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Fish Ecology

Subject Area: Natural Science
Core Curriculum Content Standards: 3.3A, 3.4A, 4.2A&D 5.1A, 5.2, 5.3B, 5.5A&B, 5.6A, 5.8B, 5.10A&B, 6.6E

DESCRIPTION:

This field activity investigates the fascinating world of fish, from a scientific, historical, aesthetic, and recreational standpoint. Students will capture fish from Lake Wapalanne in order to get a close-up view of these marvelous creatures (all fish will be returned to the lake after observing them in a lakeside aquarium). Participants will have the opportunity to learn anatomical and morphological characteristics of fish, their life cycles and value to the wildlife community, threats to their habitats, current conservation efforts, and the historical and present day impact they have on our lives.

OBJECTIVES:

1. Students will develop an appreciation of how fish have helped to shaped human society and culture, both in the past and today.
2. Students will become familiar with basic fish anatomy and physiology.
3. Students will develop an appreciation of the ecological importance of fish in the ecosystem and the recreational value of the fish resource.
4. Students will develop techniques for capturing, marking and releasing fish.
5. Students will engage in scientific data collecting techniques
6. Students will learn about the effects of water pollution on this critical species.

MATERIALS NEEDED:

- Fishing Poles
- Tackle Box
- Worms or trowel and bucket for gathering worms
- Aquarium
- Scale
- Fish measuring ruler
- Large magnifying glass (4)
- Posters
- Field Guide
- Data sheets for recording captures

•Tagging apparatus (optional)

PROCEDURES:

1. Initiate a discussion about fish by asking each student to share something they know about fish. This is an excellent way to get everyone involved right away and gives the instructor an avenue to elaborate on what the students already know. Typically, topics that are brought up by the students include anatomical characteristics (scales, gills, fins, swim bladder, slimy mucus covering, skeleton, etc.), behavioral characteristics (feeding strategies, how prey escape from predators, predation by sharks – of course, reproductive tactics such as nest building, etc.), and a variety of other interesting characteristics. Keep the discussion going as long as you like (usually 20 to 40 minutes depending on the attention of the students) and try to interject concepts related to the food chain, pollution, fish contamination and the importance of keeping our streams, rivers, ponds, lakes and oceans free of pollution. End your discussion on a light note by asking students if they have any "fish stories" to share.
2. After your discussion, tell the students that they will be assisting in a research program at Montclair State University that is studying the fish population in Lake Wapalanne. The purpose of the research project is to characterize the current fish population in the lake and to track population changes over time. They will help to collect this population data by capturing as many fish as they can, identifying the fish species, weighing and measuring each fish, tagging the fish with a unique number, and recording the data in a field log.
3. Lead the students to the beach area of Lake Wapalanne behind Long House Dining Hall. Demonstrate the safety precautions everyone must follow when using a fishing pole. Pair up the students in the group and give each pair a fishing rod with a baited hook. Have the students spread out along the beach and earthen dam so that pairs of students will not interfere with one another. Explain to everyone that when a fish is captured, it should be brought to the instructor where they will assist in the identification, weighing, measuring, and tagging (optional) of the fish before it is released.
4. Use the remainder of the session to let the students capture as many fish as possible. During the capturing phase of the session, select one fish to remain in the holding tank (aquarium) until the end of the session.

SUMMARY:

Gather the students together and use the fish in the holding tank to go over some the anatomical features of the fish.
End the session with a brief discussion of the importance of protecting our fish resource from a biological, recreational, historical and aesthetic standpoint.

ADDITIONAL/ALTERNATE ACTIVITIES:

•Have the students make fish prints from the latex fish we have in the Nature Center.
•Have the students create imaginary fish with special adaptations that allow them to survive.
•Have each student write a short "fish story"
CLASSROOM ACTIVITY
•Have the students put together a classroom aquarium after they have done some research on the fish that will occupy the tank and the kind of habitat they require.

Additional Information for Fish Ecology

BACKGROUND INFORMATION:

Fish are the undisputed masters of the aquatic environment. Because they live in a habitat that is basically alien to humans, we have not always found it easy to appreciate the incredible success of these vertebrates. However, recent scientific research has shed some light on astonishing diversity of life history attributes of this important group of animals. Even so, the average American today is uninformed about this impressive group of species and the important role they play in the environment that sustains our existence.

