Simulating A New Hampshire River Ecosystem

A RESOURCE GUIDE

CAITLIN JULIAN

I would like to deeply thank Beth Reinhart and Melissa Chapman for the inspiration and guidance they have given me. This project would not have been possible without their support.

Written by Caitlin Julian (2001)

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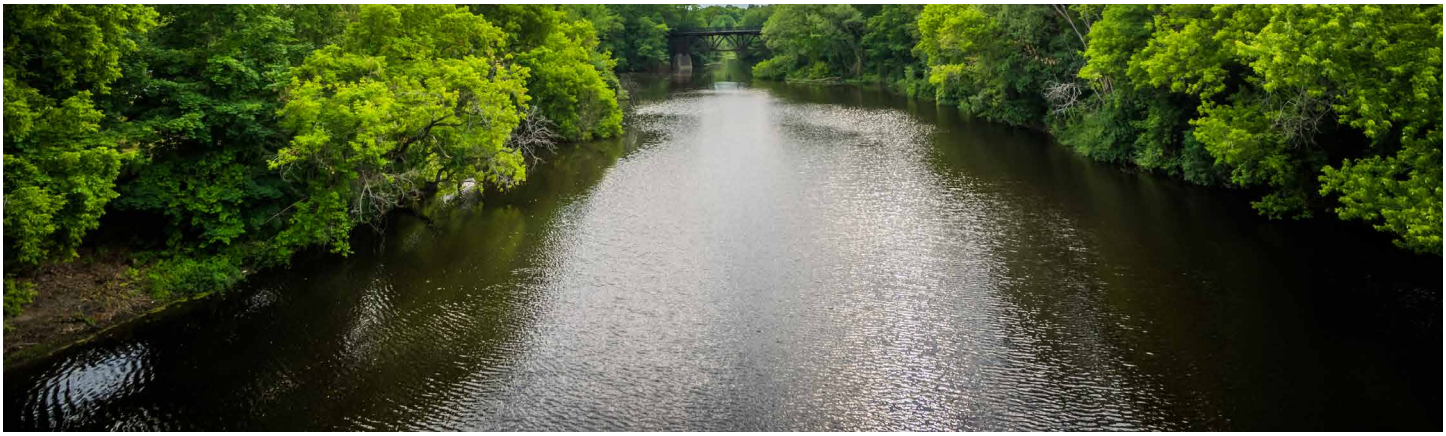


Simulating a New Hampshire River Ecosystem

PROGRAM OBJECTIVES

The 'Simulating a New Hampshire River Ecosystem" is part of the NHF&G Watershed Education Program: http://www.wildlife.state.nh.us/education/watershed.html and this manual is in Section 7 in the New Hampshire Fish and Game Department Watershed Education Program Teacher Manual. For more information about the complete watershed education experience, view the DVD "Living Like a Warm Water Fish": http://youtu.be/okUIkEnvHgI. Contact Judy Tumosa, Watershed Specialist at NH Fish and Game to participate in the watershed program: judy.l.tumosa@wildlife.nh.gov.

The objective of Simulating a New Hampshire River Ecosystem is to observe and learn about how warm water fish species behave and interact with each other and their surrounding environment. By providing and maintaining a healthy and effective aquarium, this goal can be attained.

Effectively simulating a lotic environment (moving water as in a river or stream) in a lab requires a complete replication of the natural river habitat inside the aquarium. The aquarium will need to provide a water circulation system that will:

- simulate the natural current found in the river environment.
- maintain the water quality with proper filtration.
- provide a natural substrate that provides ample hiding places for the fish
- provide and maintain healthy water.
- provide sufficient space for the organisms to prevent overcrowding that causes stress and increases susceptibility to disease.

Please note that if you want the aquarium to support a truly fluvial dependent species (one that needs flowing water for all or part of its life cycle), then the water circulation system (page 7) needs to be constructed. If the aquarium is to support a macrohabitat generalist (one that can survive in a ponded environment), then a basic aquarium set up as described in this manual without the water circulation system is adequate. For complete New Hampshire fish habitat descriptions, consult: http://www.wildlife.state.nh.us/fishing/species.html.

Complete List of Materials

From a pet store or aquarium catalogue, prices vary:

- Aquarium - 55 gallon, with cover and light
- Canister Filter (sized for the tank) Fluval 206
- Powerhead
- 2 Pond Sponge Filters
- Medium sized gravel or sand
- Plants (plastic or real)
- Aquarium nets, algae scraper
- Water quality testing kits for the tank: pH, Ammonia, Nitrite
- Chemicals to de-chlorinate tap water, if used
- Tank Thermometer

From the river or stream, if creating a natural environment:

- Water, rocks, plants, fish

From a hardware store or home tool kit:

- 3/4" diameter PVC piping, two 10' lengths
- 3/4" diameter PVC elbows (4)
- 3/4" diameter PVC caps (2)
- 1" diameter clear plastic flexible tubing – 12" (Plumbing section)
- Pipe Cleaner Fluid
- Solvent cement
- Hacksaw – to cut PVC
- Drill – to drill holes for intake pipe
- Sandpaper / File – to sand down rough edges of PVC
- Shears – to cut tubing
- Hairdryer / Hot Water – to fit tubing to pipes and powerheads
- Measuring Tape and Pencil
- Extension cords
- Cleaning Brushes and Marked Pitcher

Choosing the Aquarium

To begin construction of a lotic habitat in an aquarium requires purchasing several pieces of equipment (see Complete List of Materials). The first piece that will be needed is an aquarium, glass is suggested. The actual size depends on the space available in the classroom and the amount of fish that will be occupying it. For my simulation, I began with a fifty-five gallon tank with the dimensions of 48" x 13" x 20". This is a good size that will effectively support a small community of fish. The rule of thumb is for every inch of fish, you need to provide one gallon of water.

The new aquarium should be rinsed out, but it is very important that no soap is used on any part of the aquarium system because soap is toxic to the fish. Plan to place the tank in the classroom where it will receive a few hours of sunlight each day, but not be constantly exposed to the sun.

The Water Circulation System – *Purpose and Materials*

The water circulation system provides a current in the aquarium. Two powerheads will push out water into the tank, and two cylindrical pond sponges will filter out any silt from entering the powerheads; the powerheads and pond sponge filters need to be purchased. The piping system will recycle the water back into the powerheads and needs to be constructed (see instructions below). You can also buy a complete system from a catalog or pet store that will serve the same purpose, but building this system is simple and more cost-efficient.

Note: For my system, I ordered the filter, powerheads (Aquaclear 402) and sponges through the Doctors Foster and Smith Aquarium Supplies catalogue (*www.DrsFoster-Smith.com*) but you may choose your own source.

The Water Circulation System – *Piping System Construction*

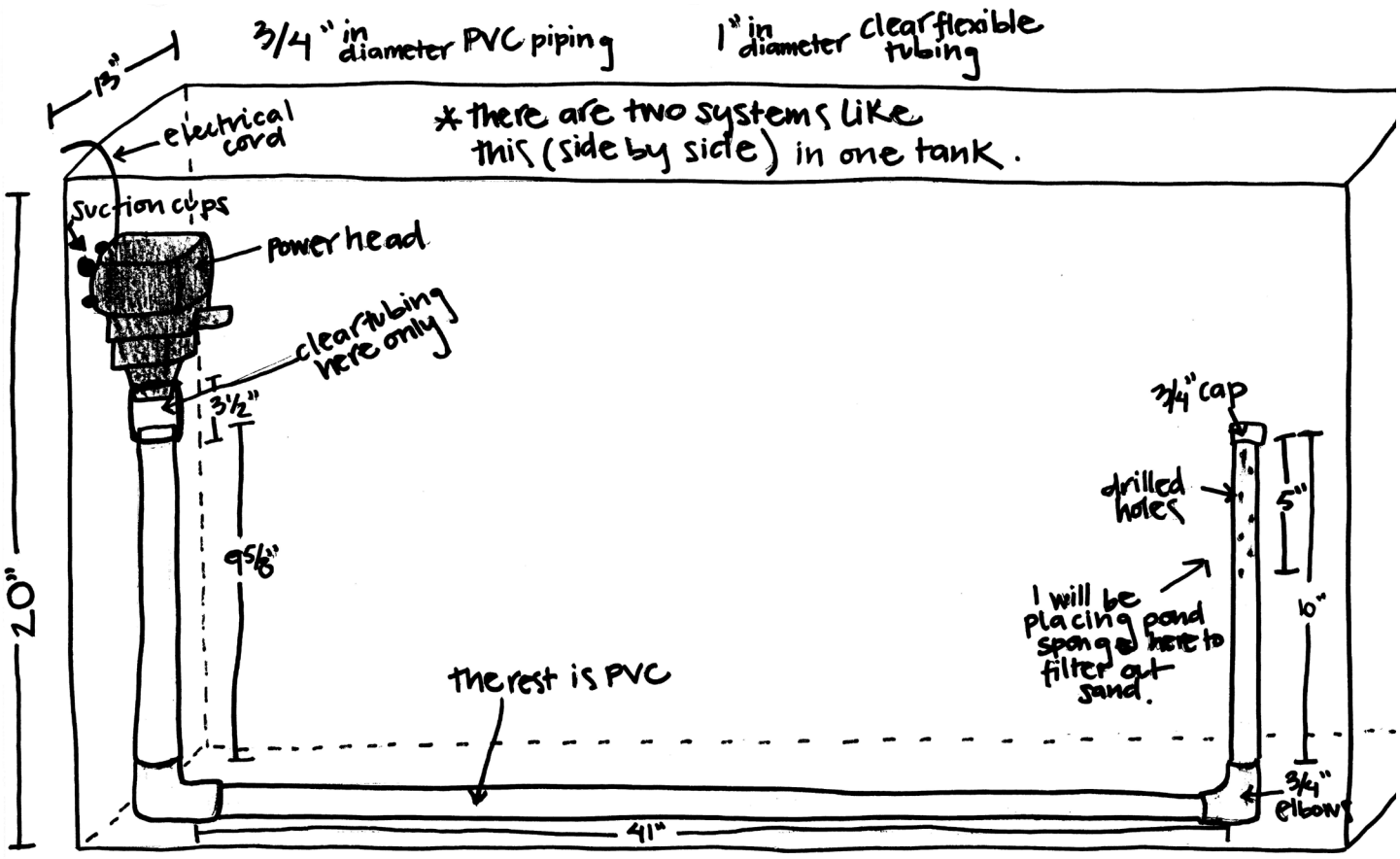
Time to collect materials and build: 2 ½ hours

Materials:

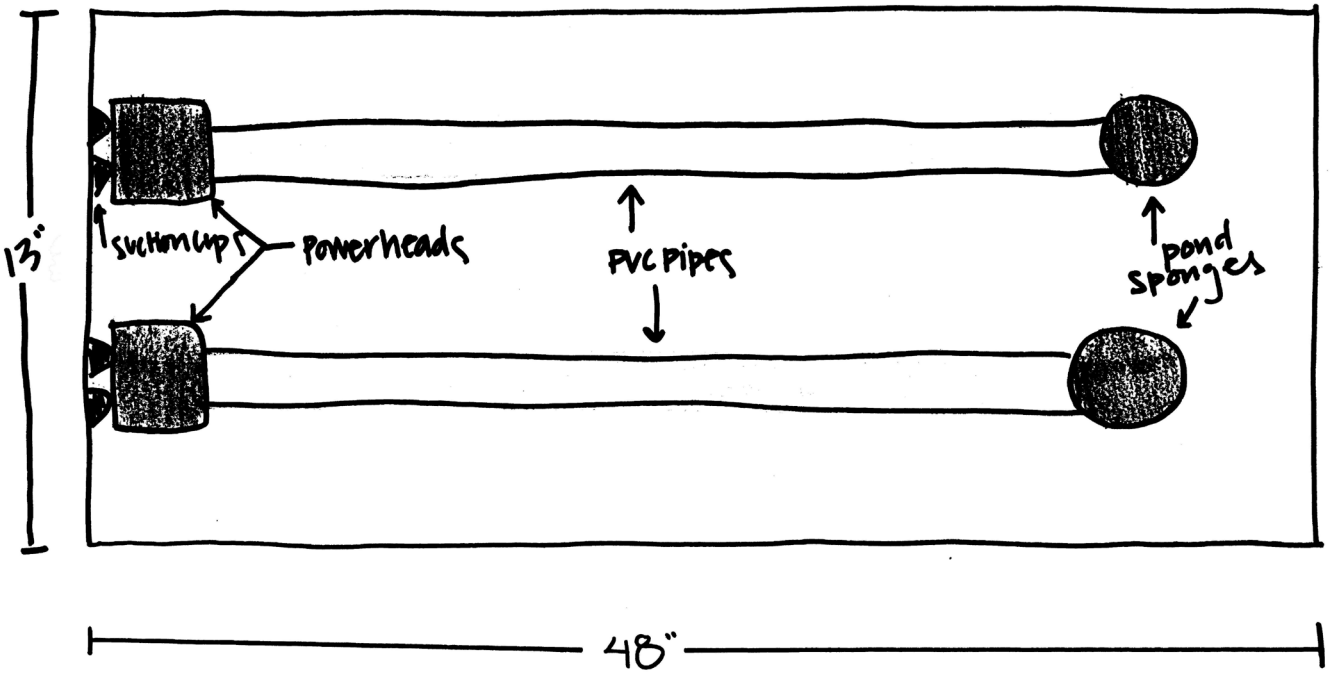
- 3/4” diameter PVC piping – bought two 10ft lengths
- 3/4” diameter PVC elbows – bought four
- 3/4” diameter PVC caps – bought two
- 1” diameter clear plastic flexible tubing – bought 12”
- pipe cleaner fluid
- solvent cement
- hacksaw – to cut PVC
- drill – to drill holes for intake pipe
- sandpaper / file – to sand down rough edges of PVC
- shears – to cut tubing
- hairdryer/hot water – to fit tubing to pipes & powerheads
- measuring tape
- pencil

Procedure: Refer to the diagrams for detail about placement and dimensions inside the aquarium. Make sure the work area is big enough and is well ventilated.

