekong catfish can grow to over 9 feet long and weigh more than 800 pounds.

The complexity of the catfish species as a whole gives us the opportunity to break this educational component into a series of topics. In doing this the catfish exhibit and associated educational programs can show museum guests the vast diversity of forms and life history traits that make catfish so important.

What is a catfish?

After visiting catfish planet, we are sure you will agree catfish are the coolest fish on the entire planet. But first we must determine what really makes a catfish a catfish? What makes catfish different from bass, herring, tuna, etc.?

To answer that question, we must look at the larger group of fish to which they belong. Catfish belong to the teleost group which is a Greek word for “perfect bone.” This group includes 96% of all living fish and includes herrings, tuna, basses and catfish.

The family tree of the teleost has four main branches. We will follow the branch of the Euteleostei. This further branches eight times, and catfish follow the twig of Ostariophysi (superorder). This branches even further and we come to the end of our journey at the order Siluriformes or catfish as we know them.

What defines a fish as a catfish? The first is the Webarian apparatus which is a series of five bones, ribs, ligaments and muscles deriving from the anterior (cervical) vertebrae. It also makes contact with the swim bladder. Sound waves hit the fish, the swim bladder picks them up, and the vibrations are then transmitted and amplified to the fish’s middle ear. Catfish have a very acute sense of hearing and pitch discrimination. The second thing that defines catfish is an alarm response. Many catfish release an alarm secretion when the skin is broken. This is sensed by nearby fish, and they take evasive action. The third is the presence of spines in the dorsal and pectoral fins which can be locked in place when erect. Some of these catfish families actually produce a toxin in the sheath covering the spines. The fourth is the presence of two to four pair of barbells (whiskers) which serve as touch and taste receptors. The fifth is the presence of an adipose fin. This is a usually small, fleshy fin just before the tail. The sixth is they have fewer skull bones than other fish in teleost groups. The seventh and final thing that defines a fish as a catfish is the lack of scales. Although many may have bony plates or tubercles, they do not have scales.

2. Habitats and Migration

As such a large and diverse group (34% of all freshwater fish are catfish) it is not surprising that they have managed almost every available freshwater, and occasionally marine niche. We could talk about the many catfish that are able to breathe atmospheric air (Clarrids, Heteropnuestids). We could show animals that are adapted for life in rapids, like the Amphilliids, and the Sisorids. Catfish also occur in caves, with a small number of species being without pigment and blind. Members of two families, the Ariids, and the Plotosids have managed to move into the oceans. One recently described catfish from Brazil is not known to live in water at all! So far it has only been found in damp leaf litter along the banks of rainforest streams.

3. Anatomy and Adaptations

Catfish as a whole have extraordinary sensory abilities. There are also a few that have special adaptations for eating, finding food, etc. Let's start with the senses.

<u>Smell:</u> Catfish have olfactory organs in front of the eyes and have two nostrils each. One takes in the water and the other pushes the water out. Folds in the tissue house the scent receptors. More folds means better smell. Channel catfish have over 140 folds as compared to eighteen on a rainbow trout and eighteen to thirty on a largemouth bass. In fact, members of the family Trichomyceridae are able to smell at a great distance the ammonia given off as a large fish exhales. This allows these small parasitic catfish to home in on their prey and attach themselves to their gills and feed on the blood of the larger fish.

<u>Taste:</u> Catfish's sense of taste is highly developed. Many species of catfish have taste buds in the mouth, on the barbells and also on the skin. The taste buds on the whiskers help the fish determine if the food is really food and the taste buds in the mouth then determine if it is actually edible. A blue catfish can actually have more than five thousand per square centimeter of skin and a six inch channel catfish can have more than a quarter million taste buds on its entire body.

<u>Hearing:</u> As mentioned in the introduction section, fish do not have an external ear, but they hear very well. To hear, catfish use the Webarian apparatus which is a series of five bones, ribs, ligaments and muscles deriving from the anterior (cervical) vertebrae. It also makes contact with the swim bladder. Sound waves hit the fish, the swim bladder picks them up, and the vibrations are then transmitted and amplified to the fish's middle ear. Catfish have a very acute sense of hearing and pitch discrimination. They also have the lateral line system which is a series of pores running in a line down the fishes side and around the head and jaw.

Inside these pores are cells with hair-like projections. These bend in response to water displacement and then stimulate nerve endings that send signals to the brain. A fish swimming by or something walking on the bank near the shore create the sort of low-frequency vibrations that the lateral line system can pick up. One thing that makes this sense of hearing so great is that the Chinese have used catfish for centuries as early warning for earthquakes because they believe they can sense the tiny tremors that proceed large earthquakes.

Vision: Many people believe the vision of catfish is very poor and that is why the other senses have adapted to such a sensitive level. This is not true with the exception of a few cave and deepwater forms of catfish. Catfish actually have excellent color vision and see well both in the light and in the dark.