The interaction between fish and humans has a long history that continues to grow today. Fish have played a direct role in human survival by providing us with a stable source of protein. Although humans acquire their nutritional requirements from a variety of sources, there are still many culture in the world that rely primarily on fish for their survival. In the United States, the importance of fish in contributing to our food requirements can be seen in any supermarket, most of which have separate seafood counters that sell a variety of fresh fish. In addition, a stroll down the canned foods aisle will reveal tuna fish, sardines, anchovies, hearing, and a variety of other creatures captured from their aquatic habitats. Fish are perhaps the only *wildlife* species regularly consumed by Americans (almost all other animal protein come from domestic stock such as cattle, chickens, turkey, and pigs).

It's not surprising that fish and fishing have been well represented in both fiction and non-fiction literature from around the world. From the often told "fish stories" of fishers to the formal writings of established authors,(e.g. Ernest Hemingway's Old Man and the Sea"), literature related to fish is abundant, spanning thousands of years of human culture. In addition to this rich literature, a variety of quotes and sayings surround our involvement with fish: "I am like a fish out of water" (Thomas Shadwell), "It's like teaching a fish to swim" (Anonymous saying), "Bait the hook well, this fish will bite" (Shakespeare), "It sticks like a fishbone in the throat" (Robert Trail Spence Lowell), "Fish and visitors stink in three days" (Ben Franklin), "The people are like water and the army is like fish" (Mao Tse-tung), "To fish in troubled waters" (Mathew Henry), "A woman without a man is like a fish without a bicycle" (Anonymous 1980's feminist slogan), and the proverbial "It always was the biggest fish I caught that got away" (Eugene Field) – and many, many more. Fish and humans have had a long history of interaction and our literature, past and present, reflect this close association.

Fish have also played role in human culture from an aesthetics standpoint. Ancient cave drawings have been discovered that depict a variety of different fish. A variety of pottery from ancient times to the present is decorated with fish. Important works of art that from Pablo Picasso, Salvador Dali, Paul Klee, Claude Monet, Leonardo Da Vinci, and many others have portrayed fish and are considered cultural treasures of our time. The ancient Japanese art of making fish prints from caught fish has been part of their rich cultural heritage for many thousands of years. Indeed, the aesthetic appreciation of fish and fishers has been, and continues to be an integral part of human culture.

From a recreational standpoint, fishing has always been a favorite American pastime, enjoyed by young and old - who doesn't have a picture, somewhere, of the first fish they caught as a youth? The range of recreational enjoyment spans every conceivable situation, from lazy summer days on the bank of a stream with a worm and a bobber, to an aggressive hunt from a high-powered boat with sophisticated tackle – and everything in between. Regardless of one's approach, fishing remains one of America's favorite pastimes – and rightly so. In addition to the recreational lure of capturing these wildlife species for fun and sport, hobbyists from around the globe have enjoyed watching fish with equal enthusiasm. Aquariums and artificial fish ponds have enchanted us for many years. From the simple goldfish bowl to the elaborate saltwater tanks that house exotic fish from the corral reef, watching fish is interesting and

entertaining, and gives many individuals a feeling of serenity. Just about every coastal state in America has a public aquarium that offers educational and aesthetic opportunities (New Jersey's state aquarium is in Camden – go visit this beautiful facility).

The countless number of individual fish making up better than 23,000 species, easily outnumber the four terrestrial vertebrate classes (amphibians, reptiles, birds and mammals) combined!

CLASSIFICATION:

Kingdom: Animalia
- Phylum: Chordata
  - Subphylum: Vertebrata
    - Superclass: Agnatha (jawless fish)
      - Class: Myxini (the hagfish)
        - -32 species
      - Class: Cephalaspidomorphi (lamprey)
        - -30 species
    - Superclass: Gnathostomata (jawed fish and all other vertebrates)
      - Class: Chondrichthyes (cartilaginous fish)
        - -630 species (all predators)
        - Subclass: Elasmobranchii (sharks, skates and rays)
        - Subclass: Holocephali (ghostfish)
      - Class: Osteichthyes (bony fish)
        - -over 22,000 species

GENERAL INFORMATION

- Fish are the undisputed masters of the aquatic environment
- Fish have enjoyed an adaptive radiation easily as spectacular as that of all the land vertebrates
- 23,000 species and counting
- The success of fishes can be attributed to perfect adaptations to their dense medium (see below)
- Fish have excellent olfactory and visual senses. A unique lateral line system, which can sense water currents and vibrations in the water column, acts as a "distant touch" organ.
- Fish gills are the most effective respiratory devices in the animal kingdom for extracting oxygen from water.
- Fish are excellent osmotic regulators, capable of fine-tuning their body fluids depending on whether they are in saltwater or freshwater.
- Fish have developed elaborate reproductive behavior concerned with courtship, nest building, and the care of the young.
- Fish comprise four of the eight vertebrate classes.