- Before starting, please read through the entire instruction manual that comes with the powerhead. Decide where to mount the two powerheads in the tank. The powerheads can be fully submerged in water or partly submerged to assure a strong current in the aquarium. As shown in the diagram, I attached mine with the suction cup attachments slightly below the water level.
- Placing the powerheads first helped me figure out how long the pieces of PVC piping needed to be. I used PVC because it is easy to work with, affordable and durable.
- For this circulation system, I attached three pieces of PVC pipe that take in water from one side of the tank and bring it across the bottom of the tank to the intake of the powerhead. The pipe on the far end was capped and had holes in it to allow water to enter the pipes. Please refer to the side view diagram of this.
- After the powerheads are placed on the side of the tank, the clear plastic flexible tubing will have to be cut and used to create a tight seal between the intake on the powerhead and the end of the PVC pipe. Cut 31/2” of this tubing with a pair of shears.
- To fit the tubing over both the intake openings in the powerheads and the end of the piping, use a hairdryer or hot water to heat the tubing. The heat makes the tubing more pliable, and when it cools, there will be a tight seal.
- Next, measure and calculate the PVC length required to fit inside the aquarium. The bottom pipe should not rest completely on the bottom of the tank because it might rattle and make too much noise. When cutting the lengths of the pipes, consider the amount of substrate that will be in the tank. Make sure the two end pieces are tall enough to stick out of the gravel.
- Six pieces of PVC will need to be cut, three for each powerhead system (please refer to the diagram for the dimensions of these pieces). PVC cuts very nicely with a hacksaw. Just mark it with a pencil and saw it off.
- After cutting the PVC, the rough edges need to be to filed and sanded. This will aid in the gluing process. Regular sandpaper or a file work fine.
- Make sure all the pieces fit together and that they fit the tank before gluing them. Lay out all the pieces in the order in which they should be glued. Clean each connection before applying the glue. The glue hardens very quickly, so work fast.
- The next step is to drill 3/16” holes into the two intake pieces (see diagram). Drill random holes around the pipe. About 18 to 20 holes in a 3/4” PVC pipe is sufficient.
- Finally, place the entire system inside the aquarium and cover the intake ends with the pond sponge filters.



- SIDE VIEW -



- TOP VIEW -

Installation of the Filtration System

The filter is a vital component of the aquarium. It will provide optimum aquarium filtration by breaking down and removing waste and organic toxins, such as ammonia and nitrite that are deadly to the fish. The canister model filter is very self sufficient, which cuts down on maintenance. I used a Fluval 206 model canister filter, which is an adequate size filter for a fifty-five gallon tank. This model contains both a mechanical and biological filter.

The installation of the filter in the aquarium is fairly simple and not time consuming. Again, read the entire manual before attempting to assemble anything. The manual will give clear assembly instructions of all pieces as well as diagrams to aid the assembly process. The manual will also detail the steps for starting up the equipment and maintaining the filter. It is important that the filter is properly set up and maintained because it is a major factor of the survival of the fish and the entire habitat in the aquarium.

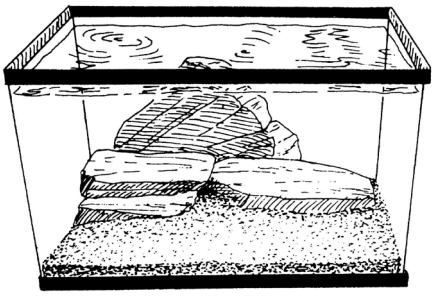
Substrate

It is important that this aquarium imitate the natural environment as closely as possible. This will allow the fish to feel at home in this new enclosed environment and will allow for more accurate observations of natural behavior and interaction of these species. Substrate can be bought from pet stores, landscaping suppliers or actually collected from the river or pond. Collecting substrate ensures a more natural looking habitat for the aquarium.

There are several layers of substrate that will be needed in the aquarium. The first layer is sand. It can be purchased from a landscaping supplier. The sand will protect the glass bottom of the aquarium from the rocks and gravel that will lie on top of it. Make sure the sand is not mixed with anything that could be harmful to the fish, such as road sand which could contain salt. Before layering the sand in the tank, it would be a good idea to rinse it off with water. Remember, do not use soap to rinse materials because it is lethal to the fish. Enough sand should be put into the tank to partially cover the bottom pipes.

The next layer should consist of medium to coarse gravel. The gravel should be a tan or gray color so it can replicate the substrate that would be found in a riverbed. The gravel can be purchased from a landscaping supplier. It is suggested that gravel not be taken from the actual site so as not to disturb the ecosystem and dynamics of that site. The gravel should also be rinsed before it is placed in the tank. Only two to three inches of gravel will be needed inside the aquarium and it should be placed so that it slopes upward towards the back of the tank. This will help to simplify waste removal and allow plants to grow in the back. Try to make the gravel imitate the actual riverbed.

Use larger stones, pieces of wood, natural materials or plants for the next layer of substrate. This will create a more natural habitat. The purpose of the stones and the other objects is to provide places for the fish to hide and feel comfortable in their new surroundings. These objects can be collected from the river test site and be used in the aquarium. Different objects can be used in tanks for different species. At left is a diagram of three different tank set ups that are commonly used. A good rule of thumb when placing these objects is to place the taller objects towards the back and provide open swimming area near the front of the tank.



Surround the back and sides of the aquarium with dark paper to create a more lifelike habitat and to provide more cover for the fish. Obtain an aquarium hood for the top to keep objects from falling into the tank and the fish from jumping out, especially Eastern chain pickerel.

Water

The aquarium will serve as a temporary home for much aquatic life. It is vital that the water filling the aquarium not be detrimental to the species that inhabit the tank. The ideal solution would be to collect water from the fish collection site. River water is great because it comes with all sorts of organisms that help to further imitate the river habitat and it helps jump start the bacterial function in the filter. It necessitates more cleaning, but it requires less preparatory work than a municipal water source. If tap water is used, be aware it may contain a disinfectant such as chlorine or chloramine. Chlorine will dissipate naturally in 2-3 days but chloramine must be neutralized using a product from the pet store. Chemicals like chlorine could be harmful to the fish.

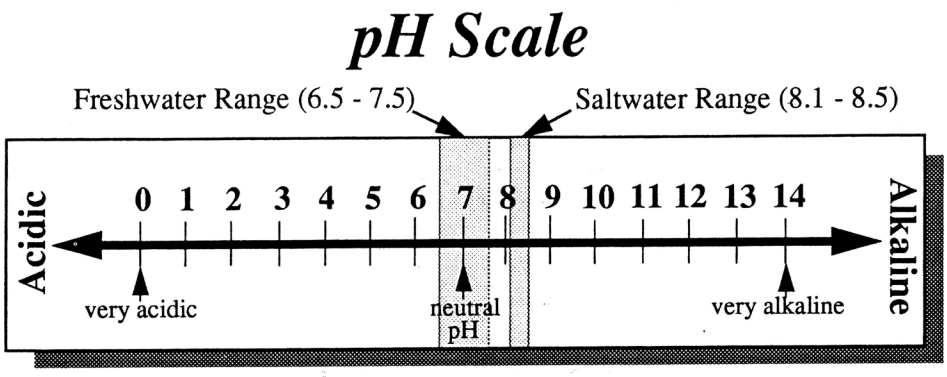
Starting up the Aquarium

Now that the water circulation and filtration systems, substrate and water are in place, it is time to start up the aquarium. Please refer to the instruction manuals for both the powerheads and the filter to see how to start each piece of equipment. Refer to the manuals or call the place where they were purchased if there are any problems with starting up the equipment. The aquarium should run about six to ten days before the fish are introduced. This allows time to observe any operational problems with the filter or other systems and also allows time for the tank to develop a healthy bacteria culture before fish are introduced.

Maintenance of the Aquarium

All aquarium owners should be familiar with the procedures involved in making sure that the water in the aquarium is in good condition. The health of the inhabitants of the aquarium depends on the water quality. Conditions, such as pH, ammonia, nitrites, nitrates, aeration, temperature, lighting, pollution, feeding and overcrowding need to be monitored closely in the tank. Daily checks should include fish count, fish behavior and signs of any disease. Other conditions such as temperature, equipment checks, the pH level and ammonia level should be checked on a weekly basis. Water changes, cleaning of the aquarium and filter and other water chemistry tests should be checked monthly.

Activity	Daily	Weekly	Montly
Visual Check of fish for headcount, disease, swimming and breathing rates	✓		
Check color, smell and temperature of water		✓	
Visual check of equipment, air, and water flow		✓	
Scrape algae growth on glass			✓
Check and prune plants			✓
Rake and siphon debris from gravel bottom			✓
Make a 25% water change (every 2 to 4 weeks)			✓
Change air and water filters			✓
Test water chemistry			✓



Weekly Maintenance

Ammonia

Ammonia, a compound of nitrogen and hydrogen, is produced by decomposition of uneaten food and also by fish waste. It is very toxic to fish; therefore, it should be one of the main pollutants to monitor. If a tank has proper filtration, has regular water changes and is not overstocked with fish that are overfed, then ammonia should not be a problem. The ammonia level should be zero in a healthy tank. Use an ammonia kit to test the amount present in the aquarium.

Temperature

The temperature of the water should be checked every week in the aquarium. If the water is too hot or cold the fish could suffer. Most freshwater species of fish should be comfortable in water that is at room temperature.

Equipment Check

Check to make sure the filter and the powerheads are functioning correctly in the tank. This equipment is vital to the survival of the entire ecosystem in the aquarium so it is important that it is functioning properly. If there are any problems, please refer to the manual or other trouble-shooting references.

The pH level

pH is a measurement of acidity and alkalinity in the tank. The pH range for a healthy freshwater river environment should be between 6.5 and 7.5 on the pH scale. Remember different fish might require different levels of pH, so make sure you know what your organisms require. Use a pH kit that can be bought at a pet store to determine the pH in your classroom aquarium.

Monthly Maintenance

Nitrite

Nitrite, another nitrogen compound, is not as toxic to fish as ammonia, but at high levels can be harmful. This should be tested monthly, but especially when new fish are added to the aquarium. Ideal levels should be below one part-per-million, and these can be measured with a nitrite kit.

Nitrate and Monthly Water Changes

Nitrate is the least toxic nitrogen compound to fish. Fish can withstand relatively high levels with no apparent effects. Regular water changes will help to prevent the nitrate levels from becoming too high. A 25% water change should occur every month. Use a bucket with gallon graduations to make the removal and refill of water consistent. Again, make sure the water has no soap or other pollutants in it before putting it into the aquarium.

Light

A basic problem concerning light is providing a realistic day/night cycle for the animals. To reduce stress, most animals require an orderly alternation of dark and light, which gives them alternate periods of activity and rest.

Cleaning

Each month the filter, powerheads, gravel and aquarium glass will need to be cleaned. Algae growth is a sign that the aquarium is healthy, but it does need to be scraped off the sides and the gravel needs to be raked. The filter sponge and the pond sponges should be cleaned and the biological filters that are inside the filter need to be replaced. This will assure a healthy environment for the entire habitat.

Accessories for Maintenance

Algae Scraper (with sponge or razor blade) can be used to clean off the algae that grows on the sides of the tank.

Hand Nets can be used to catch fish or other organisms in the aquarium.

Cleaning Brushes will help to clean the equipment that is inside the tank as well as the inside of the filter.

Marked Pitcher will be useful for water changes and will make sure the same amount of water goes in that comes out. Remember when you are changing water, to decontaminate the water and the pitcher before using it.

References for Construction and Maintenance

There are many references available that contain information about each part in the construction and maintenance of a freshwater aquarium. This includes both great online references and excellent books and literature. Be careful when looking for information on constructing a freshwater aquarium. A lot of the information pertains to tropical and exotic fish rather than our freshwater New Hampshire species. I found Our Native Fishes, a book by John R. Quinn, to be an excellent resource for constructing and maintaining a freshwater aquarium for native species. It also includes details about catching the fishes and detailed descriptions of the specific types of fish native to the United States. I highly recommend finding this book before you begin. The second book that was helpful to solve aquarium problems is The Complete Aquarium Problem Solver: A Total Trouble-Shooting Guide for Freshwater and Marine Aquariums by Kevin W. Boyd. This includes a detailed description of common problems that could occur, including fish diseases and a solution to the problem. These two references along with many others I have listed in the reference section of this guide can be very helpful to the construction, maintenance and success of this project.

Stocking the Aquarium with Freshwater Fish

The NH Fish and Game Department is very supportive of bringing aquatic resource education into the classroom through their Watershed Education Program. The Watershed Education Specialist can provide answers and information concerning the river environment and its natural organisms.

This project focuses on the aspects of aquatic resource management integrated with studies of freshwater fish species of New Hampshire and their natural habitat in both a field and a lab situation. Since the aquarium will be representing the natural habitat, it would be ideal if the fish could be collected from the same river site that the students monitor. It would complete the idea of bringing the actual test site into a lab situation.

In order to keep fish in the classroom:

- You must fill out a "Scientific License Application to Keep Warm Water Fish in the Classroom" (page 13).
- The Inland Fisheries Division will send you a "Scientific License" to collect and keep fish in an aquarium in your classroom (page 14). NH Fish and Game has advanced information and equipment. They are very knowledgeable, friendly and informative and can provide assistance with every piece of this project.
- New teachers are required to attend "Simulating a New Hampshire River Ecosystem" training provided by NH Fish and Game (sample agenda, page 15).

