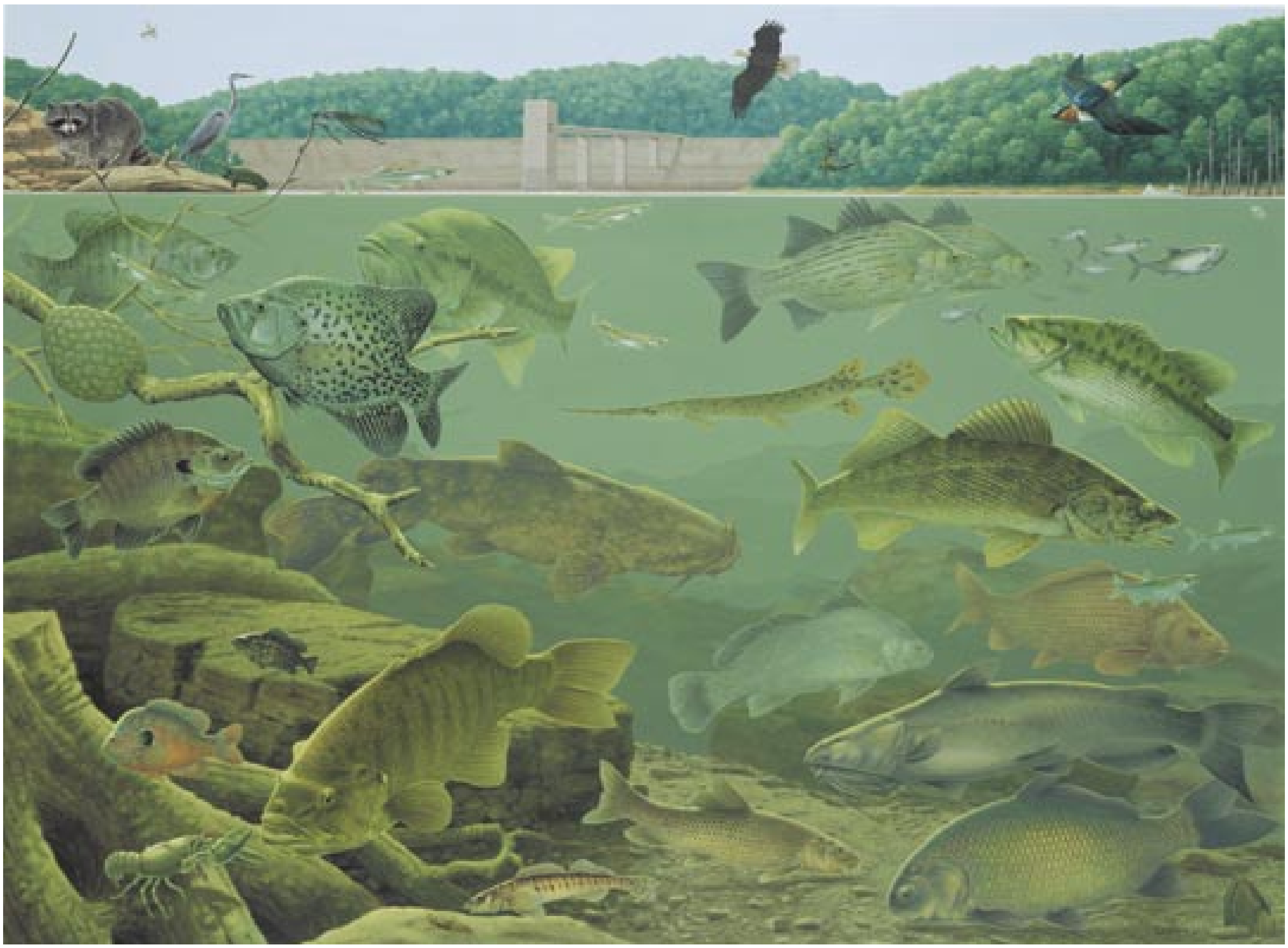
Upland Reservoir Ecosystem



KENTUCKY DEPT. OF FISH & WILDLIFE RESOURCES

Teacher's Guide

INTRODUCTION

Through the course of the river continuum series of posters, we have discussed the possibility of getting wet and investigating a similar resource. With an Upland Reservoir, we recommend either exploring shorelines or investing in life jackets, scuba diving gear, and an appropriate boat.

Upland reservoirs are found reasonably high in the watershed. They are typically built on rivers that receive water from numerous small streams or rivers. Because each watershed is different in many ways, it is impossible to describe the "typical" reservoir. The one common ingredient is these watersheds were historically prone to flooding. Therefore, the Corp of Engineers built reservoirs to control floods in the watershed below each reservoir. This is the primary reason most reservoirs have been built. Electrical power generation, irrigation water, and human recreation opportunities (fishing, boating, beaches, etc) are, in most cases, simply beneficial by-products.