Electroreception: Look very closely at a catfish head and around the lateral line, and you will see small irregularly spaced pores. These sensory organs detect the electrical fields given off by all living things. This helps the catfish in dark or muddy waters when it may not be able to see, taste, or feel its food because it is hiding in the substrate.

4. Defense and Camouflage

To survive in the wide world of nature, catfish have had to find ways to defend themselves to live long enough to reproduce. Catfish species have found a variety of ways to do this, and many employ more than one of these techniques. Disruptive coloration is used by catfish like the Line Saltwater catfish. These fish swim in large groups and are brightly colored which gives them the appearance of being one large fish and tasting bad or being poisonous.

Other fish such as the lined catfish, air sack catfish, and the North American madtoms are known to use a painful and venomous sting to remain safe. The spines and venom are often in the dorsal fin, but are sometimes also found in the pectoral fins. Crypsis (blending in by color or shape), mimicry, and armor are other ways many species of catfish defend their lives. A couple examples of these are the Helognids which lie on their side on the bottoms of streams to look like dead leaves, the twig catfish that look like twigs, and the Doradidae which have heavey bony plates covering their bodies like armor.

5. Diet

Catfish are often seen as sluggish bottom-dwellers scavenging food on the bottom of lakes and rivers. This is actually far from the truth. Catfish have evolved many ways of obtaining food. A few examples would be the cooperative pack hunting practiced by some members of the Clariidae, the electrical discharges given off by electric catfish to stun prey, parasitic catfish that feed on the blood and scales of larger fish (mostly other catfishes), Loricoriids of the genus Panaque, that feed only on wood and have bacteria in their guts like those of termites that allow them to digest cellulose, or the ceopsid catfish that feed by taking single bites out of another fish much like the cookie cutter sharks of the Pacific Ocean do. Many catfish (most Loricoriids, some Mochocids, and Sisorids) are specialized for feeding on algae. Others like the Heloginids feed exclusively on insects (mostly ants) that fall into the water. A significant number of catfishes in the tropics feed on fruit that falls into the water. These fruit eating catfish play an important role in the dispersal and distribution of seeds in the tropical ecosystems. Many of the Mochokid catfish are called “upside down catfish” because they swim permanently upside down allowing them to feed on insects at the waters surface. Several Asian Clariid catfish actually secrete a milky substance from their skin as food for their young.

As you can see catfish eat varied food and have varied ways of catching and digesting prey/food. Some even verge on the line of being parasites. Catfish can be herbivores, omnivores, or carnivores.

6. Reproduction

Finding food is only the first step a fish must make if it is going to be successful as a species. At some point it has to make more fish. Catfish may have the most diverse reproductive methods of any other group of fishes. While many species of catfish simply mate, lay eggs and leave them to fend for themselves, a large number of species exhibit a level of parental care many people might find surprising for a fish. One example would be the nest building and guarding behavior of our bullheads. The sea catfish brood their eggs in the males mouth. The banjo catfish carry their eggs in a ball on their bellies. The cuckoo nest breeders like Synodontus multipunctatus lay their eggs in the nest of spawning cichlid fishes so that the other fish protect and raise their young for them, and the armored catfish, Hoplosternum, builds a floating bubble nest to lay its eggs in. A number of Pimelodid catfish in South America undergo what amounts to the longest migrations of any freshwater fish in the world in order to reproduce. There is even a catfish, one African Cariid, that exhibits bi-parental care (both mom and dad look after and feed the young).

7. Catfish and Humans

Catfish and humans have had a long history with each other. Catfish figure prominently in human history and culture both positively and negatively. For example, species of catfish were easily identified on Egyptian hieroglyphs drawn as early as 2750 B.C.E. The electric catfish was one species depicted on the hieroglyphs and was used for curing headaches by the Egyptian peoples. The catfish was placed on the head of the sufferer and allowed to shock that person. This technique was also later used by Arab-speaking peoples in the 7th century. The electric catfish is used for food and also to cure infertility in West Africa. Another use for the electric catfish, Parasiluris asota, was recommended as a treatment for drooping of the eyelid and for facial palsy.

Today, catfish are one of the largest parts of the multi-billion dollar aquaculture industry in the production of catfish for eating. They are also prominent in the extensive aquarium fish trade which often has a negative affect on some species. Catfish are also used as food. In the United States alone, catfish account for almost half of all fish raised for food. It has even overtaken cattle as the nation’s most utilized livestock. Channel catfish are currently being reared in Russian, India, Europe, China and the United States.

8. History

Catfish have been around for a very long time in human terms. The oldest fossils date are from the late cretaceous (about 80 million years ago). This was the heyday of some other well known creatures like Tyrannnosaurus rex and Triceratops. Since several recognizable catfish families first appear in the fossil record at about the same time, it can be safely assumed that as a group the catfishes have been around even longer.