There are many ways to go about collecting freshwater fish species, some being less stressful to the fish than others. The objective of collecting and introducing the fish to a new environment is to cause as little stress as possible. For that reason, hooking fish, although effective, is probably not the best collection method. Less stressful ways to collect fish are using seine nets, dip nets and assorted fish traps that do not harm the fish. You cannot collect endangered species. For those reasons, check with the state's Fish and Game Department before the collecting trip takes place.

Remember that an overcrowded tank can end up causing problems for the whole habitat, so do not bring back too many fish. A good rule of thumb is to stock 1" of fish for every gallon of water and keep the size of the fish small. It is necessary to acclimate the fish between the collection point and the aquarium. Such a change of habitats is a big shock to the species and if not properly acclimatized, the fish will suffer from too much stress and could possibly die. The fish can be transported to the classroom in unlined styrofoam coolers. Styrofoam allows the water to exchange gasses, while plastic does not. Once the fishes are brought to the classroom, it is a good idea to hold the fish in these coolers until the water temperature reaches the temperature of the aquarium. It is also important to keep some form of oxygen in these coolers while the fish are acclimatizing. A bubbler, which forces oxygen from the air to mix with the water, can provide the needed oxygen to the fishes. Once the temperature has equalized within 10 degrees F, the fish can be introduced to their new, temporary home.

Scientific License Application to Keep Warm Water Fish in the Classroom

Note: Only warm water fish species and minnows may be kept (no salmon or trout).

Date: _____ School Year: _____

Teacher Name: _____

Teacher Email: _____

School Name: _____

School Address: _____

School Telephone Number:_____

Date of Collection: _____

Collection sites, Please Put Specific Name of River or Pond: _____

_____

_____

Method of Collection: _____

_____

_____

Subpermittees i.e. Other Teachers or Adults Assisting with collection of fish (if any): _____

_____

_____ Will attend training "Simulating a New Hampshire River Ecosystem"

_____ Has attended training "Simulating a New Hampshire River Ecosystem"

Return to: **Judy Tumosa, Watershed Education Specialist**
New Hampshire Fish and Game Department
11 Hazen Drive, Concord, NH 03301
(603)271-0456 • FAX (603)271-0465
judy.l.tumosa@wildlife.nh.gov

New Hampshire
Fish and Game Department

HEADQUARTERS: 11 Hazen Drive, Concord, NH 03301-6500
(603) 271-3421
FAX (603) 271-1438

www.WildNH.com
e-mail: info@wildlife.nh.gov
TDD Access: Relay NH 1-800-735-2964

SCIENTIFIC LICENSE #F2015-01

September 22, 2015

TO WHOM IT MAY CONCERN:

Under the authority contained in RSA 214:29, permission is hereby granted to Joe Teacher, Pillsbury Crest Elementary School, 193 Raisin Street, Wonderland, NH 03XXX, Tel. 603-555-5555 to collect various species of freshwater fish as part of an aquatic studies curriculum. Permission is also granted to transport captured specimens alive to Pillsbury Crest Elementary School to be kept in aquaria through the end of the school year.

Time of collection: September, October 2015

Collection sites: Lake Doughboy – south end near Pluto's Cove

Target species: Warmwater fish species and minnows. Not more than 10 individuals of each species. No collection of banded sunfish (Enneacanthus obesus) or bridle shiners (Notropis bifrenatus) is allowed.

Method of collection: Minnow traps, angling, seining

Final disposition of specimens collected: All fish will be returned to the water unharmed at the site of collection shortly after capture or after classroom studies are completed.

Subpermittees: Jeff Raspberry, Joan Strawberry

This permit, or a copy, shall be carried with the permittees while engaged in any activity allowed under this permit and shall be displayed to any New Hampshire Fish and Game Department Conservation Officer or employee upon request.

This permit shall expire at the end of the school year 2015-16, unless sooner revoked or rescinded.

_____

Glenn Normandeau
Executive Director

GN/srd

cc: Law Enforcement Division
Inland Fisheries Division
Judy Tumosa

Sample Simulating a NH River Ecosystem Agenda

Registration and Welcome

What is a warm water fish? “New Hampshire Fish” Power point
Activity: Am I warm or cold? Photos and “Freshwater Fishes of NH”

Why do fish live where they live?
Activity: Does your fish live there? Bathymetric map of local pond

What is in our watershed and why do we care?
Activity: GIS map exercise and watershed review

Break

How do we set up a river ecosystem tank in the classroom?
“Simulating a NH River Ecosystem” Power point

WQ and macro testing for habitat quality; ArcGIS fisheries data sets

What challenges do warm water fish face in the winter? Limiting season
Activity: “Fishy Deep Freeze” in Below Zero

Questions and wrap up

Contact:
Judy Tumosa, NHF&G Watershed Education Specialist
Phone: (603)271-0456
judy.l.tumosa@wildlife.nh.gov

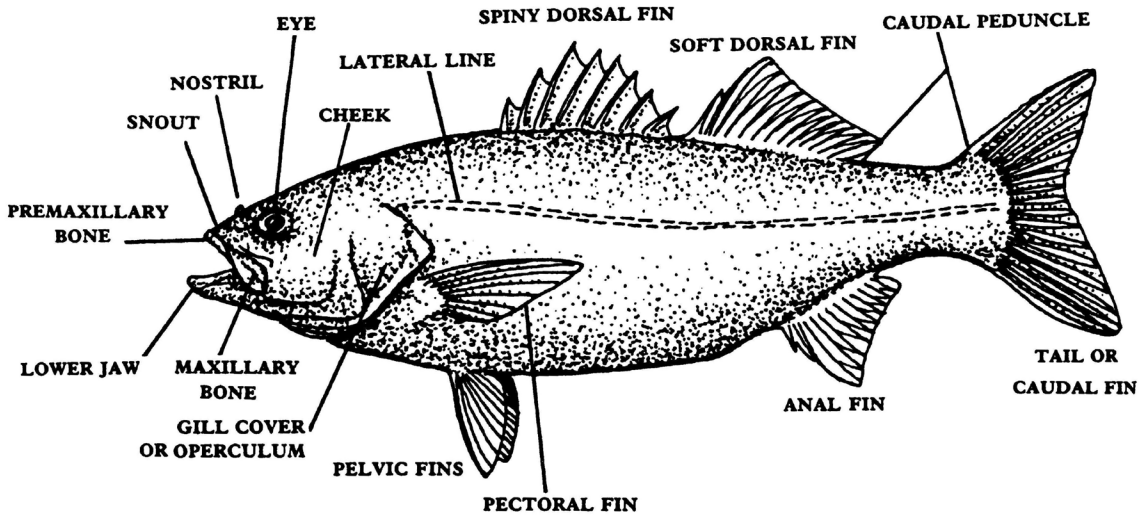
The Freshwater Fish

Background

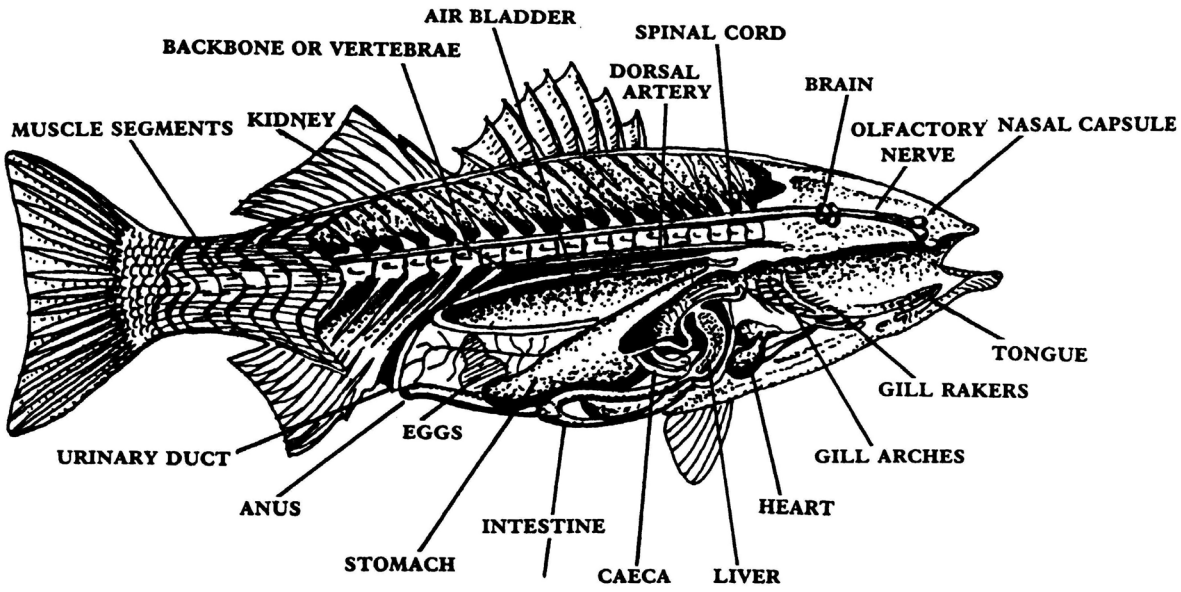
Fish are the world's most numerous and diverse vertebrate animals. Thriving for millions of centuries on this earth, fish made their first appearance in the Cambrian period, about 550 million years ago. The first species of fish lacked jaws and paired fins. They did not develop until the Devonian period or "The Age of Fishes", about 400 million years ago. The material that makes up their skeletons classifies fish. Sharks, skates and rays belong to a group called cartilaginous fish because their skeletons are composed entirely of cartilage. Fish that are native to area freshwater streams and rivers, are called bony fish (scientific name Osteichthyes) because they have skeletons made of bone. These bony fish, which are predominant in freshwater ecosystems, did not evolve until some 200 million years after the Devonian period. Today scientists have identified over 32,000 different species of fish living worldwide. One third of these fish thrive in freshwater environments. It is important that we study, observe and learn about these amazing aquatic creatures.

Anatomy and Physical Features of A Bony Fish

Physical Features of a Bony Fish



Anatomy of a Bony Fish



Shape

The shape of a fish's body tells a lot about its lifestyle. There are six basic types of body shapes of freshwater fishes: fusiform, ovate, elongate, laterally compressed, depressed and hemispherical. All of these body shapes suit the fishes' different niches and habitats. Fish with fusiform, meaning streamlined, bodies are fast swimming predators able to constantly swim at high speeds. Ovate and elongate bodies are less streamlined, slowing the fish's ability for speed underwater. Fish with laterally compressed bodies, which are flattened from side to side, are adapted to swimming in cracks and crevices of rocks. A hemispherical body is more rounded than the compressed body and a fish with a depressed body shape is a fish that is flattened from top to bottom. Fish with this body shape spend most of their time at the bottom.

Skin

The skin of most bony fish is covered with bony scales. Fish scales are waterproof and help protect the fish, but still allow it to be flexible and streamlined underwater. The fish's skin secretes a layer of mucus that covers the entire body. This helps the fish to slip through the water more easily and protect the fish from infection. Handling a fish can remove this protective mucus coating, so it is important to always handle fish with wet hands. The coloration of the fish is also used to its benefit. Most fish are bi-colored, meaning their dorsal side is dark and their ventral side is light. Fish use this as camouflage. When seen from above, they blend in with the depths of the bottom, and when seen from below, their light bellies blend with the sky above. Color is also used as a defense mechanism. The bright colors of the fish warn other organisms to stay away.

Fins

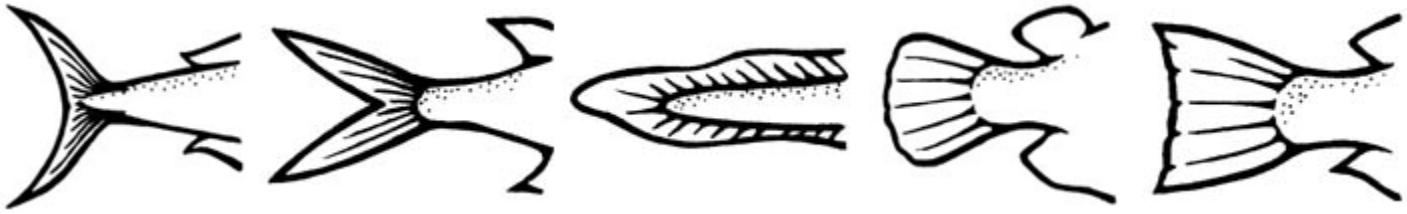
Each part of the fish's body is adapted to living underwater. A fish must have the ability to swim in its aquatic home and it does so by flexing its body and tail back and forth. Most of the fish's body consists of muscle. It expands and contracts the muscles simultaneously on each side of the body to propel itself forward through the water. The paired and unpaired fins aid in this process of locomotion by propelling, steering or balancing the fish.

Fins are made of thin membrane stretched between cartilage spines. The paired fins consist of the pectoral and pelvic fins. The unpaired fins are the dorsal, caudal and anal fins. The shape, location and size of a fish's fins are closely linked with its way of life. The paired pectoral fins are usually responsible for turning, although they can be used for other functions such as tasting, touching, support and as a source of power for swimming. The pelvic fins and the anal fin add stability to the fish's body and are sometimes used for slowing. The dorsal fin on bony fishes may be a single fin or be separated into several fins. It is mostly used for sudden direction changes and acts as a keel to keep the fish stable in the water. The caudal or tail fin is responsible for most of the propulsion in bony fishes. The specific shapes of the caudal fin indicate the rate at which the fish can swim.

The caudal fins of bony fishes are broken up into five separate shapes. Each of these shapes have evolved to fit different lifestyles and can indicate the different swimming rates of fishes. A caudal fin can be lunate, forked, continuous, rounded, or truncated. Fishes with lunate tails tend to be the fastest swimmers and can maintain a constantly rapid speed. A forked tail indicates a quick swimmer that is always on the move.