A great deal of the management theory of upland reservoirs depends on annual rainfall and anticipated peak periods of rain. Each individual reservoir may be drawn down at a different time to provide storage for anticipated floods in the next few months. At winter pool, you may see exposed banks, mud flats, and trees that had been submerged. After a period of heavy rain, a given reservoir may be high into the trees on the shoreline, above summer pool. This high degree of fluctuation makes it difficult to manage marinas or boat ramps. Fish reproduction may also suffer if fluctuations persist.

Again, it is difficult to describe a typical upland reservoir, but most reservoirs of this type are deep and reasonably clear when the water supply settles in the summer. This may vary within a reservoir, with different bays exhibiting vastly different depth and water clarity. This simply indicates the dynamic nature of water as it is related to the surrounding watershed.

The entire poster series and teacher guides have been created through funds from the Sport Fish Restoration Program. **The goal is to educate all people on the importance of healthy aquatic systems and their relationship to lifelong aquatic recreation.** Each section of this guide is intended to give you, the teacher or youth leader, knowledge on the given subject followed by activities. For Kentucky teachers, each activity is followed by one KERA Academic Expectation to illustrate various expectations that may be accomplished with this guide.

To improve our efforts, please fill out the evaluation on the following page. If you adapt other activities to this poster, please include basic information and we can pass that on to other teachers in the future. Please send all comments to:

Aquatic Education Administrator
KY Dept. Fish and Wildlife Resources
#1 Game Farm Rd.
Frankfort KY 40601
(800) 858-1549
lonnie.nelson@ky.gov

EVALUATION

Name: ______________________________ Grade taught: ____________________

School: ______________________________ Phone: ____________________

Address: ______________________________ e-mail: ____________________

____

1. I received my Upland Reservoir Ecosystem poster and teacher's guide from the following source.

____

2. On a scale of one to ten, please evaluate the poster in comparison to similar materials you have received.

1 2 3 4 5 6 7 8 9 10

3. What did you like most or least about the poster to rate it as you did?

____

4. How have you used this poster?

____

5. On a scale of one to ten please evaluate the teacher's guide you received in comparison to other similar products?

1 2 3 4 5 6 7 8 9 10

6. What did you like most or least about the teacher's guide to rate it as you did?

____

7. What other aquatic related materials would you find useful in your class or youth group?

____

ADDITIONAL COMMENTS (PLEASE INCLUDE HERE ANY ACTIVITIES YOU HAVE DEVELOPED FROM THIS POSTER):

I REQUEST THE FOLLOWING:

☐ Contact me with Project WILD training opportunities.

☐ Place me on a mailing list for future materials.

Please send copies of the following ecosystem posters for teachers at my school.

☐ copies of Upland Reservoir Ecosystem.

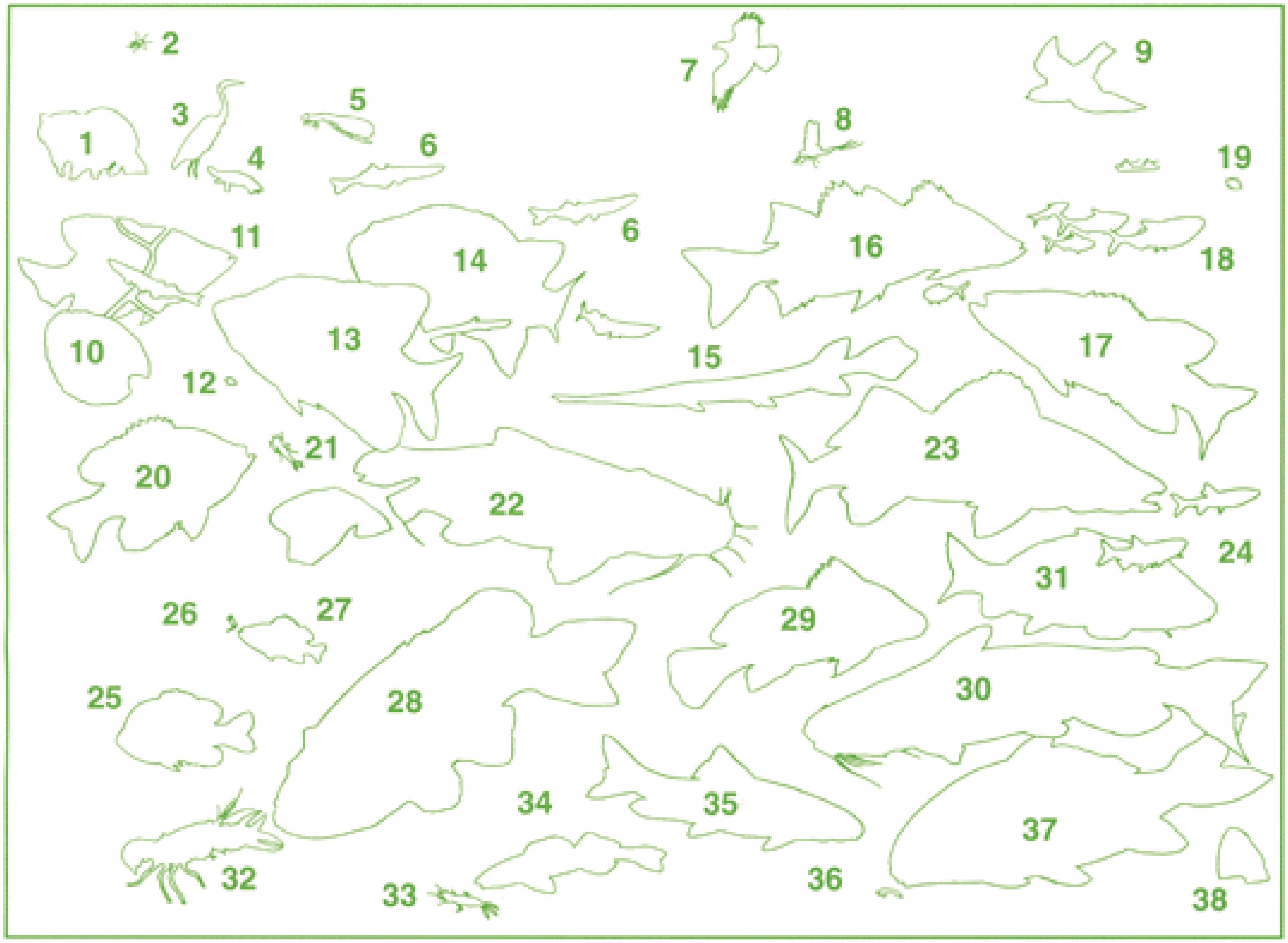
☐ copies of Stream Ecosystem.