9. Catfish Activities and related Curriculum

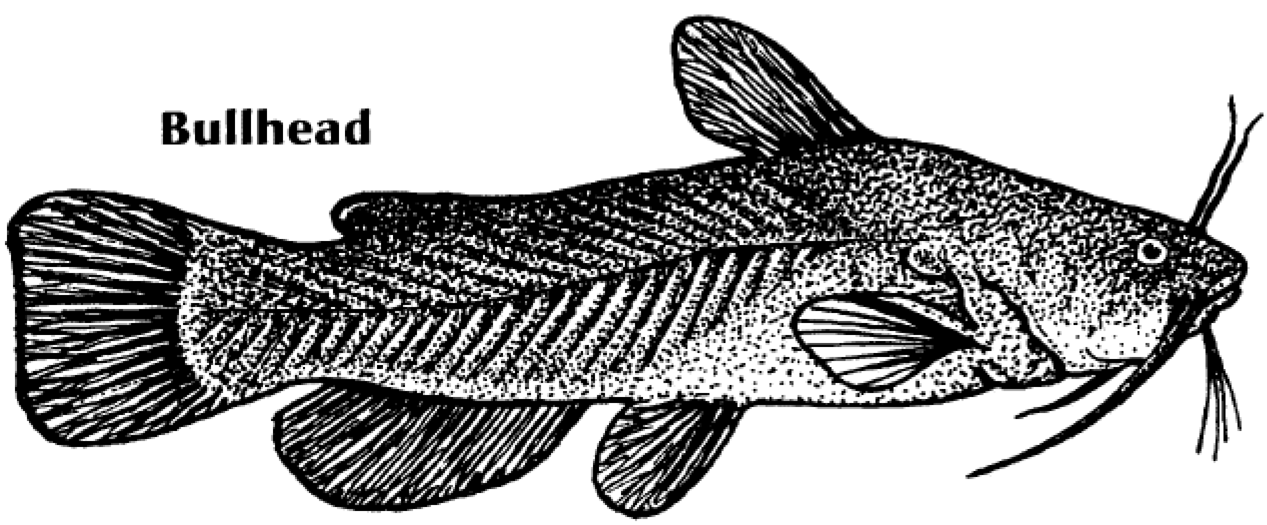
Catfish Craft Projects

Stuffed Catfish

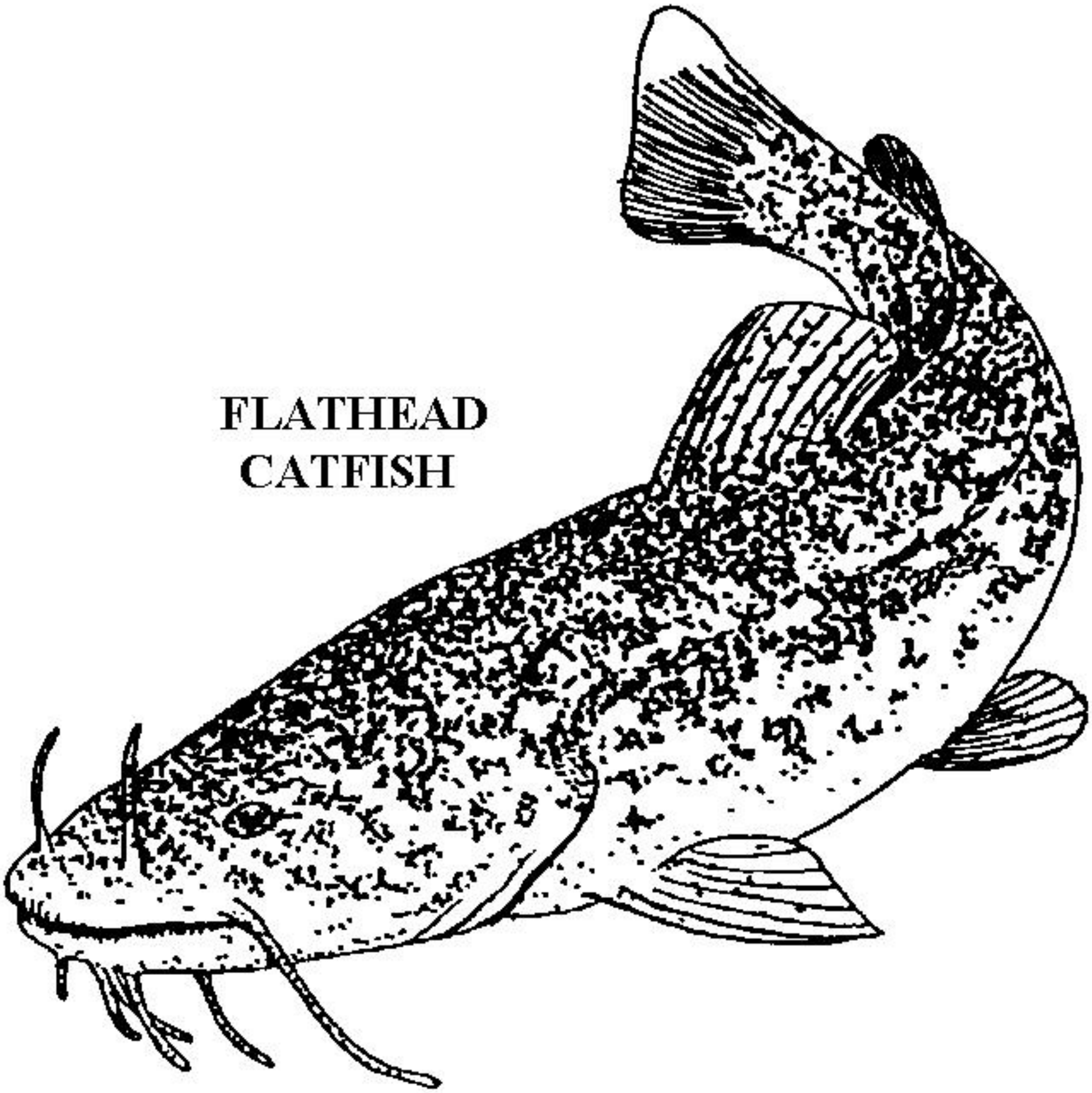
Draw a simple fish outline on construction paper (make it large enough to fill most of the paper). Cut out two. Staple around the perimeter, leaving the mouth open. Stuff body and tail fins with shredded paper, leaving the head area un-stuffed. Staple a few times to keep stuffing in place. Add paper strips or yarn for whiskers.