EVOLUTION:

Fish were the first vertebrates evolving sometime during the late Cambrian to early Ordovician period (about 500mya) from a common chordate (Anphioxus?). ancestor. The first fish were the jawless fish, which eventually gave rise to our present day hagfish and lamprey. Jawed fish first appeared in the fossil record during the Silurian Period 420 mya.

Fish are the ancestors of the tetrapods (vertebrates with four legs). The group of fishes known as the crossopterygians, of which there is only one living species, the coelacanth, is thought to be the closest ancestor of the tetrapods.

CHARATERISTICS of the BONY FISH (or Teleosts):

1. Skeleton made of bony plates
2. Body covered with scales
3. Swim bladder (buoyancy organ)
4. Closed circulatory system with 2-chambered heart
5. Respiration via gills
6. Dioecious (male and female organs in separate individuals)
7. Fertilization almost always external (as opposed to the Chondrichthyes or cartilaginous fish)

LOCOMOTION IN WATER:

Most fish, like trout and minnows, can move 10 body lengths per second, an impressive performance by human standards. However, when we convert this figure to miles per hour, a 1-foot trout can swim only about 6.5 mph! Obviously, the larger the fish the faster it can swim. The following speeds have been calculated for several species using average sizes: salmon=14mph; barrracuda=27mph; swordfish and marlin=68mph. But these speeds can only be maintained for very brief periods of time – cruising speeds are much lower. The propulsion mechanism of the fish is its trunk and tail musculature.
Swimming is possible only because of the density and non-compressibility of water. The density of water is only slightly less than that of living tissue, thus most aquatic animals are almost perfectly supported and only need to provide a little energy to overcome gravity. Consequently, swimming is the most economical form of locomotion in the animal kingdom!

FEEDING BEHAVIOR:

Most fish are carnivores, eating everything from zooplankton and insect larvae to large vertebrates.
A second group of fishes are herbivores that eat algae, grasses and flowering plants. Although there are not many plant eaters, they are crucial intermediates in the food chain, especially in freshwater rivers, lakes and ponds that contain very little plankton.
A third, group of fish is the filter feeders. These fish harvest microorganisms from the sea and include a diverse group ranging from fish larvae to basking sharks. However, most of the filter feeders are from the herring-like fishes (herring, anchovies, capelin, pilchads, menhaden, and others) that roam the open ocean in large schools. Both phytoplankton and the smaller zooplankton are strained from the water with a sieve-like devise called the gill rakers. Plankton feeders are the most abundant of all fishes and provide food for the less numerous carnivorous fishes higher on the food chain. Many freshwater fishes, especially members of the large cichlid family, also depend on plankton for food.
A forth group of fishes are omnivores that feed on both plants and animals. Finally, there are the scavengers that feed on organic debris (detritus) and the parasites that suck the body fluids of other fishes.

COLORATION AND CONCEALMENT:

Not unlike terrestrial insects, tropical fish that live around the corral reef, possess two strategies for avoiding being eaten: concealment and advertisement. Blending into your surroundings is a plausible avoidance strategy, and many corral reef fish have been selected for being cryptic. Many others, however, are brightly colored and rely on alertness, agility and/or poisonous flesh to avoid predation.

Most freshwater fish wear subdued shades of green, brown, or blue above, grading to silver and yellow-white below. This obliterative shading, often enhanced by blotches, spots and bars, makes the fish almost invisible from above. Some fish can actually change their coloration to harmonize with the patterns of their background.

Another form of concealment is protective resemblance or mimicry. Pipefish are the shape and color of the seaweeds in which they live. Pipefish even sway slowly lake seaweeds in a gentle current. There are many other examples of mimicry in the fish world.

MIGRATION:

Most fish are migratory to some extent, and some, such as freshwater eels and anadromous salmon, make remarkable migrations of great length and precision.

The European eel (*Anguilla anguilla*) and the American eel (*A. rostrata*) have an interesting migratory story that was illuminated in the early 1900's by Danish scientist Johann Schmidt. Systematic studies by Schmidt revealed the following scenario: Adult eels leave the coastal waters of North America and Europe in the Fall and travel steadily to a breeding ground located in the warm waters of the Sargasso Sea off the coast of Bermuda. Here, at a depth of 300 meters they spawn and die. The minute larvae begin an incredible three-year journey back to the coastal waters of Europe and North America. At the end of the third year, now at the mouths of coastal rivers, they metamorphose into small eels called elvers. Here, the males and females part company with the males staying in the brackish coastal rivers and estuaries and the females swimming up the rivers, often traveling hundreds of miles up stream. After 8 to 15 years the females swim down river, and travel with the males to the breeding grounds in the Atlantic.

