

Envirothon Fish Study Guide

Ichthyology: study of fishes

Biology, classification, life history

Worldwide- over 30,000 species of fish

Freshwater Fish: fish that spend most or all of their lives in freshwater, such as rivers and lakes, with a salinity of less than 1.05%

Primary Freshwater Fish: those with little or no tolerance of brackish water

Secondary Freshwater Fish: tolerant of brackish waters but normally occur in inland aquatic systems rather than the sea

Classifying Freshwater Fish: Freshwater fish species are generally separated into one of three different categories based on water temperature and the associated amount of oxygen in the water at each temperature range.

- Warm water
 - These fish can live in a wide range of conditions. **Largemouth bass, bluegill, catfish, crappies and sunfish** are all considered warm water species. Although they can survive cold winters in the northern states and can be found throughout most of the U.S., warm water species will thrive best when water temperatures are around **80 degrees Fahrenheit**.
- Cold water
 - Coldwater fish species require cold water temperatures in order to survive. **Trout, Salmon, and Smelt** are some of the most common coldwater game fish species. These types of freshwater fish prefer water temperatures **between 50 and 60 degrees**. Because these species grow best in colder temperatures they are most often found in the northern states or states with higher elevation and cold wind temperatures.
- Cool water
 - **Muskellunge, northern pike, walleye, and yellow perch** are among the most common cool water game fish species. These types of freshwater fish prefer water temperatures in-between the other two categories. Because these species grow best in water temperatures that **range in the 60's and 70's**, they are most often found in the northern and midwestern states

Meristic Trait: Meristics is an area of ichthyology which relates to counting quantitative features of fish, such as the number of fin rays or scales. A meristic (countable trait) can be used to describe a particular species of fish, or used to identify an unknown species.

Dichotomous Key: A dichotomous key is a tool that allows the user to determine the identity of items in the natural world, such as trees, wildflowers, mammals, reptiles, rocks, and fish. Keys consist of a series of choices that lead the user to the correct name of a given item.

"Dichotomous" means "divided into two parts".

Bony Fish: a fish of a large class distinguished by a skeleton of bone, scales, paired fins, one pair of gill openings, jaws, and paired nostrils.

Anadromous: fish, such as salmon, migrating up rivers from the sea to spawn. Anadromous fishes spend most of their adult lives at sea, but return to freshwater to spawn

Catadromous: fish, such as eels, migrating down rivers to sea to spawn. Spending most of their life in freshwater systems but return to saltwater to spawn

Diadromous: A general category describing fish that spend portions of their life cycles partially in fresh water and partially in salt water. These represent both anadromous and catadromous fish.

Where is fish diversity (richness is a better term) the highest in North America?

The Mississippi River basin, more specifically the southeastern Appalachian region is the most diverse. The East has more species than the west in the U.S.

What is a chordate?

An organism that has 5 major characteristics:

1. Notocord- is an elastic, rod-like anatomical structure
2. Hollow dorsal nerve cord-neural tube is the embryonic precursor to the central nervous system, which is made up of the brain and spinal cord
3. Endostyle- endocrine gland- may be a precursor to the thyroid gland
4. Pharyngeal slits- filter feeding organs
5. Post anal tail

Which families have an adipose fin?

Ictaluridae, Salmoniformes.

Which families have no jaws?

Petromyzontidae

Situational Questions:

What happens when bluegills or other sunfish are overpopulated or crowded?

They prey on bass eggs and fry and prevent them from reproducing successfully.

Fish have been found in fields or streets after a heavy rain, however it obviously does not rain fish. Explain how this is possible.

These fish swam there from nearby creeks or ponds during high water and later became stranded when water levels returned to normal.

Where are large fish often found in spring and summer?

Shallow water- more food sources available

When is the best time of day to catch fish?

Early morning and late afternoon

How can you determine the age of a fish?

Counting the annual growth ring of scales, otoliths (calcified ear structure), rays, or other bony structure.

Night habits of fish:

Some fish "sleep" by remaining quiet on the bottom at night, others, such as catfish, are most active and feed primarily at night.

Many fish can change their color to match their surroundings for protection. The fish see changes in color and expand or contract pigment cells in the skin to match the background.

True or false?

True

What should you do before handling fish that are to be returned to the water unharmed?

Wet your hands.

Fish do not have a high degree of intelligence. What do they rely on?

Their five senses- sight, hearing, vibration detection, smell, and taste.

How do fish "hear" in the water?