Catfish Graphics for coloring pages or sun printing

(see sun printing curriculum later in this packet)



FLATHEAD CATFISH



Catfish Puppets

A source for animal puppets is from ***Folkmanis***. They used to make a nice catfish puppet, but no longer produce this item. Used ones may be available.

Stuffed catfish can be purchased from ***Cabin Critters***. They carry stuffed blue and channel catfish. Contact telephone is (203) 778-4552.

Catfish T-shirts

Direct Impulse Design, Catfish T-shirt in a fresh fish package, Company representative is Barb Shelben, (319) 395-6601, cellular phone (319) 431-1021.

The following pages have curriculum and activities that relate to catfish requirements of water quality and habitat:

National Mississippi River Museum & Aquarium Conservation Education Curriculum

Catfish Planet

Target Grades:	6 grade - adult
Key Words:	pH, dissolved oxygen, watershed
Subject Areas:	science, math
Duration:	1 – 1 ½ hours

Title: ***Water Logged***

Summary:

Your class will soon be taking a field trip to study a watershed where catfish are found in a river, stream, lake, pond, or wetland. On your field trip you will be measuring certain chemical aspects of the water to determine if the water is polluted or or able to support life. These are:

1. the oxygen dissolved in the water
2. the pH of the water
3. the temperature of the water

Objectives:
Students will perform basic water analysis for dissolved oxygen, pH, and temperature, to determine life sustaining needs that support various forms of life, including catfish.

Group Size: 5 - 30 students (small groups of 5 or 6 students per test kit)

Background for Educators:
The functions of wetlands make them valuable to people. Wetlands in a watershed help keep our water clean, help prevent erosion, protect our properties from flooding, and more. The ability of different types of wetlands to perform these functions depends in part upon the living components of the community -- the plants that grow there, the animals that live there and interact with and affect the plants, water, land and each other. What lives and grows in a river, stream, lake, pond, or wetland depends upon the physical features of the water area:

- slope of the land forms the watershed feeding the body of water and determines how wet it is.
- water -- Where does it come from? Is it fresh or full of silt? Is it there all the time or only seasonally? Does it transport nutrients and pollutants? Is it clean?
- How does weather affect the watershed?

It is important to identify these features of the wetland, so that you are aware of the resources available there and the ability of the wetland to perform its valuable functions. In studying these features, we can also become more aware of our own effect on the environment.

<u>Dissolved Oxygen</u>
1. As you know, oxygen is important to almost all living things. Without oxygen living things would suffocate and die. Animals in the water remove oxygen from the water. This oxygen is called DISSOLVED OXYGEN (DO), and can be measured with a test kit. It is usually measured in parts per million (ppm). One part per million (ppm) can be compared to having one green marble in a box of 999,999 red marbles. Most water animals require at least 5 ppm of oxygen in the water for growth and well being. The water itself can only contain about 20 ppm before it starts to bubble off just as the gas escapes from a bottle of warm soda. This means that you can expect the DO measurements in the water you will be studying to be between 5 and 20 ppm. Dissolved oxygen (DO) is vital to the health of aquatic habitats, since plants and animals need oxygen to survive and for metabolism. A low amount of oxygen in the water is a sign that the habitat is stressed.