The deeper the fork, the faster the fish can swim. Fish with a rounded or truncate tail are generally slow moving, but are strong swimmers. A continuous tail, meaning the dorsal and anal fins are connected, indicates that the fish can swim in and around cracks. An example of a fish with this type of tail would be an eel.

In addition to swimming and movement, fish must develop a mechanism for neutral buoyancy. Neutral buoyancy is the ability to remain motionless in the water without rising or sinking. This is of great importance to a fish because it conserves energy, energy better spent feeding, escaping preda-



LUNATE FORKED CONTINUOUS ROUNDED TRUNCATE

tors or mating. Several strategies help achieve neutral buoyancy. Most bony fish have a structure called a swim bladder, which is a balloon-like organ that automatically controls the amount of buoyancy. Gases from the blood are also added or removed to control buoyancy at different depths.

Food and the Digestive System

Bony fishes have a diverse range of food preferences. They fill the niches of herbivores, carnivores, omnivores and detritivores. A normal diet consists of, but is not limited to, worms, snails, mussels, clams, crustaceans, insects, birds, amphibians, small mammals and other fishes. The digestion of these meals begins in the mouth. The shape, size and position of a fish's mouth gives a general indication of where it feeds and what it eats. Fishes with dorsal mouths or up pointing mouths primarily feed on the food that is found near the water surface. Some fish with mouths on the underside or ventral side of their body are bottom feeders. Large mouths indicate that the species is a predator because this mouth is designed for eating whole fishes or large chunks of fish. A small sized mouth would suggest that the species often nibbles on plants or eats small animals. The amount of food a bony fish eats is directly related to its size, its metabolic rate and the temperature of its environment.

Digestion in a fish's system begins in the mouth and moves to the esophagus. The esophagus in bony fish is short, expandable and layered with muscles so that large objects can be swallowed. Most species of bony fish have a stomach with gastric glands that release substances that break down the food to prepare it for digestion. The intestine is where the majority of food absorption takes place and the digestive system ends at the anus.

Respiration

Fish, like most organisms, need oxygen to survive. The oxygen that fish respire is dissolved in the water. Dissolved oxygen enters the water either at the surface or from aqueous plants. The respiration process of a fish begins by water entering the fish's mouth, moving across the gills and passing out the gill slits or operculum. The gills are made up of a bony arch that supports a large number of paired gill filaments. These gill filaments resemble feathery structures. The gills are the site of gas exchange between oxygen and carbon dioxide. Oxygen diffuses from the water through the filaments into the blood and carbon dioxide diffuses outward.

Senses

A bony fish's sensory system, which is perfectly adapted for underwater life, is equipped with six basic senses: sight, smell, taste, hearing, the lateral line and electroreception. Fish are visual predators, so sight is a very important feature. The structure of the fish's eye is very similar to that of other vertebrates. The eyes are well developed, allowing them to see near and distant objects. The eyes are placed on the sides of their heads, which allows them to see in all directions. This is helpful for locating prey as well as finding predators. Colorful fish can probably see in color and large eyes aid bony fish that are active at night.

The sense of smell is very important to a fish, because it helps them find their food, and warns them of danger. Fish can smell odors in the water with receptors, called nares, located on the head. Nares are similar to a human's nostrils, but fish do not use them to breathe. Their sense of smell is well developed and is useful in detecting distant odors.

Fish use their sense of taste as a close range sense. Taste buds, which can be found on the inside of the fish's mouth and on the outside of the body, are used in the identification of food. A fish's taste buds have the ability to distinguish the difference between sweet, sour, salty, and bitter.

A fish's well-developed sense of hearing is used to help locate other fishes, predators and prey. Fish have ears but they do not open to the outside and cannot be located on the exterior of the body. Water carries sound much better than air and the sound waves are picked up through the fish's body.

Fish are able to detect their location in reference to other objects by using their lateral line. The lateral line is a line of holes running along both sides of a fish from the head to the tail. The holes have nerve connections that are sensitive to vibrations and water pressure. These nerves can detect nearby fishes and obstacles without even seeing them. This is helpful to avoid objects such as rocks and detect predators that are behind the fish. The lateral line is also used in schooling to tell the fish which direction the school is going.

All living things give off weak electrical fields. A fish is able to pick up these weak signals by using electroreception. They detect these weak electrical fields through pit organs on their heads and faces. This amazing ability is used for locating prey, avoiding obstacles in murky water and in migrating.

Reproduction

In most species of bony fishes, sperm and eggs develop in separate male and female individuals with fertilization being mainly external. The males and females of a certain species may look similar, or they may look very different. Characteristics of each gender may include size, coloration, head characteristics and body shape. Reproduction in bony fishes usually follows a cycle, however, various external factors such as changes in the sunlight, temperature, moon stages and spawning areas may influence bony fish to alter their breeding habits.

Fish are R-selectors, meaning they will spend their energy laying thousands of eggs rather than spending their energy caring for a few offspring. Fish lay thousands of eggs with hopes that a few of them will survive. The number of eggs a fish will lay is related to the probability that a single egg will reach maturity and reproduce. Species, whose eggs have little chance to reach maturity, lay the most eggs. Depending on the species, fish parents may scatter, hide, guard or watch over the eggs.

Behavior

Behavior is the action of a fish in response to its environment and other animals. The most interesting and sometimes the most obvious behaviors involve interactions with other individuals. Some types of common behavior in fishes are migration, schooling, aggression, resting and communication. Many species of fish migrate during their life cycle. Fish migrate in response to changing environmental conditions, such as temperature or abundance of food. Often fish will congregate with its same species in groups called schools. A school is aligned and swims in the same direction. Sight and the lateral line are used to maintain the school.

Aggressive behavior in fish can be an interaction between two fish of the same species, called intraspecific or between different species, called interspecific. Aggressive behavior is usually associated with territory defense or during the spawning season. This behavior includes posturing, direct attacks and displays such as fin flaring and changes of color. Opposite of aggressive behavior is resting. Rest is very important to fish. They spend a good portion of their day resting. Resting reduces competition, provides protection from predators and may help in energy conservation. Communication is vital between fish. Their senses play an important part in fish communication. Visual communication is important to most fish. Body movements, postures, colors and color patterns are the primary means of visual communication. Sound is also used for communication. Grinding teeth, flexing muscles and vibrating the swim bladder produces sounds. Fish also communicate by releasing chemicals called pheromones. These are chemical signals produced by an animal that, when released, influence the behavior of others of the same species.

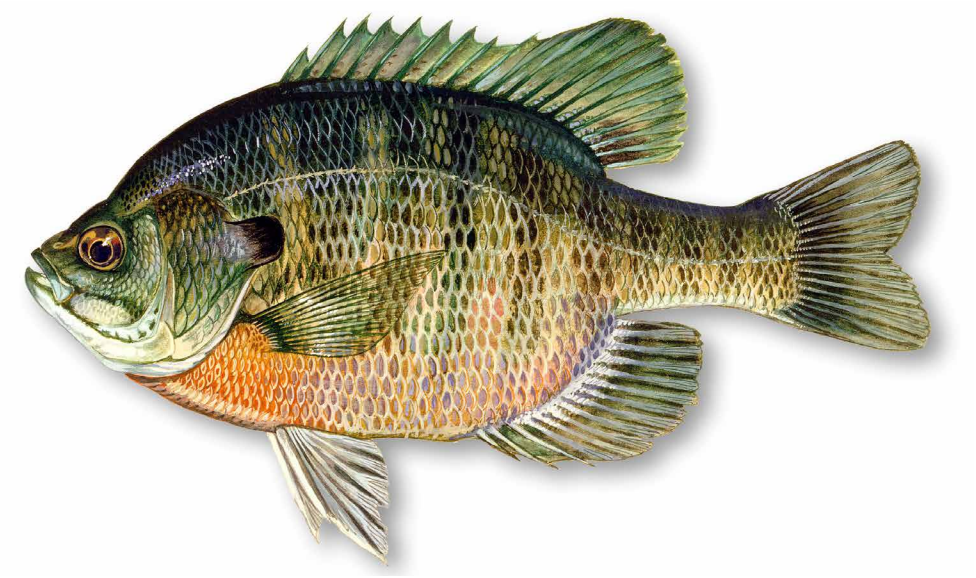
Specific Species

When the time comes to stock the aquarium with freshwater fish, it is important to know the specific information about each species that will inhabit the aquarium. Eating and behavior information of each fish species that is collected will be vital as well as any information about the interactions of certain species. You would want to know this information about a minnow and a bass before you put them in the same tank together. Field guides such as the National Audubon Society Field Guide to North American Fishes, Whales and Dolphins and Our Native Fishes and Freshwater Fishes of New Hampshire (Scarola) provide this necessary information. Fish information can also be accessed on the NH Fish and Game website: http://www.wildlife.state.nh.us/fishing/species.html, consult "At a Glance – Popular Warm Water Species" and "Resident Freshwater Species List" sections.

Fish that would be commonly collected by students in New Hampshire ponds, lakes, rivers and streams are juvenile bass, pumpkinseeds, bluegills, yellow perch, white suckers and a variety of shiners. Basic information like description, habitat, collecting methods and aquarium care for each of these freshwater species is included in the following pages in order to aid with the collection, identification and care for these fish.

BLUEGILL

Lepomis macrochirus



Description

The bluegill is one of the largest sunfishes in this family. They have been known to measure up to twelve inches and weigh up to two pounds. This sunfish has a compressed body shape and a rounded profile. Its sides, fins and dorsal area are a brassy, dark olive green, which fades into a lighter gold belly. Some specific features that make the bluegill easy to identify are the five to seven vertical bands that run down its sides. Also a dark, black spot on the tip of its operculum, which is also a bluish color and a prominent black spot on the end of the dorsal fin is apparent on young bluegill species.

Habitat

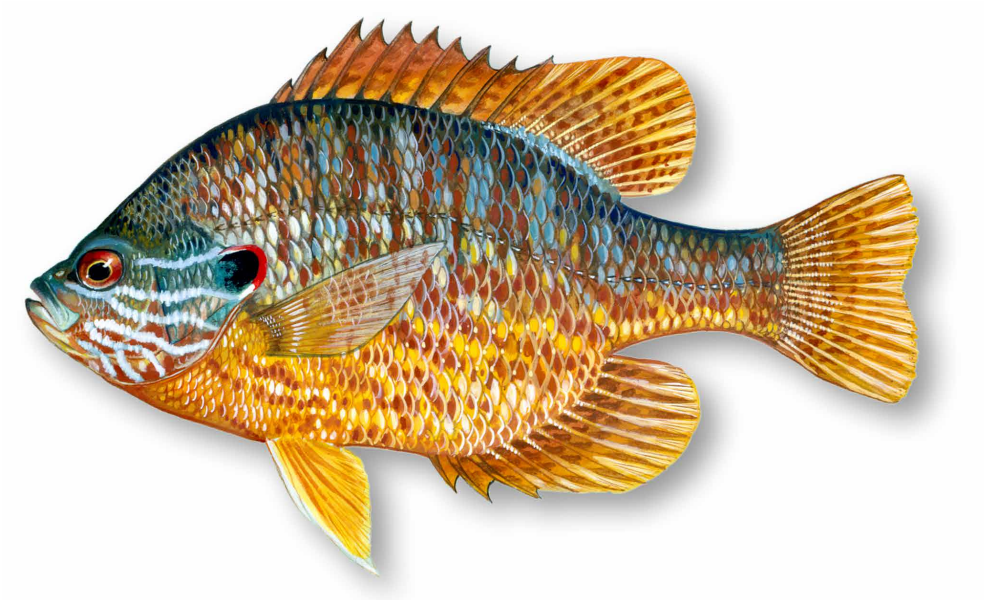
The bluegill is a hardy fish that can be found in most lakes, ponds, rivers and streams across the United States. It is native to the central and eastern portions of this country, but since the bluegill is one of the most common and popular game fish, this species has been introduced to many new regions including New Hampshire. This fish prefers slower moving water that is heavily vegetated for protection from predators, but will also be found swimming in the open in waters free of bass and pickerel.

Collecting and Aquarium Care

The bluegill can be collected from the shallow, vegetated parts of the stream or pond using a dip net. Seining is not suggested to catch these fishes because it would be difficult to seine in the aquatic vegetation. In the aquarium, the bluegill will cause little to no maintenance problems. It should be kept in a tank with other species of the same Centrarchidae family (sunfish family) that are close in size to the bluegill. Make sure there is plenty of room in the tank for territory boundaries between the fishes. It can be fed every couple of days with live foods such as insects, crustaceans like crayfish, minnows, worms or night crawlers. The bluegill is a generally peaceful and hardy fish that will thrive in a vegetated tank that is brightly lit.

PUMPKINSEED

Lepomis gibbosus



Description

The pumpkinseed is commonly caught by beginning anglers and can be an excellent species for a beginning aquarium. Pumpkinseeds have been caught up to ten inches and can weigh up to one pound. A laterally compressed body shape and a disk-like profile are characteristic to this species. The pumpkinseed is one of the most colorful sunfishes, especially when it is breeding. Its sides and dorsal area are speckled with orange, yellow, blue and emerald spots on a brown colored background, while its breast and belly are an orange-red color. Pumpkinseeds can often resemble bluegills, so some specific features that make it easy to identify are the five to seven wavy blue lines near its eye and its dark, black opercular spot that is rimmed in red.