Fishes have no external ears, but "hears" with its inner ear and connecting air bladder which serves as an underwater microphone. In addition to their inner ears, fish have a second sensory system known as the lateral-line which extends along the fish's sides and detects water movements

Baitfish: Small-sized fish (or small organism) caught and used by anglers as bait to attract larger predatory fish, particularly game fish

Commercial Fish: species of fish permitted to be taken, possessed, bought, or sold

Endangered/Threatened: An endangered species is defined under the E.S.A. as "any species which is in danger of extinction throughout all or a significant portion of its range" and is illegal to possess or sell

Non-Game Fish: Any species not specifically categorized as game, with the exception of those considered endangered. They typically have no commercial value because they aren't appetizing, often thanks to larger scales and more bones

Sport Fish: A type of fish that is prized for the sport it gives the angler in its capture rather than for its value as food

HOW TO IDENTIFY FISH

West Virginia's 182 fish species are grouped within 24 different taxonomic families. Most species are found within the families *Cyprinidae* (minnows and carps), *Percidae* (darters and perch), *Catostomidae* (suckers), *Centrarchidae* (basses and sunfish) and *Ictaluridae* (catfishes). Other fish families may not be as prevalent, but are noteworthy because they are popular with anglers. This includes *Salmonidae* (trout and chars), *Esocidae* (musky and pikes), and *Moronidae* (white, hybrid and striped bass).

Key words and definitions:

Dorsal- top of fish

Ventral- bottom of fish

Anterior (cranial)- front of fish

Posterior (caudal)- back of fish

Lateral line- sensory system with pores and canals that detect vibrations and water movement

Operculum- gill cover, occurs in bony fishes

Homocercal- caudal fin that is equal on upper and lower lobes

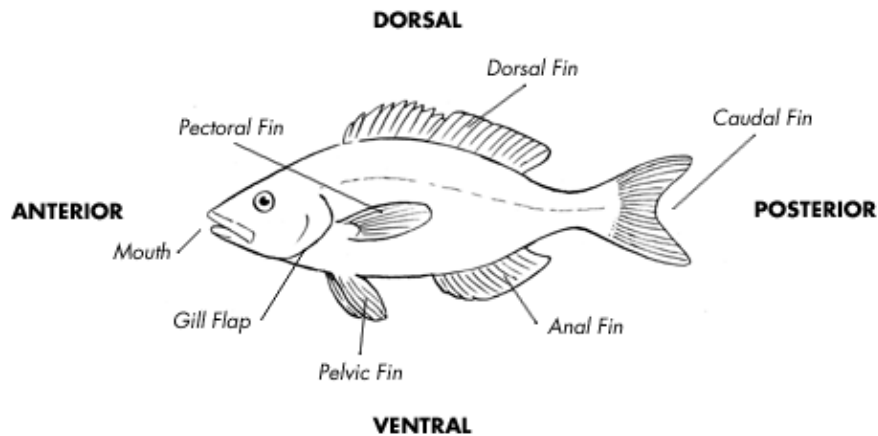
Heterocercal- caudal fin that is unequal on upper and lower lobes

Spawning Types:

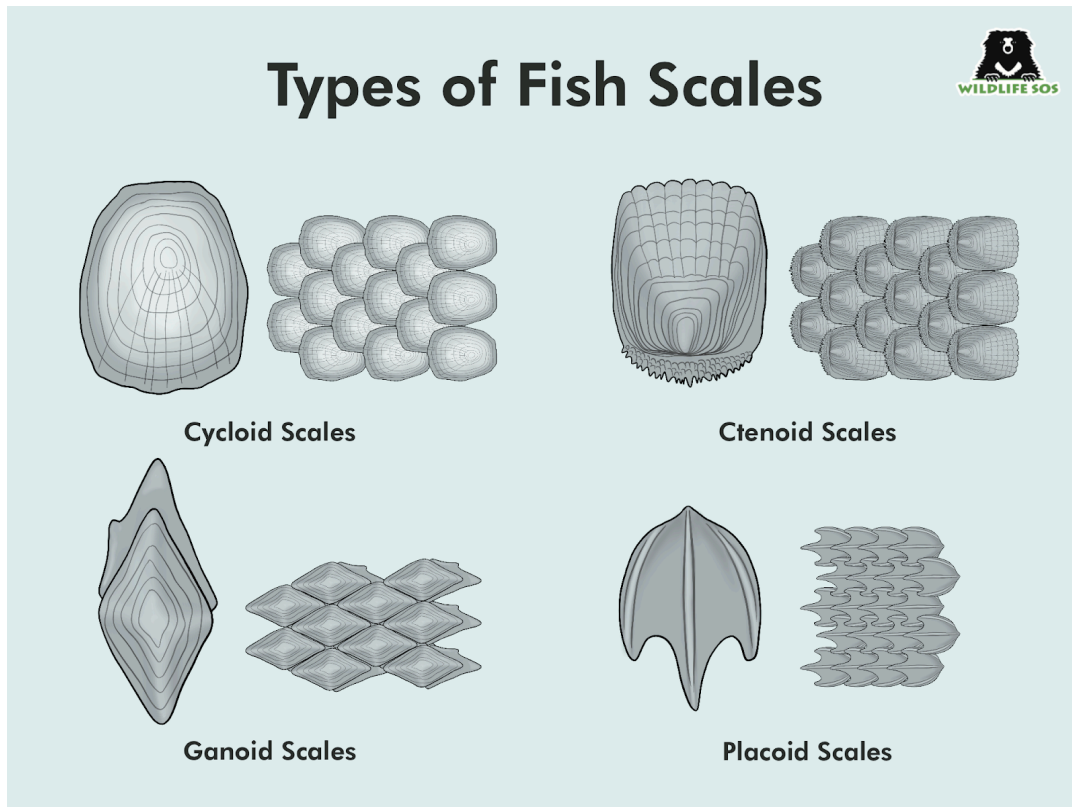
- Broadcast: spawning is a group activity where eggs are released from female body cavities straight into the water and male milt is also released in the area
 - Example: gizzard shad, paddlefish
- Nest builders: species will collect rocks or other substrate materials to build mounds
 - Example: creek chubs, lamprey species
- Substrate spawn: species will spawn in gravel or in previously made mounds, this is known as nest association
 - Example: redbreast dace
- Cavity nester: species will pick a spot such as under a ledge or a log and will protect it
 - Example: flathead catfish