☐ copies of Wetland Slough Ecosystem.

☐ copies of Small Stream Ecosystem.

☐ copies of Big River Ecosystem.

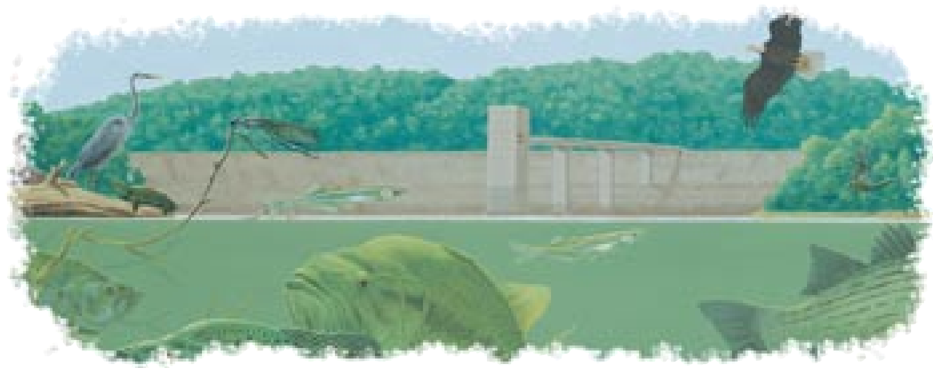
☐ Other



1. Raccoon *Procyon lotor*
2. Midge *Tanytarsus spp*
3. Great blue heron *Ardea herodias*
4. Red-eared slider *Trachemys scripta elegans*
5. Violet tail damselfly *Argia violacea*
6. Brook silverside *Labidesthes sicculus*
7. Bald eagle *Haliaeetus leucocephalus*
8. Brown drake mayfly *Ephemera simulans*
9. Cliff swallow *Petrochelidon pyrrhonata*
10. Bryozoa *Pectinatella magnifica*
11. White crappie *Poxomis annularis*
12. Snail *Aplexa* spp
13. Black crappie *Poxomis nigromaculatus*
14. Largemouth bass *Micropterus salmoides*
15. Longnose gar *Lepisosteus osseus*
16. White bass *Morone chrysops*
17. Spotted bass *Micropterus punctulatus*
18. Gizzard shad *Dorosoma cepedianum*
19. Freshwater jellyfish *Hydra spp*
20. Bluegill *Lepomis macrochirus*
21. Violet tail damselfly larva *Argia violacea*
22. Flathead catfish *Pylodictis olivaris*
23. Walleye *Stizostedion vitreum*
24. Emerald shiner *Notropis atherinoides*
25. Longear sunfish *Lepomis megalotis*
26. Midge pupa *Tanytarsus spp*
27. Warmouth *Chaenobryttus gulosus*
28. Smallmouth bass *Micropterus dolomieui*
29. Freshwater drum *Aplodinotus grunniens*
30. Channel catfish *Ictalurus punctatus*
31. Carp *Cyprinus carpio*
32. Crayfish *Cambarus ssp*
33. Brown drake mayfly nymph *Ephemera simulans*
34. Logperch *Percina caprodes*
35. Spotted sucker *Minytrema melanops*
36. Caddisfly larva *Rhyacophila spp*
37. Smallmouth buffalo *Ictiobus bubalus*
38. Giant floater mussel *Pyganodon grandis*

"TO DAM OR NOT TO DAM", THAT IS THE QUESTION

In the 20th century, a number of reservoirs were built in Kentucky. Since 1990 a few more have been proposed, but only one reservoir has actually been completed. While the snail darter issue was credited with stopping a major impoundment in Tennessee, in Kentucky we have had controversy of our own.