Habitat

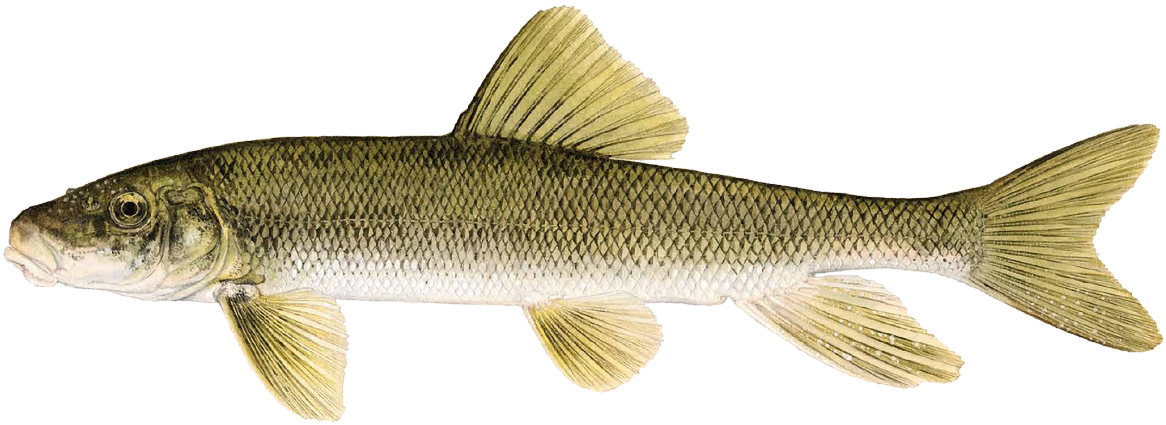
The pumpkinseed is one of the most commonly encountered fish in most of the United States. Native to the northeastern rivers, streams, lakes and ponds, this sunfish can survive in most any standing or moving water. It has been widely introduced to many different areas and although not sought after as a game species, it has been known to be caught by many beginning anglers. The pumpkinseed prefers the natural protection from predators provided by vegetation, so it can usually be found in the shallow and vegetated waters of slow streams and rivers and is rarely found in open waters.

Collecting and Aquarium Care

The pumpkinseed can be collected in most anyway possible. Traps, liftnets, seines and dipnets can all be used to collect this species. The pumpkinseed should not be taken if it seems to be nesting. These fish make their nest in the sandy substrate close to shore and during late spring and early summer. The males guard their young both day and night, so if an adult pumpkinseed was taken from the nest area, the fry or eggs will most definitely die. The pumpkinseeds are an ideal fish for a freshwater aquarium because they demand little maintenance. They can be kept in a clean, well-aerated tank with lots of room for territories because these sunfish can get aggressive as they age. Shy fishes, like shiners, dace or enneacomthus sunfish, should not be kept in the same tank with pumpkinseeds because they will bully them. They do, however, interact very well with bluegill sunfish; these two species are often found living together in nature, often interbreeding. It is a generally peaceful and hardy fish that will thrive in a vegetated tank that is brightly lit. The pumpkinseed can be feed every couple of days with live foods such as insects, crustaceans like crayfish, minnows, mollusks (snails), or worms. Feeding the pumpkinseeds live foods will maintain their beautiful coloring.

COMMON WHITE SUCKER

Catostomus commersoni



Description

The white sucker also known as the common sucker is a familiar member of the Catostomidae family. These fish have been found to measure up to twenty inches and weigh up to five pounds. This fish's body is designed for bottom feeding with a long snout and a big mouth on the underside of its body. The sucker's body is elongate and cylindrical. Its sides and dorsal area are olive-brown to a brassy green-yellow color, which fades into a white belly. The scales of a white sucker are large and create a reflective look when underwater. A rosy color and red lower fins identify breeding adults.

Habitat

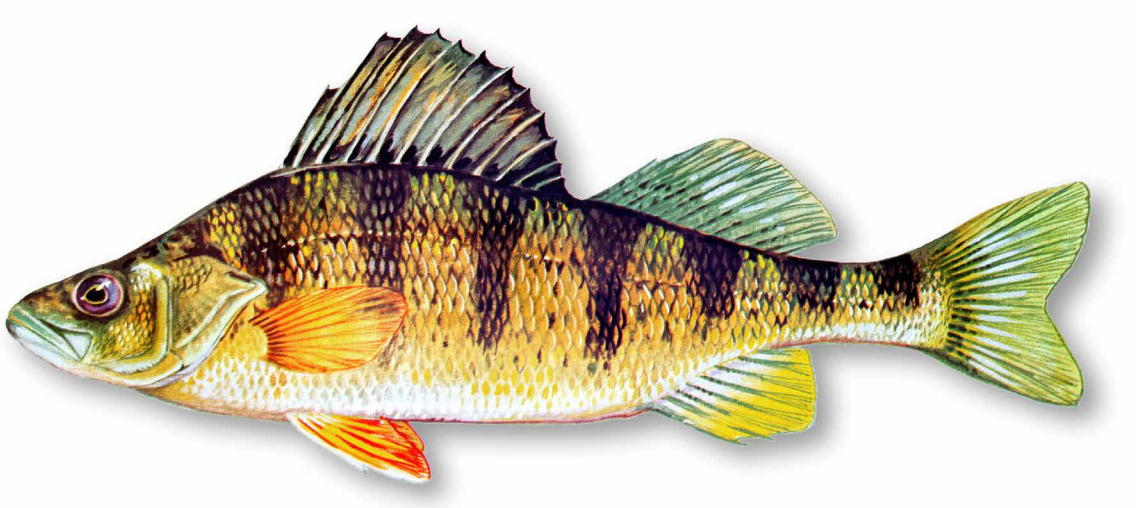
The white sucker is a bottom dweller found in most large streams and rivers. Native to areas east of the Rocky Mountains, particularly to the northeast, adult suckers can be located in the deeper pools of these streams. In New Hampshire they are most common below bridges and small dams. These fish travel in small groups and are very alert, therefore, not easily approached.

Collecting and Aquarium Care

Since the white suckers are so hard to approach a dip net or even a hook is advised to catch the big suckers. The smaller suckers can be caught in the shallow, vegetated areas using a dip net, minnow trap or even a seine. Aquariums with white suckers will not experience many problems. Suckers will thrive in a tank provided with good, vegetable-based food, such as algae or parboiled spinach. This species is an omnivore and allowing algae to grow in the tank, although not aesthetically pleasing will benefit the suckers. The tank should be large and well filtered because the suckers are messy feeders. They will uproot and eat planted plants, so plastic is advised in an aquarium with suckers. It can be fed every couple of days and will accept prepared foods as well as live foods. It will eat worms, mollusks and fish eggs. The white sucker is a very peaceful fish and hardy fish that will thrive in a vegetated tank that is brightly lit.

YELLOW PERCH

Perca flavescens



Description

The yellow perch is a favorite fish among casual anglers. They have been caught up to fifteen inches and four and a half pounds. The perch's body is oblong and moderately compressed. Reflecting its name, the sides of a yellow perch are a green-yellow color. Its dorsal area is dark green with five to eight noticeable, vertical, dark lines running down the sides. Its fins are a yellow-orange color and it has a spiny dorsal fin. This fin can be harmful so be careful when handling this fish.

Habitat

The yellow perch is capable of adapting to a variety of habitats and water temperatures, but is most comfortable in the shallow waters of quiet streams and ponds. It is native to the central and eastern portions of the United States, but due to its popularity as a game fish, this species has been introduced to many new regions. This fish prefers open areas of slow moving water because it is more of a predator. It travels in schools in deeper water during the day and moves to shallow water to feed at dawn and dusk. The yellow perch is very tolerant of acidity and poor water quality. It a good fish to survive in a simulated aquarium environment.

Collecting and Aquarium Care

The yellow perch is an active and hungry fish that will get caught easily in a baited minnow trap. It can also be dipnetted in the weeds by the shores of the pond or river and large perch will bite on barbless hooks if they must be collected in that manner. The yellow perch is not very aggressive, but it is a predator and should be kept out of aquariums with smaller fishes. The perch would eat the smaller and more timid fishes. The perch can be kept with other sunfishes of the same size. The aquarium should be a large 20 to 50 gallon aquarium filled with sunken roots and vegetation. Keep only a few perch in the tank at the same time and feed them large portions of live food or cut bait. It can be fed worms, insects, crustaceans such as crayfish, minnows and small aquatic animals. The yellow perch is a predator and should be watched so it does not eat any smaller fish. It will thrive in a vegetated tank that is brightly lit.

COMMON SHINER

Luxilus cornutus

Description

The common shiner is a member of the minnow family, one of the largest and most common families of fish in the United States. Common shiners have been measured up to six inches. This shiner's body is moderately compressed, robust with large scales and a blunt, rounded head. It has the single soft dorsal fin that is characteristic of all species in the Cyprinidae family. The shiner's tail is forked, indicating its speed to escape predators and the tail lobes are rounded. Its dorsal area is a dusky olive with a wide dorsal stripe. Its sides are a silvery bluish-purple that fades to a light underside. In breeding shiners their coloring is bright gold, orange or red with rosy fins.

Habitat

The common shiner is a small species of fish that is usually prey or used as bait. It is generally found in the northeastern part of the United States in large lakes and ponds and streams and rivers that flow fast over gravel and sand bottoms. The shiners congregate in large pools beneath bridges and dams. They are quick swimmers and are usually the prey of larger fish. This fish must use its speed to escape from predators.

Collecting and Aquarium Care

Fish traps placed in shallow, rocky areas of streams can be useful for catching common shiners. The fish are active and agile, which means they will be hard to catch by dip net or any other method. If fish traps are used, be sure to place them in slower moving water because if the current is too fast, the shiners will get jammed up against the side of the trap and die. The common shiner is a very undemanding fish. This fish is a great beginning native fish for the aquarium. All it needs is some space and a good diet. A twenty-gallon aquarium has room for six adult shiners. The minnows can also be used for food for other larger piscivorous (fish eating) fish species. The aquarium should be mostly open with a few roots or plants to hide behind. It can be fed every couple of days with live foods as well as vegetable-based goldfish or koi foods. The common shiner is a very peaceful and communal fish that will thrive in a vegetated tank that is brightly lit.

CHAIN PICKEREL

Esox niger

Description

Like other members of the pike family, the chain, or Eastern, pickerel has a slender, elongated body, large mouth with formidable teeth, and dorsal and anal fins placed far
back near the tail. A characteristic pattern of dark, chain-like markings on the sides distinguishes it from other members of the pike family.

Habitat

Any quiet, shallow water with a mud bottom, an abundance of aquatic vegetation and food fishes is ideal habitat for the chain pickerel. Their optimum water temperature is apparently 80 to 90 degrees. Pickerel like to hide in weeds waiting for a meal to swim by. The chain pickerel is a voracious carnivore. Its diet includes golden shiners, brown bullheads, yellow perch and sunfish.

Collecting and Aquarium Care

Pickerel that are small (2” – 6” long) can be cornered against the shoreline with a seine or dip netted in dense weed beds. Pickerel are an exciting challenge to have in a tank because of their voracious appetite for other fish. They do need plenty of hiding places in which to skulk and wait for prey such as small shiners. But as the pickerel puts on size, the prey will be much bigger and the pickerel may begin to feed on its tank mates so one or two pickerel are probably enough. Make sure the tank has a cover as they also like to jump out of it.

SMALLMOUTH BASS

Micropterus dolomieui

Description

The smallmouth bass is a member of the black bass family. These fish are usually gold in color with dark vertical banding down its sides. The mouth of the smallmouth bass, unlike the largemouth, does not extend past the middle of the eye. It prefers lakes and streams with cool, clear water, a gravelly or rocky bottom, and scant vegetation. One can find this fish in lakes near submerged reefs or ledges in water 3 to 20 feet deep.

Habitat

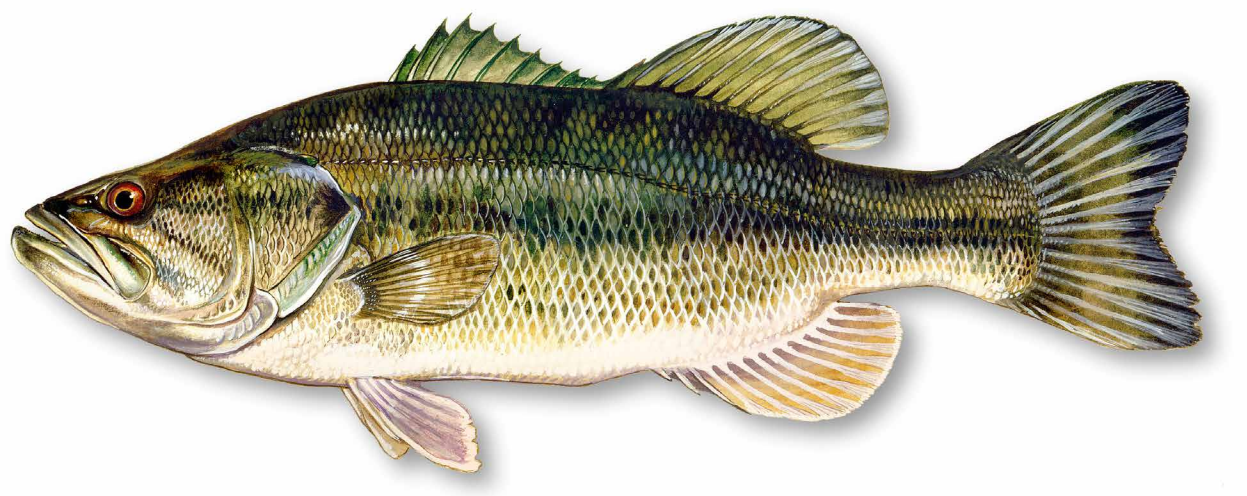
All bass are spring spawners, with nest building occurring in mid-May when water temperatures are in high 50s and low 60s. Spawning smallmouths are found in areas with gravel and boulder bottoms. In the summer, they will stay in deeper water than largemouths because they like the cooler temperatures. Look for smallmouths along rocks near drop offs. On summer nights, smallmouths will head to shallow water looking for crayfish.