When identifying a fish, look for the following characteristics:

- Dorsal Fin: Does the fish have one or two? Are the fin rays hard or soft?
- Pelvic Fin: Where are they located? Up front near the throat or farther back?

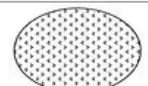


- Caudal fin: what shape is it
 - Caudal fins are associated with a species swimming behavior
 - Slower moving fishes- usually have rounded caudal fins
 - Faster swimming fishes- usually forked w/ stiff upper and lower lobes
- Adipose Fin: This functionless, fatty fin is found on trout and catfish? Does this fish have one?
- Scales: Does the fish have scales? If so, how big are they? What shape are they?

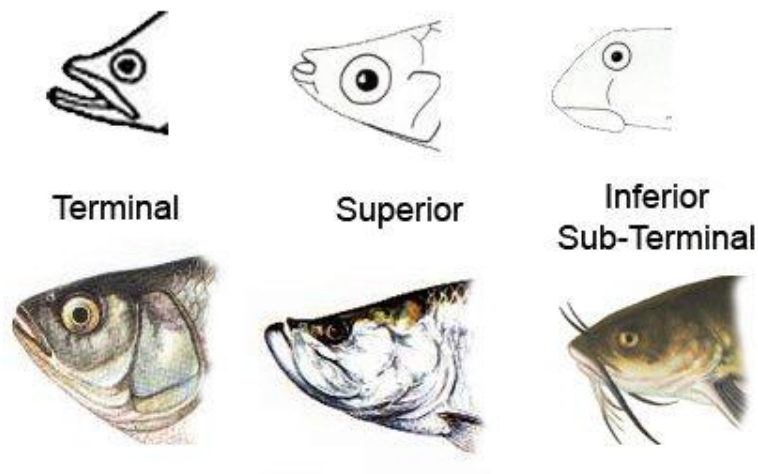


- Shape: Is the fish flattened from top to bottom like a sculpin or flattened from side to side like a sunfish?

Body shapes

CROSS-SECTION BODY SHAPE	TYPE	EXAMPLE	FISH	CHARACTERISTICS
	fusiform		Tuna Jack- Crevelle Salmon	Fast swimming, very streamlined, open water fishes
	compressed		Angelfish Filefish	Not constantly swimming, require bursts of speed, among coral or rocks
	depressed		Skates, Rays Angel Shark Flounder	Flight like swimming, may live on or near the bottom
	eel-like (anguilliform)		American Eel	Elongate, thin body, moves like a wavy ribbon, around or under rocks
	combination of shapes (globiform)		Lumpsuckers Frogfish	May be slow-moving, may be deep-water dwellers

- Mouth: Where does the mouth point and what do the lips look like? How does the mouth work and how big is the mouth? Does the head or mouth have visible barbels, such as whiskers on a catfish?



- Color: Are the fish's color patterns plotched, striped, spotted, etc.?
 - Cryptic coloration: coloration that matches surrounding areas
 - Example: catfish with darker coloration on the top of their body versus lighter coloration on the bottom of their body, these fish dwell on the

bottom therefore the coloration needed to blend in to their habitat is the top of their body

- Example 2: fish in the Ohio River are usually more muted in coloration and silvery to blend in to the water while tropical fish are bright and blend in with brightly colored coral and plants.
- We do have some stream jewel fish that are brightly colored for spawning such as the candy darter and mountain redbelly dace

COMMONLY MISIDENTIFIED FISH/HOW TO SPOT THEM

Even if you know what you're looking for, misidentifying a fish can happen to the best of us. The following species are commonly mistaken or of key management interest:

- Channel versus blue catfish
- Largemouth versus spotted bass
- Black versus white crappie
- Darters versus sculpins
- Common carp versus buffalo
- Northern snakehead versus bowfin

WHY YOU NEED TO KNOW HOW TO IDENTIFY FISH

Knowing characteristics critical to your fish's identification is important for:

- Complying with fishing regulations and creel and bag limits.
- Identifying invasive species prohibited for bait fishing.
- Determining minimum lengths for trophy citations or state record contenders.
- Researching lures, tactics and habitats for more successful angling.
- Developing a greater understanding of fish communities, relationships among species and their associations with habitats provided by local fisheries.
- Furthermore, familiarity with a multitude of sport and non-sport fishes is a characteristic of a well-rounded angler. The more you learn about any given fish species in West Virginia, the more you realize its role in our state waters and the more demystified and interesting the hidden lives of fish become.