One such case was in the Red River Gorge. A reservoir was proposed for the Red River but the landowners did not want to lose their land nor the land mark gorge. After a court battle, the reservoir was never initiated. In other cases in the past decade, the growing population has demanded more water in urban communities and reservoirs have been proposed. At this writing, no new reservoirs have been started to fulfill this need.

When the earliest reservoirs were constructed, flood control was a major concern and reservoirs were the answer. Early engineers looked at the watersheds, picked likely spots and began construction. There was limited research about the long-term effects on aquatic life, and the economic benefits outweighed potential biological costs.

Today we know that many species have adapted over time to **riverine** conditions. Aquatic species can live there despite flooding followed by extreme low water conditions, great fluctuation of temperature, and periodic heavy silt conditions. Many of these river species are not adapted to reservoirs with deep water, nearly constant temperature in the lower levels, and variable oxygen levels.

Therefore, what we find is that adaptable fish species do extremely well in a reservoir. Those fish that are specialized to specific conditions retreat to that portion of the watershed that is still riverine, where each species can find its required habitat conditions. In the case of mussels, however, migration is not an option, and many species have been eliminated from the impounded region of Kentucky watersheds. Also, if the water discharged from the bottom of a reservoir is constantly cold, the water temperature in the tail-waters may never reach the temperature that is required for reproduction for given aquatic species, including fish and mussels.

These "cold water tail-waters" have given rise to **mitigation**. One example of mitigation in Kentucky is the Wolf Creek Hatchery below Wolf Creek Dam. The hatchery was constructed and is operated to provide a constant supply of fish (trout) for given rivers below reservoirs where the environment has been changed. Historically most evidence indicates there were no trout in Kentucky and certainly no brown or rainbow trout. The mitigation, Wolf Creek Hatchery, provides trout to many tail-water areas in

ACTIVITIES:
1. Build a model of a reservoir in the student's community. Determine when and why it was built. Show features which make this reservoir unique or where different fish might be found.

Recommended for grades 5 to 9. **KERA Learner Outcome 2.4: Students use models and scale to explain or predict the organization, function, and behavior of objects, materials, or living things in their environment.**

2. See Project WILD Aquatic for "To Dam or Not to Dam".

Recommended for grades 5 to 8. Easily adapted for high school. **KERA Learner Outcome 5.3: Students create and modify their understanding of a concept through organizing information.**

Kentucky where the water is cold year-around. This allows trout anglers an opportunity to fish for a very popular game fish as a substitute for the fish they might have caught in the original river.

There is also an effort to re-establish mussels that are considered endangered, threatened or potentially could be so listed. In this case, captive breeding programs are being perfected to help mussels reproduce. The young mussels will then be placed in suitable habitat to try to re-establish those species. Beyond reservoirs, other factors that complicate the plight of the mussels include water pollution and introduction of zebra mussels.

THE JOY OF THE UNUSUAL

This is the fifth in the Ecosystem Poster series. In each individual poster, we have depicted a few species that are unique and unusual. This one is no different. There are at least two species represented that are at best misunderstood, and in most cases unknown. They are bryozoa and fresh water jellyfish.

Bryozoa

Bryozoa is a term that describes a variety of fresh water organisms. They typically live in **colonies** and probably originated in oceans. Their appearance is much the same as their salt water relatives (sponges) but they have adapted to survive in fresh water with some interesting characteristics. In some families they appear much like coral with the mass looking like plants with no leaves. In the one illustrated in the Upland Reservoir Poster, we see a "jelly like" mass which looks like a large fungus or strange egg mass.

The mass you observe is actually a multitude of individual animals living together. Each individual animal feeds independently with tiny tentacles guiding food particles toward the mouth. Bryozoa eat small animals called diatoms or other microscopic food particles. Their digestive system is simple with the waste products expelled very near the mouth.

When disturbed, each individual animal retracts its tentacles into the mass. This keeps potential predators from identifying them as individual food items. After they are undisturbed for a few minutes they will resume feeding, They live in this mass until it is exposed by decreasing water levels or when the water becomes colder. In both cases, the mass and the individual animals break apart leaving a "**statoblast**" from each individual as the next generation.

The statoblast may be smooth or have hooks on it to attach to vegetation. Those with hooks may also attach to migrating birds or animals and be transported to new locations. In some species they have a buoyant sheath which allows them to float freely. Even if exposed to dry air (droughts), they will survive until the area is once again flooded. Those found in the tropics also form statoblasts which illustrates this is a dual adaptation for cold water and drought conditions. Hatched individuals once again form a mass and repeat the cycle.