Collecting and Aquarium Care

Young bass can be collected by surrounding a group by a 20-foot seine and moving in, keeping in mind they are very swift and agile. Very small fry can be collected by sweeping a dip net through the vegetation. Bass are fearsome predators that must have living prey and lots of it, such as feeder guppies, goldfish, night crawlers or small crayfish. Bass of equal size get along well and should probably be released before they become too large to feed and house.

LARGEMOUTH BASS

Micropterus salmoides



Description

The largemouth bass closely resembles the smallmouth in body shape. The largemouth is usually green in color that fades to white at the belly. It exhibits a horizontal dark band or stripe along its side. The jaw of the largemouth, when the mouth is closed, extends well beyond the eye.

Habitat

In contrast to the smallmouth bass, the largemouth thrives best in warm, shallow, mud-bottomed lakes, ponds or streams with plenty of vegetation. It is a solitary fish. Most of its time is spent lurking among aquatic vegetation, beneath an overhanging branch or under a brush-covered bank, waiting for prey to swim by. Its diet consists of frogs and bait fish, though almost anything can become a meal: snakes, mice, snails and worms. Juvenile bass feed on a lot of insects.

Collecting and Aquarium Care

Young bass can be collected by surrounding a group by a 20-foot seine and moving in, keeping in mind they are very swift and agile. Very small fry can be collected by sweeping a dip net through the vegetation. Bass are fearsome predators that must have living prey and lots of it, such as feeder guppies, goldfish, nightcrawlers or small crayfish. Bass of equal size get along well and should probably be released before they become too large to feed and house.

Experimentation and Observation

A freshwater aquarium in the classroom provides wonderful opportunities to experiment and observe the freshwater species up close and notice their interactions with the surrounding environment. Experimentation provides students with a clearer idea of the basic anatomy and physiology of the bony fishes as well as adaptations and qualities specific to certain species. Observation of the aquarium allows students to discover the different behavior of the fishes and the niches they occupy. Students will also become knowledgeable about the natural habitat that these fishes inhabit through aquarium activities. Overall, a freshwater aquarium in the classroom will promote awareness, appreciation and knowledge of the river ecosystem and its resident species.

This section consists of various suggested lessons that could be used in combination with the freshwater aquarium. Provided in this section are three entire lab procedures of varying difficulty along with descriptions of how to go about creating other classroom activities. These activities and experiments focus on the different aspects of the fish species in their simulated natural habitat.

Basic observations of the fish in the classroom can teach the students a lot about fish anatomy, physiology, basic functions and behavior. Students can learn how a fish swims, eats, digests, breathes and survives in its natural environment. Age and fish growth can also be observed and measured in the classroom. The aquarium can also be a tool to teach about water quality and chemistry. Students can learn about the basic and complex chemical and physical parameters of a stream or river as well as how to test and maintain the chemical balances in the tank.

The environment and the dynamics of a fish's natural habitat contribute to their behavior and health. Fish react to changes in their natural environment and habitat and a fish's natural and altered behaviors can be observed in the aquarium by conducting certain experiments. Physical and behavioral changes to the fish can be noted when certain parameters in the aquarium are altered. A food selectivity lab can be run by partitioning the aquarium into two sections. The partition can be made of perforated Plexiglas to allow the water to flow through, but separate the fish in the aquarium. The fish on one side of the partition can be fed live foods, such as worms, minnows and insects while the other fish could be fed pellet foods. The students can observe the changes in behavior and appearance of the fish and conclude how food affects them. By adjusting the set up of the aquarium, students can observe the effects that current and water flow have on the fish. The powerheads can be adjusted and the placement of the substrate can be changed to alter the water flow. Students can observe where the fish tend to stay and changes in their behavior. New species of fish or other aquatic life can be added to the aquarium. Students will then be able to learn and observe relationships between the organisms.

The following lab procedures contain the methods and materials necessary for completion of the lab. The labs vary in their difficulty and can be easily added to and manipulated in order to increase their difficulty. These labs were provided online by Tetra, an aquarium company, in their program called Aquademics Aquarium Education for America's Schools. For more references on suggested lesson plans you can visit Tetra's website online at: http://www.tetra-fish.com/aquarium-information/aquademics-aquarium-education.aspx. Organizations like New Hampshire Fish and Game will also be very helpful in designing a curriculum centered on the fish and the aquarium. The first lab provided is aimed at a younger age group. It looks at the nitrogen cycle in the aquarium and teaches students how to test for ammonia in the tank. The second lab, which is the importance of water quality in the aquarium, requires more discussion about water quality and pollutants that commonly contaminate rivers and streams. The third lab is a long-term observation of fish and their behaviors. Students will recognize common behavior of their assigned fish in the aquarium.

Understanding the Nitrogen Cycle in the Aquarium

Objective:

The student will be able to explain the importance of the nitrogen cycle and how control of the ammonia in this cycle is critical to the overall health of the aquarium. Students also will be able to check their tank's ammonia level. (This lesson is most effective if conducted after the lesson on filtration.)

Materials Needed:

- A fully-operational aquarium
- Worksheet on the Nitrogen Cycle (one per student)
- Worksheet on the Water Quality (one per classroom)
- An Ammonia Kit

Background Information:

A fish's waste product and uneaten food produce ammonia. It is very toxic to fish; therefore it should be one of the elements to monitor regularly in the tank. If a tank has proper filtration, has regular water changes, is not overstocked with fish and has fish that are not overfed, then ammonia should not be a problem. The ammonia reading in the healthy tank should be zero. The ammonia kit can give a simple, accurate determination of ammonia in a freshwater tank. If the ammonia level is too high, the kit also suggests the appropriate remedy.

For information on the nitrogen cycle in aquarium tanks:

- *http://www.troutintheclassroom.org/Teachers/Technical%20Information/Ammonia%20Explained*
- *http://www.troutintheclassroom.org/teachers/technical-information/nitrogen-cycle*
- *http://www.troutintheclassroom.org/teachers/library/tic-hydroponics*

Activity:

Ask the students if they have ever heard of a substance called ammonia. Let several students respond to this question. They may know that some household cleaning agents contain ammonia. (The teacher could dilute a small amount of cleanser like Mr. Clean into a bowl and let students quickly smell the pungent scent of ammonia.)
Explain to students that, in order for fish to survive successfully in the aquarium, it is all right - even necessary - to have a very small amount of impurities in an aquarium, but a large amount can be dangerous and even fatal to the fish. In fact, ammonia is the number one killer of fish.

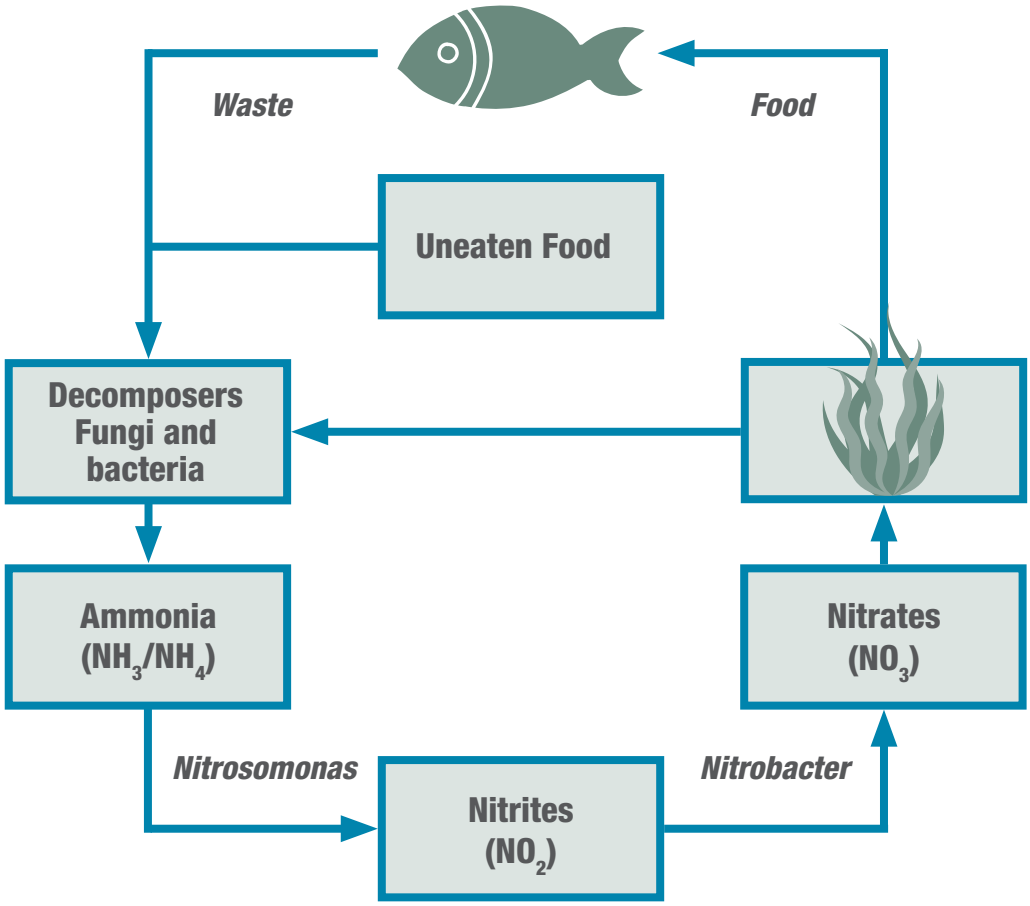
Distribute a copy of the nitrogen cycle worksheet to each student. Review the nitrogen cycle with the students. Tell students that ammonia is a compound of nitrogen and hydrogen and write these terms and their chemical symbols on the board. The nitrites in ammonia are extremely hazardous to fish if allowed to accumulate in large quantities. Explain that proper filtration and regular water changes will ensure that ammonia and nitrite levels never reach dangerous proportions. It is necessary that students acquire a very elementary knowledge of nitrogen and hydrogen. A healthy aquarium will depend upon proper control of both of these chemical elements.

Train all students on how to test the tank's ammonia level using the ammonia kit according to the instructions found inside the box. Note ammonia status on the water quality worksheet.

Result:

Students will make sure that dangerous ammonia levels never occur in their tank.

The Nitrogen Cycle



Date	Temp.	pH	Ammonia	Other	Comments

The Importance of Water Quality in a Fish's Habitat

Objective:

The student will be able to compare and contrast differences in water quality by observing and recording changes to water during an experiment in control and polluted environments.

Materials Needed:

- Ecology Worksheet
- Several clear plastic 16-20 oz. drinking cups or jars
- Several small aquatic plants (can be purchased at the local pet store)
- Two teaspoons motor oil*
- Two teaspoons sugar
- Small amounts of various household detergents*
- Non water-soluble paint*
- One or two crushed charcoal briquettes*
- (must NOT be treated with any formula for quick lighting)
- Several straws
- Peel and stick labels

  **These materials should be brought in kid-safe containers. The teacher should handle and dispose of all materials when the experiment has concluded.*

Activity:

Before beginning this experiment, engage students in a discussion of the importance of water quality for humans. Using the chalkboard, make a list of the many ways we use water and then make a list of the pollutants that would poison our water supply.

Then, ask the students to consider why water quality is so important to fish—not only those in the classroom aquarium, but also for fish in lakes, ponds and rivers. Ask students to make predictions about what happens to water that is polluted by chemicals or that is stagnant.

Divide the class into several small groups. Have labels ready to put on cups as they are filled with different ingredients.

First, prepare a "control" cup by placing the crushed charcoal as a filter on the bottom, pressing the roots of an aquatic plant into the charcoal, filling the cup with clean tap water and positioning this cup away from immediate sunlight. At least once a day, a student should insert a straw about 1/8 inch into the water and blow a few gentle puffs of air into the water (Teachers should supervise to ensure that students blow out, not suck in.). This will simulate the filtration and exchange of gases that must take place within a healthy aquarium.

For the remaining cups, first place the aquatic plant on the bottom (with no charcoal), fill with clean tap water and;

1. Put two teaspoons of motor oil in one cup.
2. Put a teaspoon of dishwashing detergent in one cup.
3. Put a teaspoon of clothes detergent in one cup.
4. Put some non-water-soluble paint in one cup.
5. Put two teaspoons of sugar in one cup.

All cups (except for the control cup) can be placed in a windowsill, which will enable students to easily measure the effect of evaporation in addition to the impact that the "pollutant" has on the water quality inside the cup.

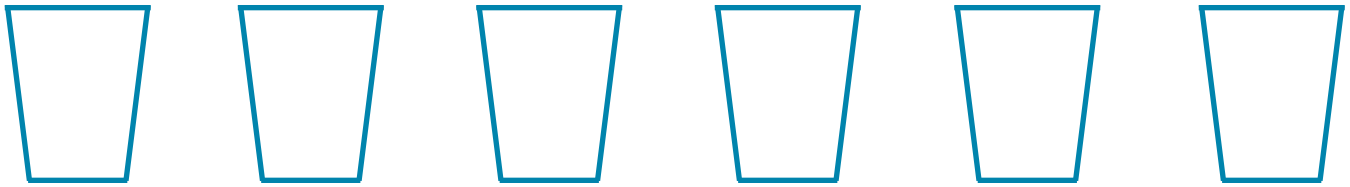
Ask students to make predictions about what will happen to the water quality in their cup. Students will make sure that dangerous ammonia levels never occur in their tank.