Invasive Aquatic Species

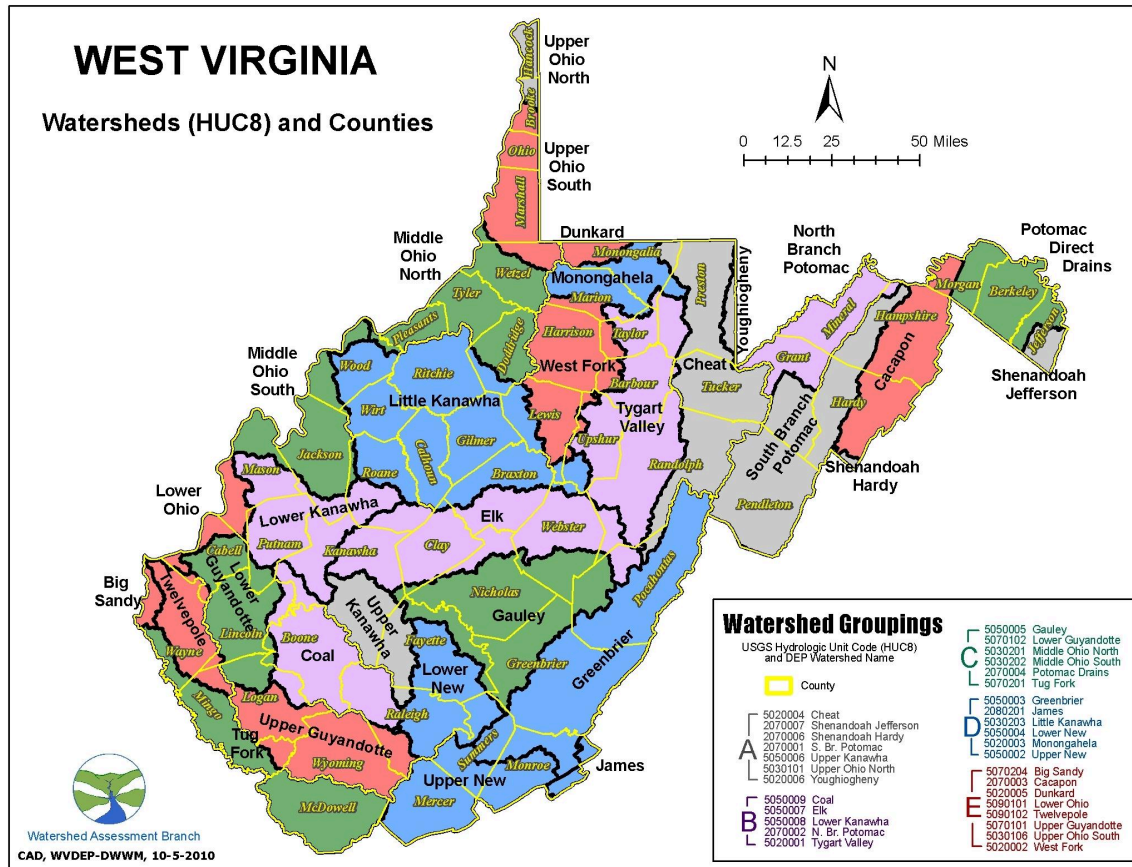
West Virginia also has aquatic invasive species. Didymo, a microscopic algae, produces large amounts of stalk material that form thick brown mats on stream bottoms suffocating everything in its path. It covers and suffocates trout eggs which results in fewer trout and less fishing opportunities. Aquatic invasive plants can be categorized as submerged and grow underwater (parrotfeather); emergent and grow in shallow water (watercress) or be floating with most leaves and plant tissue on the water surface (water chestnut). Invasive plants can also be found in wetlands (Phragmites and purple loosestrife). West Virginia also has aquatic invasive molluscs (zebra mussels and Asian clams), crayfish (rusty and virile) and aquatic invasive fish (Asian carp). Invasive species threaten aquatic habitats and species biodiversity and recreational opportunities, and they spread easily and rapidly and can quickly take over an area. The spread of aquatic invasive species can greatly impact aquatic recreational opportunities especially fishing and boating. Therefore, it is very important to clean and disinfect all gear (boots, boats, 4-wheelers etc.) after each use and when moving between water bodies. Also, live or dead organisms should not be moved from one body of water to another.