How does oxygen get into the water? Oxygen is mixed in from the air above, with the help of rain, wind, waves, and currents. Faster moving water contains more DO because it has more contact with the air than still water. Underwater plants and algae also contribute oxygen that is given off during the process of *photosynthesis* (green plants use the sun's energy to make their own food).

DO is affected by weather, temperature and salinity. Cold, fresh water holds more oxygen than warm or salty water. Since trout need a high level of oxygen to survive, they live in streams with fast-moving, cold water. *Anoxic* conditions (less than 2 ppm DO) result from dry, hot weather, when the water is warmed and evaporation increases. If these conditions are severe, large "fish kills" or die offs may result.

Anoxia is also caused by runoff of fertilizer and manure from lawns and farms. These excess nutrients, nitrogen and phosphorous, encourage the growth of too much algae, which uses up oxygen quickly. When the algae, other plants and animals die and sink to the bottom, they are decayed by bacteria. This process also uses up a great deal of oxygen. When ice freezes over the water in winter, this loss of oxygen is especially severe.

It is important to monitor DO, since it is an indicator of poor water quality.

pH measurement

2. The percentage of hydrogen ions (H+) in a solution is called the pH. The pH is a measurement of the acidity or basicity (alkalinity) of a liquid. pH is measured on a scale of 1-14. A paper or a liquid that changes color when placed in liquids of different pH is usually used to measure pH.

A solution is more acidic when it contains more hydrogen ions. The level of acidity of the water in wetlands is important to the plant and animal life there. Most animals are adapted to living in *neutral* (neither acidic nor basic) conditions. Changes in pH endanger the lives of young animals in particular. Peat bogs are naturally more acidic than other wetlands -- the plants and animals there are adapted to this acidity.

People's actions can change the level of acidity in wetlands. *Acid rain is* a result of air pollution from automobiles and coal-burning utilities and factories. Sulfur dioxide (S02) and nitrogen oxides are emitted from tailpipes and smokestacks. When these compounds combine with water in the atmosphere, they form sulfuric and nitric acids, then fall to the earth as acid rain, snow, hail, and fog. This precipitation mixes with water already on the earth, in creeks, rivers, ponds, and wetlands. The acidity of the water in wetlands can also be changed by other pollutants brought in by runoff from the land.

The following activity would be good to do with your class before the trip into the field.

Provide the students with 4 bottles of different kinds of liquids:

Bottle
#1: vinegar
#2: water
#3: sodium bicarbonate (baking soda)
#4: household ammonia

Divide the students into teams of four. Each member of the team will receive one piece of the pH testing paper. Each member of the group will place his or her paper into a different one of the liquids that have been provided. Have the students check the color of the paper on the color chart provided, to determine the pH of the liquid tested. Have the students record the name of the liquid below its pH number on a copy of the chart below. Also have them record the findings of the other members of their team.

ACID NEUTRAL BASE (Alkaline)

1 2 3 4 5 6 7 8 9 10 11 12 13 14

lemon juice vinegar rain distilled water baking soda ammonia

Which of the four liquids are acidic? basic? neutral? What pH do you think most aquatic animals need to live? Why do you think so?

Most aquatic animals are very sensitive to changes in pH. Some animals will die at the slightest change in pH. Other animals will survive large changes in pH. Changes in pH can be caused by pollution of the water from factories, farm runoff, and sewage.

Temperature

3. The animals that live in water are affected by the temperature of the water. Some water animals need cold water and others need warm water.

Most creatures living in water are cold-blooded, so their body temperatures and metabolism and growth rates are determined (and limited) by the surrounding water temperature. Most can tolerate only a certain range of temperatures.

Dissolved oxygen (DO), necessary for the survival of aquatic life, is also dependent upon temperature. Cold water can hold more DO than warm water. Warm water, therefore, supports less life than cold.

Water around power plants is polluted by increased temperatures (called *thermal pollution).* Water used to cool the plant's machinery or reactors picks up the heat from the power plant, then it is released into waterways. Most aquatic life cannot tolerate such an increase in temperature.

After reviewing the above information with your class you will have looked at many of the factors important to the study of conservation. They are now ready to look at these factors in the field.

Materials Needed:

- *Hach*, *CHEMets*, or other water test kits for dissolved oxygen, pH, and temperature (and possibly nitrates and phosphates)
- charts of the dissolved oxygen (D.O.), pH, and temperature requirements for aquatic life
- clip boards and pencils
- water from a hydrant or sink faucet
- map of the watershed or water body where tests are to be made

Procedure:

Review the following charts of aquatic life requirements for dissolved oxygen, pH, and temperature. Discuss these needs with the class and each student should make predictions as to the estimated test result. Follow the steps for performing the water tests. If there are several groups making the tests, one group should be a control group and take their test from a hydrant or a sink faucet. The rest of the groups should test the water from a river, stream, lake, pond, or wetland.