Fresh Water Jellyfish

Fresh water jellyfish or hydra are much smaller than their salt-water relatives, but similar. Each individual has tentacles on one end and a foot on the other. With their tentacles extended, they are no more than an inch long and when the tentacles are retracted they practically disappear.

These animals live as individuals. They normally attach to vegetation with their foot, and have been found "attached" to the surface layer of water. Hydra feed by guiding the food particles toward the mouth with the tentacles. There are poison sacs in the tentacle arrangement that provides some defensive potential, but this poison is much more likely used to subdue food.

Jellyfish are gluttonous feeders. When full, the body extends and food particles can be seen through the transparent body. The food is digested and waste products are expelled through the mouth.

Hydras reproduce by **budding** and by producing sex cells. It appears these two separate functions occur at different times of the year depending on the species and living conditions. Buds seem to appear when the animal is well fed (enough food for more animals). The new specimen remains attached to its parent for some time, but food may either be maintained in the new jellyfishes' body or shared with the parent.

Sex cells in most hydra are produced with thousands of sperm produced by the males and one egg by the female. In one species both male and female parts are on the same individual. Initially, the fertilized egg is maintained inside the adult, with a crude form of parental care.

Winter eggs are laid to allow the species to survive cold weather. These eggs are fertilized in late fall and form a protective shell. It is dropped from the parent's body and lays on the bottom of the reservoir until the following spring, when it hatches.

ACTIVITIES:

1. Have students identify an organism on the poster they would like to research. Have them look for those features that make it "unusual".

Recommended for grades 4 to 8.
KERA Learner Outcome 1.1: Students use research tools to locate sources of information and ideas relevant to a specific need or problem.

2. See Project WILD Aquatic for "Mermaids and Manatees".

Recommended for grades 5 to 8.
KERA Learner Outcome 1.11: Students communicate ideas and information to a variety of audiences for a variety of purposes in a variety of modes through writing.

FEAST OR FAMINE

The animals of the natural world are, in most ways, quite different from students. While a student selects the cloths they wear, the television program they watch, or the friends with whom they will talk/email tonight, the animals simply answer two primary questions: what do I eat today, and who is trying to eat me. So it is with the aquatic creatures that live in a reservoir.

Neither of these questions is easily answered nor can the animals get complacent that the answers today will be the same tomorrow. Everything changes daily, weekly, monthly and by the seasons. To explain this ever-changing environment, we'll start at the beginning of winter, Dec.22.

Winter

At the beginning of winter, the water is still cooling. The coldest water temperatures are typically in January and February. Another factor is sunshine. The shortest day is the first day of winter, plus the angle of sunlight striking the water is increased causing more reflection rather than light penetration. Plants, basic elements of the food chain, do not grow well in cold water and lack of sunshine. Most aquatic animals are known as "cold-blooded" or **poikilothermic** with greatly reduced metabolism rates during winter months. Therefore, everything is normally fairly quiet during the winter months.

One more factor that affects the food chain is the process of drawing the reservoir down to winter pool. To prepare for possible winter or spring floods, the reservoir managers reduce the water levels. Much of the normal hiding habitat for smaller fish and crayfish is now exposed. Therefore, predators may find more food concentrated in a smaller region of habitat.

In most cases, the animals now live on the energy they have saved during the previous summer and fall. For fish that were spawned in the spring, the first winter is extremely critical. Those who were hatched late in the annual spawn or those that did not have ample food supplies during the growing season may either perish as they use all their energy or become food for a larger fish when they get weaker.

Fish are more active in winter than other animals in the water. As fish are not truly cold blooded, their temperature will be a few degrees above the water temperature, and their metabolism rate is higher than other aquatic animals.

Each winter, there are periods with several days of warmer weather. After a few days of warmer air temperatures and sunshine, several species of reservoir fish will feed actively. It is not unusual to have anglers catch a limit of crappie or bass during these periods.

Spring

Ah, the warmth of Spring! This is a busy time for the survivors of winter. Plants respond to the warming of the water and increased hours of sunshine, and all animals respond similarly. As the water slowly warms and day length increases, each species reacts differently to prepare for **growth, maintenance**, and annual reproduction.

Springtime may bring wild fluctuation in water levels, water temperature, **turbidity**, and amount of floating debris. While these conditions are temporary, it can be frustrating when a family arrives for their spring break and finds the reservoir in a state that is not good for their intended recreation. But for the animals that live in the system, these are normal events, and life continues.

Reproduction is the prime consideration for most animal species in spring, and it requires energy, regardless what species we study. It is not unusual in early spring to find fish concentrated in a given area, eating to build up their fat supplies. Because females form the eggs, they need more energy. This is a probable factor in females being slightly larger in certain fish species, able to store more energy.

Timing is everything when it comes to spawning. If all conditions were perfect, those fish within each species that spawn earliest would have offspring that would grow best. They would be large enough to eat the offspring of later spawners, plus they would be the most aggressive predators when the young prey species such as bluegill, shad, and minnows hatch.