Watersheds

Watershed: A watershed is an area of land that drains or “sheds” water into a specific waterbody. Every body of water has a watershed. Watersheds drain rainfall and snowmelt into streams and rivers.

West Virginia Watersheds:

West Virginia has 32 watersheds divided according to **hydrologic unit codes** (HUC) that contribute to the **Chesapeake Bay** and the **Gulf of Mexico**. The waters west of the **eastern continental divide** flow into the **Ohio River**. The Ohio joins the **Mississippi River** at Cairo, IL. The Mississippi flows into the Gulf of Mexico at New Orleans, LA. The eastern continental divide also changes the course of five of our eastern rivers towards the **Potomac River**. The Potomac flows into the Chesapeake Bay southeast of Washington DC. A few streams in the southeastern corner of the state flow towards the **James River**



West Virginia Gold Rush

The West Virginia Gold Rush returns March 28 – April 8, 2023.

50,000 Golden Rainbow Trout

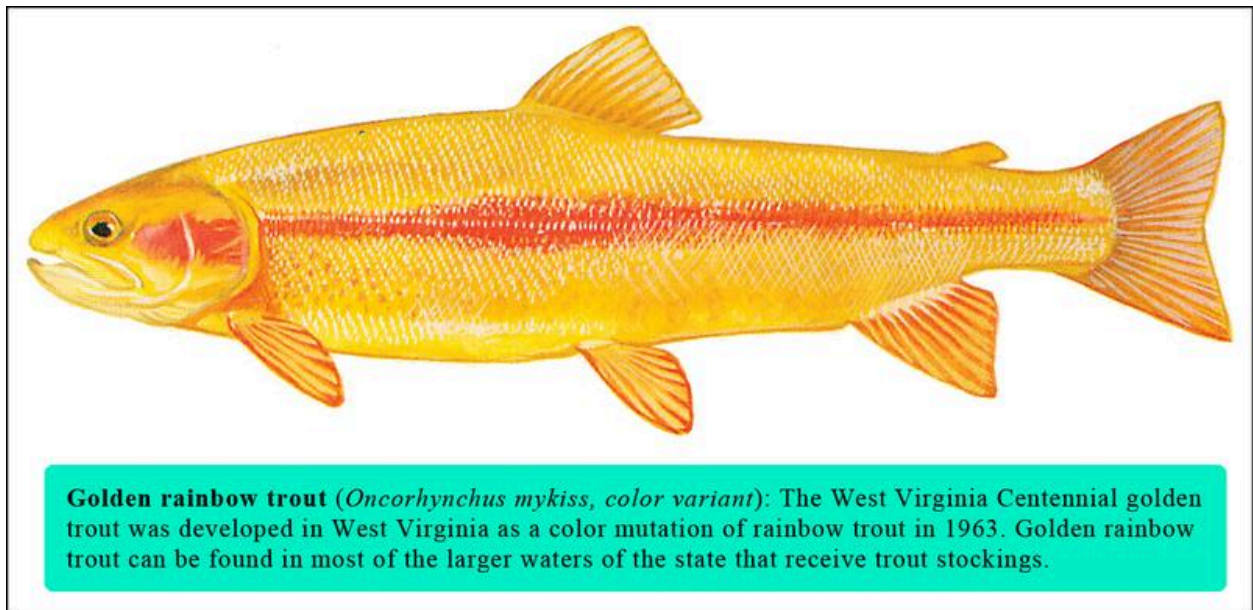
62 Lakes and streams

About the Golden Rainbow Trout:

Golden rainbow trout, also known as Centennial trout, banana trout and other names, evoke a true West Virginia legend. In fall 1949, the Petersburg State Trout Hatchery in Grant County received 10,000 rainbow trout fry from a California strain as a gift from the White Sulphur Springs Federal Hatchery. Less than 300 survived, but those fish were bred over the years to create a brood stock that went on to produce a single embryo that started the golden strain. The first golden rainbow, “Little Camouflage,” was a product of this work.

The golden rainbow was introduced to the public in 1963 as part of West Virginia’s Centennial celebration. The legacy continues with the annual Gold Rush fishing event held statewide each spring. Golden rainbow trout are not albino, nor are they to be confused with the true golden trout of the Sierra Nevada Mountains, a subspecies of the rainbow trout. Golden rainbow trout

are in fact a mutated strain of the rainbow trout and have been selectively and successfully bred for their golden pigmentation by WVDNR biologists.



West Virginia's golden rainbow trout is prized by anglers young and old for its unmistakable, bright-yellow color. These fish were selectively and successfully bred by West Virginia Division of Natural Resources biologists over several years and introduced to the public in 1963 as part of West Virginia's centennial celebration. Decades later, the West Virginia golden rainbow trout has been a popular sport fish, reeling in anglers from all over the country.