Use the water test kits to determine the actual dissolved oxygen count, pH, and water temperature of the water body. Record your findings as well as your predictions on the appropriate space located below each chart. Make sure everyone in your team gets to do some part of the testing.

INSTRUCTIONS:

A. **Dissolved Oxygen (DO)** (using the CHEMetrics test kits)

1. Fill the sample cup to 25 ML mark with the water sample.

2. Place the Chemet ampoule in the sample cup and snap off the small tip by pressing it against the side of the cup. The ampoule will fill with water.

3. Remove the ampoule from the cup and mix the ampoule by inverting several times, allowing the bubble to travel from end to end each time. Wait for **2 minutes** for full color to develop.

4. Hold the comparator ampoules in a flat or horizontal position to allow the light to enter the sides of the ampoules. Place the sample ampoule between the comparison ampoules and estimate the closest reading of Dissolved Oxygen in parts per million (PPM).

Dissolved Oxygen (DO) (using the Hach test kits)

1. Fill the glass-stoppered DO bottle (A) with the water to be tested. Be certain there are no air bubbles in the bottle.
2. Use a clippers or have your teacher open the chemical pillows with a sharp knife. Add the contents of <u>one pillow</u> of DO #1 (B) and DO #2 (C). Stopper the bottle carefully so that air is not trapped in the bottle. Grip the bottle, stopper firmly, and shake vigorously to mix. A flocculent precipitate will be formed. If oxygen is present the precipitate will be brownish orange in color. Allow the bottle to stand and then shake again.
3. Remove the stopper and add the contents of one pillow of DO #3 reagent (D). Carefully re-stopper and shake to mix. The flocculent will dissolve and a yellow color will develop if oxygen is present. This is the prepared sample you will use for testing.
4. Fill the plastic measuring tube (E) level full with prepared sample and pour it into the mixing bottle (F).
5. Add the PAO titrate (G) one drop at a time, counting each drop, until the sample changes from yellow to clear. THE DROPPER MUST BE HELD IN A VERTICAL MANNER, WITHOUT TOUCHING THE SIDES OF THE SAMPLE BOTTLE. BE SURE TO SWIRL AFTER EACH DROP IS ADDED.
6. Record the number of drops taken to turn the sample clear. The number of drops is equal to the number of parts per million (ppm) of oxygen.

Dissolved Oxygen Requirements for Native Fish and Other Aquatic Life

	Dissolved Oxygen in parts per million (ppm)
Warm-Water Organisms (including fish such as bass, crappie, catfish, and sunfish; above 68° F)	
For Life and Growth	5 ppm and above
Cold Water Organisms (including fish such as trout; below water temperature of 68° F)	
For Life and Growth	6 ppm and above
For Spawning (reproduction)	7 ppm and above

DISSOLVED OXYGEN (ppm)
I predict the dissolved oxygen count will be:_________________________.
Actual dissolved oxygen tests______________________.

Replace the parts of the DO test kit making sure the testing containers are rinsed. PLACE ALL GLASS OR PLASTIC TRASH IN GARBAGE BAG OR CAN.

B. pH (using HACH test strips)

1. Dip a test strip into the water and remove immediately.
2. Hold the strip level for 15 seconds, but do not shake excess water from strip.
3. Compare the pH test pad to the color chart above. Estimate the results if they are between two color blocks.

pH (using HACH test cubes)
Fill the test cube from the pH test kit with fresh water from the pond or stream. Fill only to the mark. Add eight drops of the phenol red indicator. Cap the cube and invert until mixed. Match the color with the color guide on the cube and record this number. Rinse the cube when done.

Electronic pH testers can also be used.

pH Ranges That Support Aquatic Life

	Most Acid					Neutral						Most Alkaline		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
bacteria	1.0												13.0	

plants (algae, rooted on bottom)	6.5	12.0
carp, suckers, catfish, some insects	6.0	9.0
bass, crappie, sunfish	6.5	8.5
snails, clams, mussels	7.0	9.0
largest variety of animals (trout, mayfly, stonefly, caddis fly)	6.5	7.5

pH

My prediction: ________________ Actual test:____________________.

C. Water Temperature

At the pond or stream, test and record the temperature of the water in several places. Do not hold the bulb end of the thermometer in your hand before taking the water temperature. To get a more accurate reading, keep the thermometer in place in the water for a minute or more and read it while it is still under water. Record this number. While you record the water temperature, leave a thermometer out to take the air temperature. How does this compare to the water temperature?