Result:

Each day, students can observe the change in water quality of the cups in the windowsill compared to the control cup. Different groups of students can be responsible for observing and recording data on different cups. At the end of a specific time period, groups can report their findings to the class. Ask students to comment on what their findings mean to the fish and plants that must have clean water to survive in their underwater habitat.

What do you think will happen?

Control	Oil	Dish Detergent	Clothes Detergent	Paint	Sugar



What actually happened?

Control	Oil	Dish Detergent	Clothes Detergent	Paint	Sugar

Observing Fish Behavior (Over Several Months)

Objective:

The student will be able to identify and explain the purpose of at least five different fish behaviors by observing one fish in the classroom aquarium over a period of time.

Materials Needed:

- Science Worksheets: Fish Classification, Fish Information Sheet, Behavioral Observations Reference, Behavioral Observations Data Table, Fish Behavior Profile
- Pencil and paper for each student
- A fully-operational aquarium
- Notebook or folder for each student group
- Rulers (class set)
- Calculators (class set)

Activity:

1. Engage students in a brief discussion of behavior.
2. Remind students that simple observations can provide them with a great deal of information about the fish in the classroom aquarium. Some of the observational data include:
   How are the fish adapting to their new environment?
   Have you noticed any changes in the behavior of an individual fish?
   Is one fish behaving aggressively towards the others?
   Has there been a change in the feeding habits?
3. Divide students into pairs or small groups. Assign each pair/group a fish in the aquarium. Each pair/group will be responsible for making regular observations of their assigned fish. This procedure ensures that every student will be actively involved in the activity and that observations can continue to be made even if one student in the pair/group is sick.
4. Each pair/group should have a special folder or notebook to contain their fish observations and the worksheets for this lesson.
5. Before observations begin, review fish classification and external anatomy using the background material in the fish classification worksheet. Have each group place this sheet in their notebook/folder.
6. Have each pair/group complete the Fish Information Sheet. The background material on the fish classification sheet will provide most of the information students will need. Set up a classroom aquarium library with reference books on fish. Have the students share what they have learned about their fish with the rest of the class.
7. Establish a program routine and share it with the students. Each student pair/group will need to take turns at the aquarium for about 10 minutes every couple of days. The students will gain a sense of ownership and responsibility for the classroom aquarium if they are a part of the process at every stage.
8. Explain to the students that it is not always easy to determine what the fish is doing and that sometimes the fish will perform many activities during the course of one observation session. A behavioral observation is like a snapshot of the fish at a particular point in time. What the students record should be exactly what they see regardless of how uneventful the behavior. Select a fish in the aquarium and use it as an example to demonstrate how to observe and record properly. Review the Behavioral Observations Worksheet to help the students learn the behaviors they will be observing.
9. The students are now ready to begin observing. Have them use the Behavioral Observations Reference to help them complete the Behavioral Observations Data Table over a period of time.
10. Once a good quantity of data has been collected over a selected period of time (at least one month), have each student pair/group complete the Fish Behavioral Profile.

Teacher's Note:

Stress to the students the importance of keeping accurate and complete records for referral and analysis purposes. After all, that's what real scientists require.

Result:

Discuss the results of this long-term observation lesson as a class. Allow each pair/group to present their findings and report at least three new things they learned about their fish.

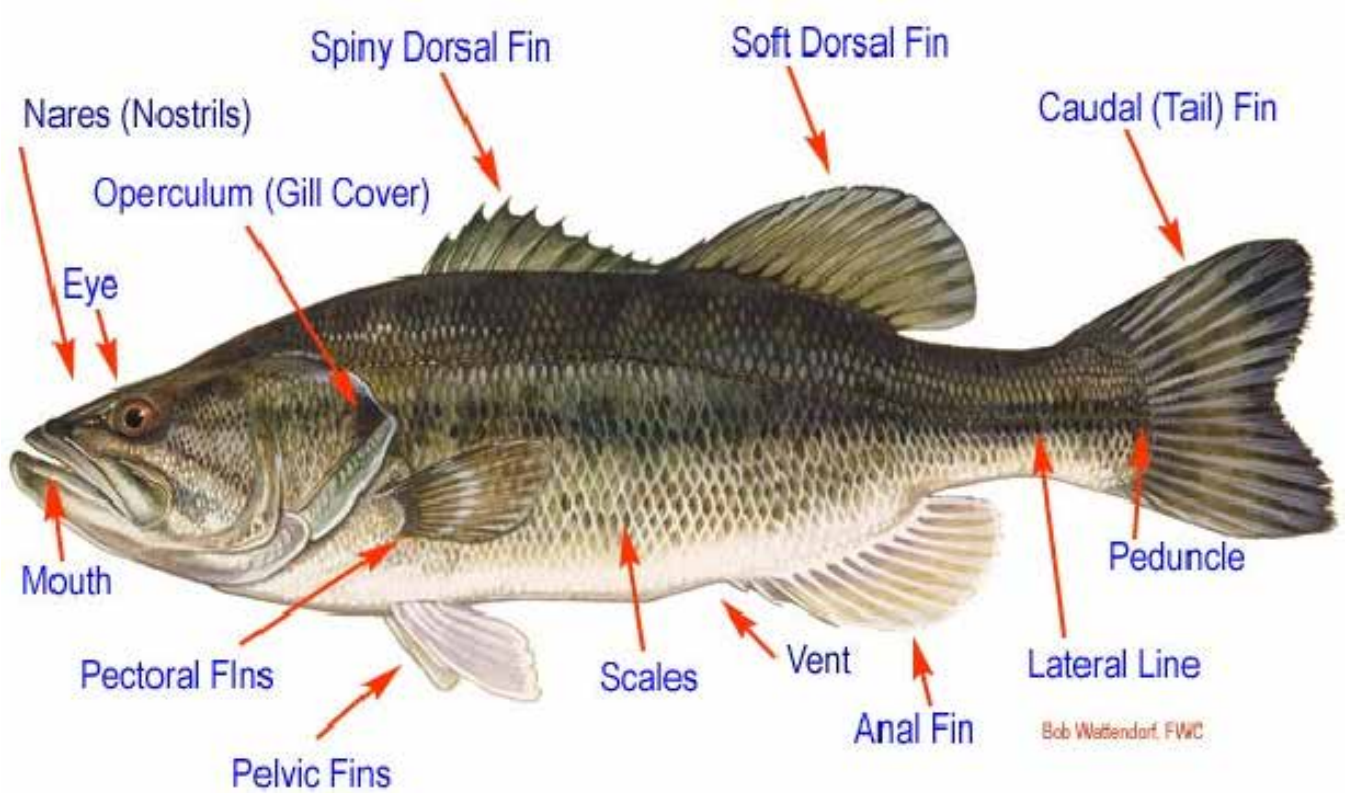
Fish Classification

Kingdom: Animalia **Phylum:** Chordata **Subphylum:** Vertebrata **Class:** Osteichthyes (bony fish)

Characteristics of Bony Fish

- Coldblooded
- Bony skeleton
- Scales on skin
- Internal or external fertilization
- Jaws
- Egg laying or live birth
- Paired fins

Fish External Anatomy



Behavioral Observation Reference

Location:
What zone is the fish located in?

C	D
B	A

Depth:
At what level does the fish usually stay?

TOP
MIDDLE
BOTTOM

Open water or Undercover:
Is the fish in open water or does it appear to be hiding under or near a plant or object?

Proximity to Other fish:
Is the fish near other fish? If so, who and how many?

Swimming or Stationary:
Is the fish moving or motionless in the water? Do not count fin movement, only whole body movement.

Feeding:
Is the fish feeding? If so, on what (gravel, plants, object, tank wall surface)?

Respiration Rate:
How many times does the fish open and close its gill opening (called the operculum) in one minute?

Fish use their gills to capture oxygen from the water, and oxygen is used to convert food energy into **ATP** (ready) energy. A high respiration rate can mean the fish has just eaten or the fish has been moving rapidly or the dissolved oxygen in the water is low.

Swimming Speed:
This observation will only apply if the fish is swimming horizontally in the water. To determine swimming speed, mark the start point on the front of the tank with a finger, pencil, or ruler. Time the fish until it stops. Mark the finish point on the front of the tank, and measure the distance from start to finish, preferably in centimeters. Record the swimming speed in centimeters per second.

For example:
Distance = 15 centimeters
Time = 3 seconds
Swimming speed = 15cm/3 sec = 5 cm/sec

Fish Behavior Profile *Complete after observations*

Nickname:

Common Name:

Scientific Name:

Location:

1. What zone does your fish spend most of its time in?

2. What percentage of the time does your fish spend in this zone? (*# times fish found in this zone x 100 = Total # of observations)*

Depth:

1. At what level does your fish spend the most time?

2. What percentage of the time does your fish spend at this level? (*# times fish found at this level x 100 = Total # of observations)*

Open water or Undercover:

1. What is the ratio? (*Open water:undercover)*

Proximity to Other Fish:

1. Was your fish solitary most of the time?

2. If not, with whom did your fish spend most of its time?

Swimming or Stationary:

1. What is the ratio? (*moving:still)*

Swimming Speed:

1. If you were able to calculate swimming speed more than once, how did the speeds compare?

2. If you were able to calculate swimming speed more than once, what is the average swimming speed of your fish? *(Add every swimming speed you observed and divide the value by the total number of swimming speed observations you made.)*

Feeding:

Did you observe your fish feeding?

If so, in what location did your fish prefer to feed?

Respiration Rate:

What was the highest respiration rate you observed?

The lowest?

Suggest some possible reasons for any high rates you may have observed.

Fish Information Sheet *Complete prior to observations*

Nickname: **Common Name:**

Scientific Name: **Native Habitat:**

Illustration: (Label the Parts)

Body shape: **Shape of Caudal fin:** **Body Length (approx):**

Coloration: **Type of Mouth:**

Herivore / Carnivore (Circle One)
Social / Aggressive (Circle One)
Live Bearer / Egg Layer (Circle One)

Behavioral Observations Data Table

Nickname: **Common Name:**

Behaviors	Date/Time of Observation
Location in Tank	
Depth in the Water column	
Open Water or Undercover	
Proximity to Other Fish	
Swimming and Stationary	
Swimming Speed (cm/s)	
Respiration Rate (gill Opening/min)	

References

CONSTRUCTING AND MAINTAINING AN AQUARIUM:

"A River Runs Through It." http://www.loaches.com/river_tank.shtml

- This website is a guide to setting up a riffle tank that simulates fast flowing rivers and streams. It gives examples of tank setup and how to simulate the river habitat for the fish.

Boyd, Kevin W. *The Complete Aquarium Problem Solver, A Total Trouble-Shooting Guide for Freshwater and Marine Aquariums.* Virginia: Tetra Press, 1990.

- This is an excellent guide and resource for any aquarium owner to use. It includes a complete list of common problems that might occur in the aquarium and solutions for these problems. It also includes a flow chart to help diagnose any unknown problems. This book is one of the best resources to turn to if an aquarium or its inhabitants are experiencing problems.

Doctors Foster and Smith Aquarium Supplies can be found on the internet at www.DrsFosterSmith.com.

- This company carries everything needed for a freshwater aquarium and is less expensive than buying the equipment at a pet store. Note: There are other companies to research.

Quinn, John R. *Our Native Fishes*. Woodstock, Vermont: The Countryman Press, 1990.

- This book was very helpful for this project. It is a guide for the aquarium hobbyist. It has extensive details about how to collect fish and how to have a productive aquarium. In the second section, it identifies fish species native to North America and gives details about maintaining these specific types of fish.

"Setting Up a Native Fish and Plant Collecting Trip." http://www.nanfa.org/articles/accollectingtrip.shtml

- "Setting up a Native Fish and Plant Collecting Trip," by Robert J. Goldstein is a good example of what to expect when collecting specimens for the tank and what materials to bring. It is a good overview to read before going out to collect the organisms.

"Setting Up a Riffle Tank." http://www.nanfa.org/articles/zoller.shtml

- Cliff Zoller, the author of "Setting Up a Riffle Tank," provides a good guide to setting up a riffle tank habitat. This website also includes pictures to clarify certain methods he used while setting up his riffle tank.

FRESHWATER FISHES AND THEIR HABITAT:

Barrett, Katherine and Cary I. Sneider. *Mapping Fish Habitats: Teacher's Guide.* University of California at Berkeley: Lawrence Hall of Science, 1987.

- This teacher's guide provides excellent examples and tips on how to set up and maintain an in-class aquarium. It also provides experiments, mostly geared to lower grade levels, to do once the aquarium is set up in the classroom.

Caduto, Michael J. *Pond and Brook*. New Jersey: Prentice-Hall, Inc., 1990.

- This is a well-written book explaining the dynamics and ecology behind various freshwater ecosystems, such as lakes and wetlands, rivers and streams. It goes over both the living and nonliving factors that affect these environments and the origin of freshwater habitats.

Herald, Earl S. *Fishes of North America*. New York: Doubleday and Company, Inc., 1985.

- This book describes both freshwater and marine fishes in North America and separates them into their different families, providing specific examples of species in each family. This book also provides color pictures of many different freshwater and marine species.

Hylander, Clarence J. *Fishes and Their Ways*. New York: The Macmillan Company, 1964.
- As its title suggests, this book provides a good look into fishes and their lifestyles. It goes into their anatomy and physiology as well as their specific habitat requirements. It classifies the freshwater fishes and the marine fishes with their different families and provides information and sketches of these separate families. Although it is an old book, it provides basic knowledge and background of fishes and their ways.

New Hampshire Fish and Game websites:
- Bathymetric maps: http://www.wildlife.state.nh.us/maps/bathymetry.html
- NH fish species: http://www.wildlife.state.nh.us/fishing/species.html
- NH fisheries management: http://www.wildlife.state.nh.us/fishing/fisheries-mgt.html

Scarola, John F. *Freshwater Fishes of New Hampshire.* New Hampshire Fish and Game Department, 1987.
- This book is the definitive source for information on the identification, distribution, habitat requirements and behavior of fish species in New Hampshire. It classifies the freshwater fishes and the marine fishes with their different families and provides information and sketches of these separate families.