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WV Fishing Regulations

Regulations represent one tool that fisheries managers utilize to provide sustainable recreational fishing opportunities and protect fishery resources. Generally, the purposes of recreational fishing regulations address one or more of three broad areas. First, a regulation may be intended to prevent over-harvest of a sport fish population, especially larger fish that many anglers value. Second, regulations like daily creel limits may be established to distribute harvest among anglers. Third, regulations may be required to protect a rare species or control harmful exotic species.

The DNR is careful to collect adequate biological information and to consider angler attitudes and preferences before recommending regulation changes. The agency's management goal is to balance the obligation to protect sport fish populations and other aquatic resources while providing a diverse array of recreational fishing opportunities throughout the state.

<https://wvdnr.gov/wp-content/uploads/2023/01/2023.01.20-Fishing-Regulations-Summary.pdf>

Water Quality

Water samples should be collected from the most represented portion of a stream, which is usually the **run** (a fast moving area without surface breaks) and as close to the downstream end of the reach as possible. Analysis can be performed either in the field or lab. Most of your results should fall within the excellent or good ranges. The exceptions are pH (marginal – excellent) and dissolved oxygen (marginal – excellent). The total metals category is a combination of all metals that may be present. This **document** contains an overview on basic water chemistry. The formula to convert **temperature** from Fahrenheit °F to Celsius °C is: $([°F - 32] \div 9) \times 5 = °C$.

Constituents	Excellent	Good	Marginal	Poor	Units
Alkalinity	> 40	21 - 40	5 - 20	< 5	ppm
pH	7.6 - 9.0	6.5 - 7.5	6.0 - 6.5	< 6.0 > 9.0	
Dissolved oxygen	> 10.0	7.0 - 10.0	7.0 - 5.0	< 5.0	ppm
Conductivity	< 150	150 - 300	300 - 500	> 500	µs/cm
Nutrients N/P	< 1.0	1.0 - 2.0	2.0 - 4.0	> 4.0	ppm
Metals	< 1.0	1.0 - 1.5	1.6 - 3.0	> 3.0	ppm
Bacteria	< 100	100 - 200	201 - 400	> 400	CFU

Note: The values provided here are for guidance and educational purposes; they do not conform to water quality standards and in some cases a standard may not exist (e.g. nutrients, conductivity). However, the values are based upon ranges that most agree are needed to maintain healthy ecological integrity of stream environments.

Fish Stocking

- West Virginia fish hatcheries and fish stockings began in the late 1800s, but it wasn't until the 1950s that larger hatcheries were built, and fish production and stocking began to increase.
- Without the hatchery program, many of the state's waters would not sustain recreational sport fishing at the current level. This is especially true for most stocked trout waters due to increased temperatures during summer months that prevent fish from surviving year around.
- WVDNR currently manages and operates nine fish hatcheries statewide. Seven of these hatcheries are cold water and include the Bowden, Edray, Petersburg, Reeds Creek, Ridge, Spring Run and Tate Lohr hatcheries. These facilities raise warm-water species that commonly include walleye, musky, channel catfish, blue catfish, striped bass and hybrid striped bass.
- Warmwater fish are cultured through several sources: collecting wild brood stock, the purchase of eggs or fry from a private vendor or trading surplus of various species with other state agencies. Wild brood fish are spawned at the two warm-water hatcheries and then returned to the wild at the location of collection. Once eggs are hatched for warm-water fish species, the young fry are placed in grow-out ponds until they reach fingerling size. Ponds are drained in early summer and the collected fingerlings are distributed to various waters across the state. Some of the ponds are not drained and the fingerling fish are grown to a larger size, known as advanced fingerlings; the additional growth increases their survival and helps with avoiding predation. These advanced fingerlings are stocked during the fall.
- The allotment of fish stocked in a body of water is primarily determined by its size and acreage.
- In the trout stocking program, annual allotment is determined by multiplying the water acreage included in the stocking area by the number of fish to be stocked per acre annually. This is referred to as the stocking factor. The stocking factor can vary throughout the stocking season and is based on the pounds of trout available in the hatchery system for stocking. Changing the stocking factor means all stocked waters are adjusted to receive more or less pounds of trout on an equal basis. This allotment method makes for fair and equitable fish distribution across all waters statewide.
- Stocking suitability ranges from zero to one and is a measure of numerous biological and sociological factors. One of the main considerations when determining the stocking suitability is the number of available stocking locations and angler access to the stream or lake for fishing.

- Trout stocking allotment determines the pounds of trout stocked annually in each water. Therefore, if a body of water receives weekly trout stockings, the total annual allotment is divided by 16 (the number of weeks in the spring stocking season). Waters receiving biweekly stockings would be divided by eight, and monthly stocked waters divided by four. Therefore, an increase in stocking frequency means the number of stockings

Fish Hatcheries

The West Virginia [Division of Natural Resources](#) operates seven coldwater fish hatcheries and two warmwater fish hatcheries.

The coldwater fish hatcheries produce catchable-sized trout for the state's statewide stocking program. Rainbow, golden rainbow, [brook](#), and brown trout are raised. The hatcheries are located primarily in the mountains of east-central West Virginia to take advantage of the many springs in that region of the state. The hatcheries hatch, raise, and stock fish.