Unfortunately, everything is not perfect in the natural world. In some years, changes in water levels, water temperature, pH, or silt may eliminate the nests or offspring from certain spawning attempts. Therefore, it is important to have different groups of fish within each species that spawn repeatedly over a few weeks. That allows a much greater opportunity for some young for that species to survive and continue the species in the future.

The ability or inability to eat available food can be the difference in survival during the following winter. **Mouth gape**, or the size of the mouth, determines what prey can be eaten. If the young predator is hatched early and its mouth is large enough to eat prey species they grow rapidly.

In periods of drought, the number of days water remains in a given reservoir may be increased. In this condition plankton blooms increase and fish such as young-of-the year bluegill or shad will grow more rapidly, eating the plankton.

The young predator fish with smaller mouths, such as crappie may not be able to get individuals from these growing prey species in their mouth, while larger mouthed fish, such as bass, get more energy for each prey specimen they eat. This can contribute to poor year classes of one fish (crappie in this example) and good year classes of another (bass in this example).

Summer

As we transition from spring to summer, some dynamic changes are occurring in the reservoir. First, water levels will be stabilizing at or near summer pool with fairly stable conditions. The surface water warms and the reservoirs normally stratify. (See Recreational Opportunities.) Summer is also a peak period for **insect hatches** and crayfish reproduction. Some species of fish, such as bluegill, will continue to hatch well into the summer.

Insect hatches are important to those fish species in the food chain. While some insect larva (such as dragonflies) may serve as predators on newly hatched fish, aquatic insects in all stages are important food items for fish. First the larvae are available in the environment for several months. As they begin metamorphosis into an adult, insects are vulnerable as they swim or crawl toward the surface. In some cases they must stay on the surface for a short period while their wings dry. More are eaten in this stage. When insect adults return to lay their eggs in the water, they are again vulnerable to predation. All of this contributes to the growth and storage of energy for the fish.

Crayfish that are ready to reproduce are referred to as "in berry". Females will appear to have clusters of berries on the underside of the tail section. When the eggs hatch and young crayfish disperse from the female, they are small and excellent food for small predator fish. Adult crayfish are also vulnerable when they grow and shed their shells. In this stage they are referred to as soft-craws. One feature that crayfish have that allows them to survive attacks by predators is known as **regeneration**. One or both claws of the crayfish are sometimes pulled away by a predator. The crayfish survives and "regenerates" a new claw.

Fall

As summer winds down, the days again are getting shorter. Eventually, water temperatures will again be reduced as cool evenings cool the surface water. Plants begin to die back or at least not grow as readily. If too many die and decompose, the oxygen available in the water can be very low, causing stress to the fish and other aquatic animals or even "**fish kills**". This problem is usually accompanied by several days of cloudy weather where living plants receive no sunshine to produce oxygen through photosynthesis.

In the fall, the manager of each reservoir prepares for potential future floods by lowering water levels toward winter pool. Reservoirs also receive the leaves from surrounding forests that can stain the water with a brownish tint. Caused by tannic acid, it is soon diluted in large reservoirs and it does nothing to harm the fish. It may, however, be a contributing cause to less activity in feeding.

In most reservoirs, fall is another feeding opportunity. Shortening days and lower temperatures trigger the need to build up energy for the coming winter. Once again, a few days of warm weather can result in certain species feeding heavily on the available prey. One example of this is the feeding frenzies exhibited by white bass or their relatives, the striped bass. These fish gather in large schools and surround shad schools. They drive the shad to the surface and feed actively for several minutes. The water looks like it is boiling with so many fish eating or trying to escape. Anglers look for these "jumps" by watching the gulls that gather to share in the feast on shad.

ACTIVITIES:
1. See Project WILD Aquatic "Marsh Munchers". Adapt to reservoir species rather than those found in a wetland.

Recommended for grades K to 4.
KERA Learner Outcome 2.2: Students identify, compare, and contrast patterns and use patterns to understand and interpret past and present events and predict future events.

2. Encourage students to compare the needs of aquatic organisms in different seasons to their own needs or those of a pet as seasons change.

Recommended for grades 2 to 6.
KERA Learner Outcome 2.6: Students complete tasks and/or develop products which identify, describe, and direct evolutionary change which has occurred or is occurring around them.

RECREATIONAL OPPORTUNITIES

Kentucky has some of the finest recreational reservoirs in the nation. The fishing, boating, camping, and swimming provided on or near the water is a tradition in many Kentucky families. However, we must understand they were built primarily for flood control with hydroelectric power generation a secondary purpose. Herrington Lake is an exception having been built for electrical generation. (Flood control is still achieved by Herrington.) Recreational use is important to all managers, but primary purposes take precedence. Most reservoirs in Kentucky are managed by the Corp of Engineers. Exceptions are Kentucky Lake, managed by TVA, and Herrington Lake, managed by Kentucky Electric Authority.