Temperature Ranges (approximate) Required for Growth of Certain Organisms

Temperature		Examples of Life
Greater than 68° F	(warm water)	Much plant life, many fish diseases, bass, crappie, sunfish, carp, catfish, caddisfly.
Less than 68° F (cold water)	upper range (55° - 68° F)	Some plant life, some fish diseases, salmon, trout, stonefly, mayfly, caddisfly, water beetles, water striders
	lower range (less than 55° F)	Trout, caddisfly, stonefly, mayfly

WATER TEMPERATURE

My prediction: ________________ Actual test: ____________________.

Evaluation:

By using the following activity after the field trip, or both before and after the field trip, the students grasp of how water chemistry effects aquatic life can be evaluated. This exercise can also lead to good discussion.

Name five things done in this watershed that might affect the quality of the water:

1.____

2.____

3.____

4.____

5.____

The following exercise could also be done as a follow-up assignment that would help evaluate the knowledge about water chemistry requirements and testing gained by the student.
Work in teams of 2 or 3

You are a team of scientists studying wetlands and water resources along the ____________________ (name of water body). You have been collecting evidence about the quality of the water and how the plants and animals, as well as nearby farmland affects the water quality.

Write a report based on the evidence you collected, for the U.S. Fish and Wildlife Service or the City of ___________________. Be specific and use some of the data you collected when testing the water. Include in this report some of the problems you found existing in this watershed. Is the water pure, polluted, or in between? Include recommendations on how people could better manage the land and the watersheds along the ___________________________ (name of water body).

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Additional resources:

- *Save Our Streams*, Izaak Walton League
- *You And Your Environment,* Jasper County Conservation Board, Iowa
- *Project LS (Land Stewardship), (The* wetlands), by Mary and Jay Norton, 1992.
- *Wild, Aquatic Wild* Support materials
- *AQUATIC, Project Wild,*

Extensions:

- pond netting to determine the diversity of species of animals living in the water, for a comparison to the water testing results
- log this information into a national computer data base

- Older students may carry the activities further: monitor these parameters of the wetland for several days, graph results and correlate with weather conditions and any noticeable polluting events *e.g.,* a rainstorm washes sediment in from a nearby construction site or parking lots.

- test for nitrates and phosphates

- have the students write a mock report to the U.S. Fish and Wildlife Service, about the water quality (see evaluation section).

Credits:
Mark D. Wagner, Iowa State University Extension, Director of Education for the National Mississippi River Museum & Aquarium; Dubuque, Iowa
***YOU AND YOUR ENVIRONMENT**,* Jasper County Conservation Board, Newton, Iowa
WOW! The Wonders of Wetlands, Environmental Concern Inc., Michaels, Maryland
Investigating Your Environment series, U.S. Forest Service, Portland, Oregon

National Mississippi River Museum and Aquarium
Conservation Education Curriculum

Target Grades: 3 - 8

Key Words: Sun printing

Subject Areas: Science, visual arts

Energy from the sun, photograph (photo=light, graph =picture)
Vision process using light and photo receptors (eyes)

Duration: 30 – 45 minutes

Title: ***Sun Printing***

Summary:
This activity uses a special photo or light sensitive paper, called Ozalid Acid paper or blueprint paper to produce an image from the sun's light. By placing an object or transparent line drawing on a sheet of photo-sensitive paper, the light from the sun can produce an image on paper much like a photograph in a camera.

After exposure to the sun the paper is developed in the fumes of ammonia (ammonium hydroxide), and thus making a permanent image on the paper. This is the same process that has been used for many years to make copies of architect and engineer drawings on to blueprint paper.

Objectives:
The objective of this activity can be twofold, one to demonstrate the science of the power of light and discuss its importance to plants, animals, and sight. The other purpose of this activity is to allow students to be creative in producing a light picture or "photo-graph" of an historical drawing or natural object that they can keep as a souvenir or reminder of the lesson learned during their field trip visit.

Group Size:
Ideally the number of students corresponds to the number of boards, glasses, and developing containers available, as it is good to have the students arrange the materials or drawings that they will be sunprinting, before receiving their

light sensitive paper. Students can share the boards and glasses, as the number of students engaged in exposing their paper to make a sun print will be determined by the number of ammonia developing jars. It works best to develop only one print in the jar at a time.

Background for Educators:
It would be good for students to have learned about the importance of sun energy for photosynthesis in plants and the use of light for vision in seeing. It might also be helpful for students to understand how and why a film camera works and what happens when the film is processed.

Materials Needed:
Clipboard or heavy cardboard base, glass or acrylic cover, sun printing paper (ammonia developed) in a light tight envelope, food service jar with rocks in the bottom, household or commercial ammonia to be placed in the bottom of the jar.