Perhaps the most widely known fish migration is that of the salmon. Salmon are anadromous; that is they spend their adult life at sea then return to fresh water to spawn. There are six species of Pacific salmon and a single Atlantic salmon species. After spending nearly 4 years in the ocean, salmon return to the same stream that they originated in (some straying does occur and is an important means for increasing genetic diversity). They are guided up stream by the characteristic odor of their parent stream. The odor imprinting occurs before hatching since eggs that are moved to another stream produce salmon that return to the original stream to reproduce. But how do the salmon find the mouth of their river after spending 4 years at sea? Odor still plays an important role even hundreds of miles away from the mouth, but recent research suggests that salmon may use the sun and stars to guide their migration. Amazing!

REPRODUCTION AND GROWTH:

The vast majority of fish are dioecious (male and female sex organs in different individuals), with external fertilization and external development of the eggs and embryos (oviparous). Most fish spawn at certain times or seasons within a restricted range of temperature. Temperature is critical both for successful spawning and for the survival of the sensitive eggs and young. Egg laying behavior is highly variable: some merely casting eggs into the current, some attach them to vegetation, some lay their eggs in nests, some burying them, while still others incubate the eggs in their mouths. The males of many fish species guard the egg cache against predation. Freshwater fish typically produce non-buoyant eggs. Fish that guard their eggs produce fewer and larger eggs that those fish that don't guard.

There are two other modes of reproduction in fishes: internal fertilization with external development and internal fertilization with internal development. The second of these two

modes is practices by the live-bearers. The guppy is an example of a typical live-bearer where the eggs are fertilized within the ovarian follicle where they develop for a time. Then the follicle ruptures and the embryos complete their gestation in the cavity of the ovary (ovoviviparous).

Growth is temperature dependent. Fish growing in temperate regions, like ours, grow rapidly during the summer months. The age of a fish can be determined by annual growth rings on their scales (much like trees rings). Unlike birds and mammals who reach a definitive adult size, fish continue to grow after reaching sexual maturity, for the rest of their lives. This is possible because the dense medium in which they live (water) offsets the pull of gravity. Large size in fish has probably been selected for, since larger fish produce more germ cells than small ones, and thus have greater contributions to future generations.

THREATS TO FISH:

•More people are living near the ocean and by 2010 at least 53 percent of the population of the United States is expected to live within 50 miles of the ocean. Untreated waste can sometimes enter the water and create problems for the fish.
•Commercial fishers are using high tech methods of fishing to maximize their take. Unfortunately, many fish are being over harvested.
•Boats with motors discharge oil and gas into the water, polluting the fish habitat.
•Non-point source pollution such as fertilizers, insecticides, and oil find their way into the water via storm drains and runoff. These pollutants degrade the water environment and contribute the toxic contamination of fish.

FUN FACTS:

•You can tell the age of a fish by looking though a microscope at the rings on the scales, which are added each year, just like the growth rings of a tree.
•Most fish have nostrils, and many can smell quite well. Salmon return to their birth place to spawn by 'smelling' their way back to their natal stream.
•Most fish have fins but not always the same size or shape. Fins help the fish swim and keep their balance.
•Most fish have one eye on each side of their head (like where your ears are!). Some bottom feeding fish like flounder have two eyes on one side of their head.. Some fish who live in deep water where the light cannot penetrate, are blind. Fish don't have eyelids, so their eyes are always open.
•Fish are 'cold-blooded' – their body temperature is the same as the water around them.
•Fish are vertebrates – animals with backbones.
•Fish and fish products are combined with other products to make fertilizer, pet food, ink, glue, and food for livestock.
•The most primitive fish are the jawless fish (hagfish and lampreys). These fish have no scales, are eel-like in appearance, have bodies covered with a very sticky substance, and are common in the Big Flatbrook, at the School of Conservation.
•Most fish have skeletons made of bones but some fish (sharks and rays) have skeletons made of cartilage. Cartilage is a rubber-like tissue similar to what you find in your ears and at the tip of your nose.
•Most fish have swim bladders located right under their backbones. These organs are filled with gas – regulated by the fish - and help the fish remain buoyant. When the fish wants to rise it adds gas to the bladder, when it wants to sink gas is expelled.
•Three-fifths of all fish live in saltwater

•Fish spend most of their time looking for food and trying to avoid being eaten themselves. Very few fish die of old age. They protect themselves from predators by hiding, swimming fast, thick scales, spines, or enlarging themselves - like the puffer fish.