Williams, James D., et al. *National Audubon Society Field Guide to North American Fishes, Whales and Dolphins*. New York: Alfred A. Knopf, Inc., 1998.
- This is a basic field guide to North American fishes, whales and dolphins. It provides descriptions, color pictures, anatomical and physiological and habitat information of many of the species in New Hampshire.

EDUCATIONAL MATERIALS AND CONTENT INFORMATION:

Aquarium lesson plans from Tetra's Aquademics Aquarium Education for America's Schools:
- http://www.tetra-fish.com/aquarium-information/aquademics-aquarium-education.aspx

Maintaining water quality in the aquarium (nitrogen cycle):
- http://www.troutintheclassroom.org/Teachers/Technical%20Information/Ammonia%20Explained
- http://www.troutintheclassroom.org/teachers/technical-information/nitrogen-cycle
- http://www.troutintheclassroom.org/teachers/library/tic-hydroponics

NH Fish and Game Department:
- Main web page: http://www.wildlife.state.nh.us/
- "Living Like a Warm Water Fish" DVD: http://youtu.be/okUIkEnvHgI.
- Watershed Education Program (WEP): http://www.wildlife.state.nh.us/education/watershed.html

  For more information about WEP (including "Simulating a NH River Ecosystem"), contact:
  Judy Tumosa, Watershed Education Specialist
  NH Fish and Game Department
  11 Hazen Drive
  Concord, NH 03301
  (603)271-0456
  Judy.l.tumosa@wildlife.nh.gov

Fish Diseases

Contributed by Dr. Joel Bader, Fish Pathologist, previously of the NH Fish & Game Department

Preventing Stress = Preventing Disease

Q: Can reducing stress keep fish healthy?

A: Yes. Stress weakens fishes' immune systems, leading to increased susceptibility to disease. The majority of fish diseases can be prevented by avoiding stress. Typically, disease-causing organisms (pathogens) can only cause disease when there is a readied host (stressed animal), a poor environment (water quality) and the presence of a pathogen. Pathogens are almost always present in tanks, but a healthy fish's immune system usually prevents them from being a problem. Pathogens in the presence of a stressed fish, with a weakened immune system and combined with dirty or poor water can readily result in sick fish.

Q: How do I avoid stress?

A: Common stressors for aquarium fish include one or more of the following:

- Poor water quality: measurable amounts of ammonia or nitrites, or very high nitrates.
- Too bright a light or lights for too long each day.
- Water temperatures that fluctuate more than 2 degrees Fahrenheit per day.
- Incompatible species in the tank.
- Too many fish in the tank.
- A tank too small for the fish.
- Water too warm or too cold for the species.
- Wrong pH for species.
- pH fluctuations greater than 0.2 units/day.
- Insufficient cover or hiding places for fish.
- Wrong water hardness for the species.
- Insufficient oxygen in the water.
- Improper fish nutrition (wrong food, foods not varied).
- Tapping on the tank, or disturbing tank and or water.
- Sticking hands in the tank needlessly.
- Changing more than ½ volume of water at a time.
- Over feeding (Better to underfeed then overfeed).

Recognizing and treating disease

Q: How do I know my fish is sick?

A: Watch your fish and know what normal behavior and appearance is. If you don't know what normal is, you can't know what sick is.

Bad signs:

- Clamped fins (fins are held unusually close to body).
- Refusing usual food for more than 2 days.
- Visible spots, lesions, or white patches on the fish.
- The fish gasps at the surface of the water.
- The fish floats, sinks, whirls, or swims sideways.
- The fish shimmies (moves from side to side without going forward).
- A normally active fish becomes still.
- A normally still fish becomes very active.
- The fish suddenly bloats up, and it's not due to eggs or young.
- The fish is scratching against tank decorations.

Q: What do I do if my fish are sick?

A: Consider setting up a "fish medicine cabinet". It seems like fish always get sick when the store is closed. Use these tools to treat the diseases listed in the upcoming sections.

- Water qu ality test kits to determine pH, ammonia, nitrite, nitrate levels.
- Aquarium salt (NOT table salt. Most table salts contain additives to keep them from clumping. Kosher or rock salt is okay).
- Ich remedy: Malachite Green or Formalin.
- Methylene Blue.
- Chlorine bleach for disinfection.
- Maybe one antibiotic (Kaynamycin or Furanace).
- Antibiotic-containing food (always check the expiration date).
- Copper remedy for parasites

And for fish big enough to handle:

- Q-tips
- Soft cotton gloves used for handling fish securely.
- Malachite Green or Mercurochrome

What's Wrong with my fish?

Water quality

Most fish become sick as a result of poor water quality. Typically fish are gasping at the surface, or very inactive, but there are no visible lesions when it first starts. Fins may be clamped. Many fish of different species are affected, and possibly the whole tank. If the water has been bad for a while, the fish may have fin-rot, or streaks of blood in their fins.

- Gasping at the surface, or purple gills: high ammonia or low dissolved oxygen may be the problem. Test to determine levels for ammonia and for dissolved oxygen levels.
- Inactivity is the main sympton: test nitrite and nitrate levels, pH and dissolved oxygen levels.

Depending on your test results, try the following:

Ammonia

Change enough of the water to reduce ammonia levels to 1-2 ppm for freshwater or below 1 ppm for saltwater. If that means changing more than a third of the water volume, be sure the new water is the same temperature, salinity, hardness and pH of the tank water. Consider multiple smaller water changes over a few days. Aerate, and make sure pH is at or below 7.0 for freshwater tanks. In addition to or instead of changing water, you can also add a dose of AmQuel to give fish immediate relief. Find out why ammonia is present and correct the problem.

Nitrites

Change enough of the water to bring nitrites down to below 2 ppm (as with ammonia, if this is a lot of water, match water parameters or do multiple water changes), add 1 tsp. salt per gallon (if the fish tolerate this well, more can be added but do not exceed 1 Tbs. per gallon), and add supplemental aeration. Find out why the nitrite levels are high and correct the problem.

Nitrates

Change the water and clean the filter. If your filter is dirty, there is more waste material present to break down into nitrate. Feed less and change water more often.

Low oxygen

Run an airstone. If this helps a lot, the fish probably don't have enough oxygen in the water. Your tank may need cleaning, fewer fish, or additional water movement at the surface from a power head, airstone, or filter.

Improper pH

If pH is too low: make sure carbonate buffering is adequate -- at least 5dKH. In general, adding baking soda at 1 tsp. per 30 gallon. raises dKH about 2 degrees. For a 10-20g tank that needs the pH just a little higher, try about a quarter teaspoonful. If that isn't enough, add up to a teaspoonful more. You can scale this up to 1 tsp per 30 gallons for larger tanks. If the pH is still too low and the KH is at least 5-6 dKH, clean the tank. For long-term buffering in saltwater and alkaline freshwater systems, add crushed coral. If pH is too high, phosphoric acid can be added, but do not rely on this acid except in extreme situations like ammonia poisoning because it can cause excessive algal growth. To lower pH long-term, filter over peat, or use distilled or deionized water mixed with your tapwater.

Freshwater Ich

White Spot Disease (Ichthyopthirius multifiliis) or "Ich" is caused by a protozoan with a life cycle that includes a free-living stage. It is considered the most serious disease of freshwater diseases encountered in fish tanks. Ich grows on a fish, then it falls off and attaches to gravel or tank glass, then it reproduces to become MANY parasites, then these "swarmers" attach to other fish. If the swarmers do not find a fish host, they die in about 3 days (depending on the water temperature). Ich is most often triggered by temperature fluctuations. Fish with Ich typically look like they have little white salt grains on them and fish may scratch against objects in the tank.

> *Treatment:* For most fish, use a medication with formalin and Malachite Green. These are the active ingredients in many ich medications at fish shops. Some products are Kordon's Rid Ich and Aquarium Products' Quick Cure. Just read the label. Check for temperature fluctuations in the tank and fix them to avoid recurrences. Note that some fish can be a little sensitive to Malachite Green, so use it at half the dose. Use these products as directed (usually a daily dose) until all of the fish are spot-free. Then dose every three days for a total of four more doses. This will kill any free-swimming parasites as they hatch out of cysts. Another remedy is to raise the tank temperature to about 90 deg Fahrenheit and add 1 tsp, salt per gallon to the water. Not all fish tolerate this. Do not use for salmonid fishes.

Fin Rot

Fin rot is caused by the bacteria Columnaris and its relatives. It is one of the most serious and least understood fish diseases. Fish fins actually turn whitish or grayish and die back. Fin rot often follows damage or injury. It can also be caused by poor water quality. Bacterial fin rot is whitish or grey, but not cottony (see Cotton Ball Disease, below), and it can be contagious.

> *Treatment:* First, fix the water and remove any fin-nipping fish. Change some water (25% of the volume is good) and add 1 tsp salt per gallon to promote healing. If bad water quality or an aggressive tank mate was the problem, this should be adequate. Healing will begin within a couple of days. If the rot worsens, use an antibiotic treatment. Antibiotic treatment is stressful for the fish, and doesn't always work, so be sure of what you are doing before you attempt it. If you have questions, seek professional advice. If the fish is still eating, the best bet is an antibiotic food. Tetra makes one that works well -- just buy the one for bacterial diseases and follow the directions on the can. If the fish is not eating, a bath treatment is necessary. A combination of Kaynamycin and Furanace usually works, especially for Columnaris. Always remember when treating to aerate your tank heavily.

Cotton Ball Disease

Cotton Ball Disease looks like clumps of cotton on the fins and usually follows injury or spawning of fish. It is commonly seen in winter or when fish have injured themselves against decorations in the tank.

> *Treatment*: Typically fish need to be removed from the tank and medicated. For fish large enough to handle: catch the fish, and dab Malachite Green directly on the fungus with a Q-tip. This is extremely effective. Repeat treatments may be necessary. For small fish, a commercial fungicide such as Maroxy may work. For severe infestations, try a bath in Methylene Blue (enough so you can barely see the fish) until the fungus turns blue or for 20 minutes. If you add methylene blue directly to a tank, you will kill plants and trash your biological filter. This can color your hands, so always use gloves.

Injuries
Handling and "poking" fish often results in visible and invisible injuries. Fighting amongst incompatible fish and "bullying" can result in such injuries. Other fish are injured by running into tank decorations, walls, or rocks.

> *Treatments:* Larger fish can be netted and their injuries dabbed with mercurochrome (available at drug stores) or Betadine (an iodine-based antibiotic also available at drug stores) to help prevent infection. Be sure to keep these chemicals off of the gills and eyes. For really small fish, put the affected fish in dilute Methylene Blue (pale blue) and 1 tsp salt per gallon in a separate tank. If you want to keep the fish in the main tank, just add salt, as Methylene Blue will trash your biological filter. Note: Be sure injuries are healing cleanly, and repeat the mercurochrome dosage if necessary. If Fin Rot or fungus sets in, see the above section on Fin Rot.

Dropsy
If fish appear to swell up like a balloon and possibly show a distinct "pop eye", this is called Dropsy. It is most often caused by poor water quality and viral and bacterial infections.

> *Treatments:* Often fish may recover with no treatment or may die despite rapid treatment. The swelling is because the fish is absorbing water faster than it can eliminate it, and it can be caused by many different problems. High nitrates are one thing to check. Internal bacterial infections, including fish TB, are other possibilities. If there are no water quality problems, you may want to attempt antibiotic treatment in a separate tank.

Swim Bladder Disorders
Swim bladder disorders can be observed in all fish. Fish typically float upside-down or sideways. This is commonly seen when dry food eaten quickly swells up in the fish's intestine and keeps the fish from controlling its swim bladder properly. Bacterial infection can also cause this disorder.

> *Treatment:* feed the fish pre-soaked or gel-based foods. Green foods are also helpful; peas in particular. If bacteria are causing the disorder, treat in the same manner as finrot. Use antibiotic food if the fish is eating, or add antibiotic to the water in a quarantine tank if the fish is too sick to eat.

Large external parasites (as opposed to Ich)
Anchor worms or leeches on fish can easily be seen without magnification as worm-like or insect-like animals on the skin of fish or on their gills.

> *Treatment:* Remove them from the affected fish with tweezers and swab the area with mercurochrome to prevent infection. Add a copper remedy to the tank and monitor it with a copper test kit. Also, Mardel's Maroxy works well.

Bloody Sores
Bacteria and virus both can make fish sick with bloody sores. Deep bloody sores require thorough investigation to determine what is causing them. Most will require consulting a local fish pathologist. The pathologist will determine if the cause is bacterial and recommend an antibiotic treatment or, if the infection is viral, a means of managing and preventing future infection.

Fish Disease References

The Manual of Fish Health
Dr. Chris Andrews, Adrian Exell and Dr. Neville Carrington.
New Jersey: Tetra Press, 1988
This is an outstanding book, and I highly recommend it to anyone who is interested in reading about fish disease.

Fish diseases FAQ
Elaine Thompson
This is an excellent website
http://faq.thekrib.com/disease-fw.html

Textbook of Fish Health
Dr. George Post.
New Jersey: T.H.S. Publications, 1983
This is an outstanding book, and worth reading for who is interested in a deeper understanding of fish disease.

Handbook of Fish Diseases
Dieter Untergasser
Translation by Howard H. Hirschhorn
T.F.H. Publications, Inc., 1989
This is my second-choice disease book. It is very good, but some of the treatments may be difficult to obtain, and it goes into more detail than the average hobbyist needs (or wants) to know.