Petersburg Hatchery, built in the early 1930s, is located near [Petersburg](#) in Grant County. It produces catchable-sized fish and provides rainbow and golden rainbow eggs and fingerlings to other hatcheries. Ridge Hatchery, located in Morgan County near [Berkeley Springs](#), was also built in the early 1930s. It stocks trout in many of the streams and small impoundments in the Eastern Panhandle. Edray Hatchery, near [Marlinton](#) in Pocahontas County, was built in the 1930s and expanded in the 1940s.

Spring Run Hatchery is located near Dorcas in [Grant County](#). This hatchery was constructed in the early 1950s at one of West Virginia's largest springs, which supplies about 3,000 gallons per minute. Spring Run is one of the largest hatcheries operated by the Division of Natural Resources, and supplies trout for stocking by the smaller hatcheries. Bowden Hatchery, another large hatchery, is located near [Elkins](#) in Randolph County. It was constructed by the U.S. Fish and Wildlife Service in the early 1960s and transferred to the state in 1997. Bowden's annual trout production was similar to Spring Run but has been expanded by 50 percent in recent years.

Reeds Creek Hatchery, located west of Ruddle in [Pendleton County](#), was completed in 1979. Unique among West Virginia's trout hatcheries, Reeds Creek filters and re-uses 80 percent of its water. Reeds Creek, like Spring Run, provides trout to the smaller hatcheries that have low summer flows, and also transfers catchable-sized trout in the spring for stocking by other hatcheries.

Tate Lohr Hatchery is located near Oakvale in [Mercer County](#) and was also completed in 1979. It stocks much of southern West Virginia. This hatchery is a small rearing facility, and the majority of its trout are hauled in by Reeds Creek and Spring Run hatcheries during the spring.

The seven coldwater hatcheries annually produce and stock approximately 750,000 pounds of trout in 200 streams and small impoundments scattered across the Mountain State. Between January and May 2023, the DNR stocked 802,481 trout, a 19 percent increase from the previous year.

Palestine Warmwater Hatchery near [Elizabeth](#), Wirt County, has been in operation since the 1930s. Apple Grove Warmwater Hatchery near Apple Grove, [Mason County](#), opened in 2001. Walleye, musky, channel catfish, blue catfish, hybrid striped bass, largemouth bass, smallmouth bass, and striped bass are raised at the warmwater hatcheries and stocked into streams and lakes across the state.

West Virginia is also home to a federal fish hatchery operated by the U.S. Fish and Wildlife Service. The [White Sulphur Springs](#) National Fish Hatchery raises rainbow trout eggs that are shipped to 20 fish hatcheries across the country. After the eggs are shipped, the trout are then provided to the West Virginia Division of Natural Resources, the Maryland Department of Natural Resources, and the Eastern Band of Cherokee Nation. Since 1995, the federal hatchery has also raised freshwater mussels to improve wild populations of the endangered creatures. It also raises endangered [crayfish](#) and candy darters.

Stream Ecology

In 1995, the West Virginia Department of Environmental Protection (DEP) established the Watershed Assessment Program to assess and report on the water quality of the State's streams and lakes.

Benthic Macroinvertebrates

Definition: Benthic macroinvertebrates are aquatic animals without backbones that are large enough to see without a microscope.

- Benthic macroinvertebrates (also known as "benthos") are small animals living among stones, logs, sediments and aquatic plants on the bottom of streams, rivers and lakes.
- **Includes:** mayflies, stoneflies, caddisflies, beetles, midges, crane flies, dragonflies.
- They are large enough to see with the naked eye (macro) and have no backbone (invertebrate)
- Insects comprise the largest diversity of these organisms and include mayflies, stoneflies, caddisflies, beetles, midges, crane flies, dragonflies and others.
- Non-insect members of the benthic macroinvertebrate community are snails, clams, aquatic worms and crayfish
- Watershed Assessment Branch (WAB) collected and identified 538 different kinds (mostly Genus level identifications) of benthos from 6,202 stations on 5,530 different streams throughout West Virginia.

Habitats

In general, benthic organisms are most diverse in the fast flowing riffle and run areas of streams. Riffles and runs are shallower and have higher stream gradients and faster water velocities. They are composed of rough materials, such as large gravel, cobbles and small boulders that create turbulence and oxygenate the water, while providing a stable habitat for benthos to live.

Many insect benthos spend the majority of their lives (anywhere from 1 month to 4 years, depending on the species) in the water and only emerge as adults for a few hours (or up to several days) to reproduce and complete their life cycle. After emerging, adult aquatic insects can fly to new stream locations during their winged terrestrial stage.

Adaptations

Benthic macroinvertebrates have specialized adaptations for living in stream environments.

Adaptations include unique physical features and specialized behaviors.

Flattened bodies in many species allow them to hide between boulders and cobbles, reducing stress from fast-moving water.