Upland reservoirs are important for recreation but opportunities vary. Nearly all are scenic which encourages slower boating. Narrow, winding reservoirs deter speedboats and water skiers. Many of these lakes are very clear, and scuba divers enjoy the visibility. Fishing is also variable from one reservoir to the next.

For anglers, habitat defines the number of species and the quality (numbers and size) of any given species. Habitat is always a very complex formula in reservoirs. Water depth, steepness of the terrain underwater, availability of hiding cover, water clarity, temperature, land use in the watershed and nutrient loading are but a few of the variables which determine habitat quality. The habitat can be unbalanced in different directions by fluctuations in several combinations of variables. This is a great example of "**chaos in nature**".

NAME THAT TROPHIC LEVEL!

To better understand habitat in reservoirs, a short description of three trophic levels and their relationship to aquatic organisms is included here. Trophic levels are one of the major reasons why different systems have varying quantity and quality fish.

- An **OLIGOTROPHIC** aquatic system receives low levels of nutrients from the watershed. Without nutrients, aquatic plants grow sparsely and the resulting food chain is limited. Thus, predator fish at the top of the food chain, such as bass, experience either slow growth rates with normal populations or good growth with low numbers. Oligotrophic systems typically have clear water (visibility often to 20 feet or more) because of low phytoplankton/algae growth. Oxygen levels are usually within normal ranges to depths of 20 feet or more in summer months.
- **MESOTROPHIC** aquatic systems are "in the middle" in regards to nutrient loading. Here, plants provide a stable base for the food chain with occasional increased production or "blooms" by phytoplankton and algae. Animals in mesotrophic reservoirs usually exhibit normal growth rates. Water clarity is good, visibility several feet, decreasing during plankton blooms. Oxygen is usually at sufficient levels for aquatic life in lakes to depths of 10 - 20 feet in summer.
- **EUTROPHIC** lakes and rivers have high levels of nutrients, and resultant plant growth may become dominant. Plant eating animals may not be able to keep up with phytoplankton/algae blooms during the growing season. Predators usually have good growth rates because of an active food chain. Visibility in the water is limited with suspended plants noticeable. When excessive plants die, **decomposition** uses **dissolved oxygen**, which, in worst case, can cause fish kills. Oxygen becomes depleted below suitable levels for aquatic life at depths of 5 - 10 feet during the summer. NOTE: A eutrophic condition related to human activities is called "cultural eutrophication".

Reservoirs in Kentucky are referred to with these three terms, however, a reservoir which is referred to with one trophic level may have bays where the conditions are different. This may be due to land use activity within a small watershed or a sewage treatment plant from a community on that bay. Aquatic systems are extremely dynamic and trying to assign one trophic level to a complete body of water is no different.

ACTIVITIES:

1. Using the Upland Reservoir Ecosystem poster, have individual students give a presentation to the class on different organisms found in a reservoir. Presentation could include what they eat and who eats them.

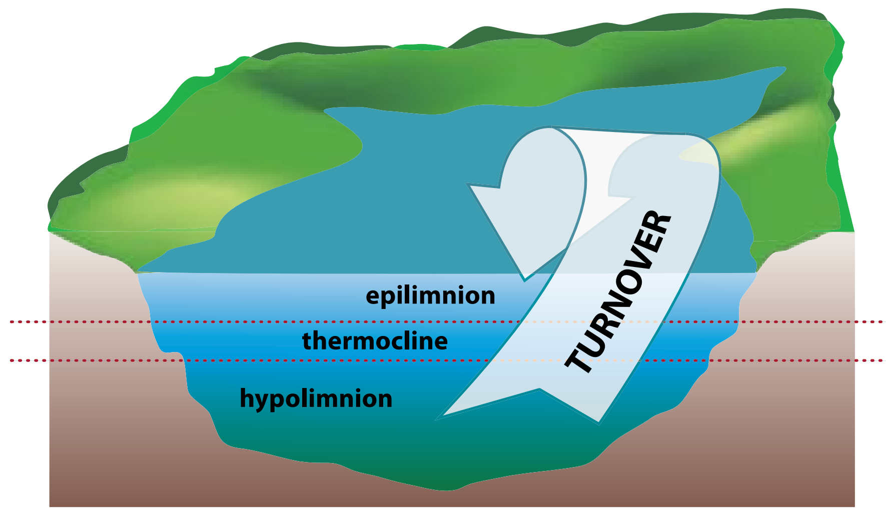
Recommended for grades 7 to 12.
KERA Learner Outcome 1.12: Students communicate ideas and information to a variety of audiences for a variety of purposes in a variety of modes through speaking.

2. See Project WILD Aquatic for "The Glass Menagerie".

Recommended for grades 9 to 12.
KERA Learner Outcome 2.5: Students understand the tendency of nature to remain constant or move toward a steady state in closed systems.