Procedure:
An explanation should be given to students of the importance of light energy to the living things on Earth. Along with the discussion on light energy may also be a discussion of the use of light for seeing and just how this process works. After the students have a chance to grasp these concepts and explanation of the sun printing procedure can be given. It is good to make the parallel connection between the Greek word **"photo"** meaning light and **"graph"** meaning picture.

It is best to do this activity outside in and area where there is full shade and nearby full sunlight. The sun prints can be done on an overcast day, but the exposure time takes considerably longer. The final sun print sometimes turns out even sharper on an overcast day. It easiest to work from a table top, such as a picnic table, but students can also sit on the ground for this activity.

Boards and glasses should be passed to students and the student should perhaps have a partner who will help hold objects in case of wind. The students should be allowed time to find the flat objects that they want to make sun prints of, either from nature or from a supply of flat objects or drawings provided. Objects such as leaves (green or dried), feathers, flowers, drawings on clear acetate or plastic, seeds, grass, or anything flat will work for the sun print.

The preparation of the sun print should be done in full shade if possible. Objects should be arranged and placed on the board with the glass holding the arrangement in place. It is best to demonstrate the process once before any of the students make their own sun print. This will help the students realize the size that their finished picture will be and just how the process works to produce their finished sun picture.

It should be explained to students that there should only be one exposed paper placed into each jar at a time, and only as many students as there are jars will have a paper at any one time. It is best for the facilitator to manage the paper distribution as when the paper is removed from the light tight container, the objects must be quickly arranged on the paper and covered with the glass. If it takes too long to arrange the objects the final result will be a very faded print, and an unhappy student.

When the objects are arranged on top of the yellow side of the sun printing paper, and the glass put in place, the student can carefully carry the glass and board into the full sun. Care should be taken so that the student does not have their fingers or shadows from their body or other objects over the sun print paper. It is often helpful to place the glass on the paper at an angle thus forming a diamond over the paper. The student can tan hold the glass down on the corners not over the sun print paper.

After the sun has changed the visible portion of the paper to completely white (no yellow visible) the sun print should be taken back to a shaded spot and the paper removed from the board and glass. The paper can then be rolled and quickly placed into the ammonia developing jar. The rocks in the bottom of the jar keep the paper out of the liquid ammonia and allow just the fumes to develop the paper. The jar should **not** be shaken while developing the paper as it will splatter liquid and ruin the print.

- ❖ **Warning** –the ammonia has very strong fumes that can irritate or damage nasal and eye tissue so students should be warned not to smell or get their face near the mouth of the jar. The fumes will not hurt hands, but may burn a bit if someone has a cut or sore on their hand. An adult teacher or chaperone should always help younger children if possible.

After several seconds of developing, the paper will turn dark blue where the yellow was covered by the object being copied. If any yellow or green remains on the paper the developing process must continue until everything is totally blue.

Evaluation:
The quality and clarity of the final sun print will evaluate the success of the sun printing process. If the image is faint or too light it was exposed to too much light prior to covering by the object or moving the paper from the glass and board to the developing jar. If the image is blurred or doubled, the objects were moved during exposure (this sometimes gives an unplanned but interesting effect).

Additional resources:
Materials can be purchased from a blue print or engineer supply company. Diazo Products Company manufactures the blueprint paper and the commercial grade ammonia. The ammonia is called Ammonium Hydroxide and is Baume concentrated at 25.5%. If the commercial ammonia is too strong it can be diluted with water. Household ammonia from a grocery store can be used, but the developing time may take several minutes, depending on the ammonia strength and air temperature.

Possible sources for materials are:

- Tri State Blueprint Company in Dubuque, Iowa
- Rapids Reproductions, Inc. in Cedar Rapids 1((800) 383-1223
- Action Reprographics in Des Moines, Iowa 1(515) 288-2146
- Technigraphics, Inc. Iowa City, Iowa
- Any firm selling blueprint or engineering supplies

Additional sun printing equipment can be made:

- Clipboards make a good base or 1/8" hardboard or masonite can be cut 10" X 12" at a lumber company
- Double weight glass can be cut to 6" X 6" pieces and sanded or smoothed on all sides at a glass, hardware, or lumber company (make sure they are able to smooth the sharp glass edges) or this can be done on a belt sander or by hand with emery cloth.
- Ammonia jars can acquired from school food service cafeterias, restaurants, or home supply stores

Extensions:
Nature collage of objects collected such as leaves and feathers. Prints made from old photographs to make a cyanograph photograph. Copy of drawings made on clear acetate to show how architectural or engineering blueprints were made.

There is a similar process that can be done on cloth to make sun printed T shirts, wall hangings or quilt squares.

A collection of various leaf shapes from various tree species can be made for leaf identification

Credits:
Mark D. Wagner, Iowa State University Extension, Director of Education for the National Mississippi River Museum & Aquarium

Outdoor Biology Instructional Strategies (OBIS)