3. Establish an aquarium (without aerator) with room temperature water. Gently add a large quantity of ice cold, colored water to the aquarium. Repeatedly measure water temperature at both surface and at the bottom of the tank. Watch to see where the colored water goes. With a similar aquarium, start with cold water and gently add much warmer colored water. See if the colored water "stratifies".

Recommended for grades 2 to 7.
KERA Learner Outcome 2.3: Students identify and describe systems, subsystems, and components and their interactions by completing tasks and/or creating products.



STRATIFICATION AND TURNOVER

Another factor in reservoir habitat is temperature change from surface to bottom. In larger lakes during summer, layers of water develop with different temperatures. This is called **stratification**. Water is most dense at 39 degrees F., and is less dense if it is either cooler or warmer. In summer, water warmed by the sun is less dense, and it "floats" on the surface. The cold, denser, water sinks to the bottom. The warm water layer is called the "**epilimnion**" while the deep cold water is called the "**hypolimnion**". In between these two zones is a layer called the "**thermocline**". The thermocline is the plane or zone of maximum rate of decrease of temperature. The water in and above the thermocline has acceptable oxygen levels, while the cold water below is deficient of oxygen due to decomposition. Therefore, the thermocline, with acceptable oxygen levels at the boundary of temperature change, is an area of high fish concentration during summer when there are high surface temperatures.

Through the summer, the surface water continues to get warmer, and the cooler water at the bottom also gets warmer gradually. In the fall, air temperatures cool the surface water until the surface is cooler than the water on the bottom. The cool water then sinks, because it has higher density, and the warmer, less dense water rises. This is referred to as "fall **turnover**". The suspended nutrients from the bottom are carried with the water rising from the bottom, and become evenly distributed through the water column. This causes the water to look very muddy or turbid. Along with the nutrients, the food and oxygen are more evenly mixed and while fish were concentrated in the thermocline during the summer, they are more evenly distributed throughout the reservoir after turnover.

Turnover can happen again in springtime when surface water reaches 39 degrees F. (most dense) and bottom waters are still cooler (less dense). As the temperatures are closer, the spring turnover is less pronounced. In Kentucky, normal mixing due to winds and inflow of rivers usually masks the effects of spring turnover.

GLOSSARY

Budding – A method of reproduction where a portion of the parent becomes a separate organism. The new individual may remain attached to the parent or establish independently.

Chaos in nature – The ever changing, unpredictable circumstances of the natural world.

Colony – Several individuals living together for mutual protection, growth, reproductive potential or other beneficial factor.

Decomposition – The process of organic material breaking down to simpler forms that can be used for growth of new organisms.

Dissolved oxygen – Oxygen typically is dissolved in water at very low concentrations, less than 15 parts per million. This compares to earth's atmosphere at near 20% or 20 parts per hundred.

Epilimnion – (ĕp-lĭm´ nĭ•ŏn) The top or warm level of a lake that has separate layers of warm and cold water.

Eutrophic – A situation where a high level of nutrients in the water encourages plant growth.

Fish kills – Caused by conditions in the water that either removes or prevents replacement of dissolved oxygen. Oxygen levels fall below that level that is lethal to given species of fish.

Growth – One of the potential results when organisms gain energy. Fish grow nearly all their lives, with growth stopping in the last year when individuals begin using all stored energy and slowly degenerate. Excess energy, after growth and maintenance are accomplished, is available for reproduction.

Hypolimnion – (hī´ po-lĭm´ nĭ•ŏn) The bottom or cold level of a lake that has separate layers of warm and cold water.

Insect hatches – The final stage of metamorphosis as insects change into adults. This is a signal for fly fishers as they attempt to "match the hatch".

Maintenance – One of the potential results when organisms gain energy. Individuals need to maintain their body to heal injuries or recover from various stress factors. Excess energy, after growth and maintenance are accomplished, is available for reproduction.

Mesotrophic – (mĕz´ə-trō´ fĭk)A condition where normal levels of nutrients are available for plant growth.

Mitigation – The process of replacing a lost resource with a similar resource.

Mouth gape – The size of the mouth opening which determines what sized prey species can be eaten.

Oligotrophic – (ŏl´ ĭ-gō-trō´ fĭk) A condition where low levels of nutrients inhibit plant growth.

Poikilothermic – (poi´kĭl-ə-thûr´mic) The scientific term to describe cold-blooded.

Regeneration – The ability to replace a lost body part.

Riverine – Refers to conditions that are associated with moving water – rivers.

Statoblast – An enclosed reproductive feature left by dying organisms to allow the species to survive through harsh conditions.

Stratification – A process where warm less dense water rises and creates layers of water with different temperatures and dissolved oxygen levels.

Thermocline – The layer of water in a stratified water body where the temperature change is greatest, but still has ample dissolved oxygen.

Turbidity – A condition where visibility through the water is greatly reduced.

Turnover – A situation where surface water reaches a density greater than the water at the bottom, sinks toward the bottom, and is replaced on the surface with water that was on the bottom but is now less dense.