Some species have sharp claws, suction cups, or other grasping mechanisms to prevent being swept away in swift currents.

Black fly larvae use silk glands and posterior hooks to anchor themselves while actively capturing food with fan-like mouth parts.

Net-building caddisfly larvae construct funnel-shaped nets attached to stable substrates for food harvesting.

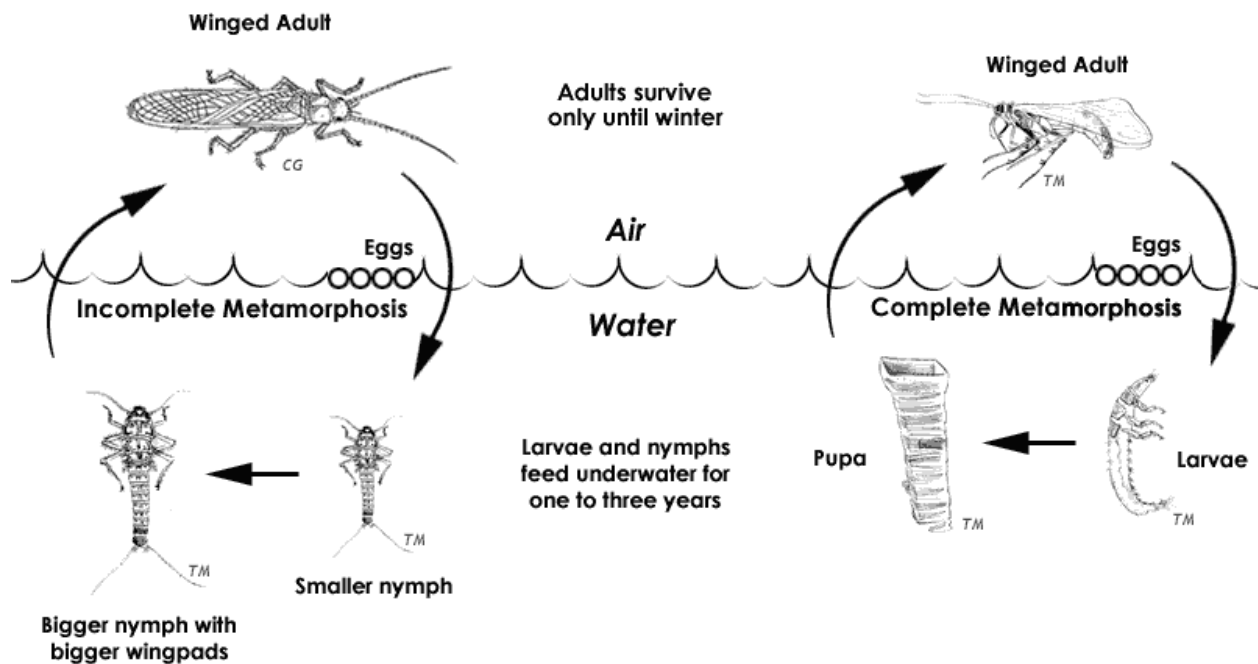
-Stonefly species may burrow into the stream bottom substrate to avoid high water temperatures.

Extracting oxygen from water is a crucial adaptation for benthos.

Aquatic insects use external gills to remove oxygen from surrounding water, while others rely on cutaneous respiration.

Feeding

- Benthos classification is often based on feeding strategy.
- Stonefly Pteronarcys belongs to the shredder functional feeding group, primarily consuming decaying leaves in streams.
- Water penny beetle is a scraper, grazing on algae covering rocks and logs.
- Mayfly Family Baetidae is a collector-gatherer, feeding on fine pieces of organic material on the stream bottom.
- Hellgrammite, larval form of the dobsonfly (Family Corydalidae), is a recognized predator in the aquatic insect world.
- Hellgrammites are active predators, crawling on cobble and boulders in swift stream habitats to hunt other benthic macroinvertebrates.



Importance of Food Webs

- Benthic macroinvertebrates play a crucial role in aquatic food webs.
- Energy stored by plants in streams is accessible to benthos through fallen leaves or algae on the stream bottom.
- Energy obtained by consuming leaves and algae is transferred to other stream life forms, including fish, frogs, salamanders, snakes, birds, and anglers.
- Benthos are important for recreational purposes, particularly for trout anglers who aim to "match the hatch" of various mayfly species.

Biological Indicators

- Benthic macroinvertebrates serve as reliable and comprehensive biological indicators for water and habitat quality.
- They have been used globally for nearly a century for this purpose.
- Chemistry data alone may not be sufficient to identify pollutants and stressors in streams.
- The presence of fish may not accurately reflect the stream's status, as fish can swim away from polluted water and return when conditions improve.
- Benthic macroinvertebrates, being less mobile than fish, provide an indication of past water quality conditions.
- Their diversity allows for a wide range of sensitivity and responses to stressors like metals, nutrients, and sediments.
- Benthos are effective tools for assessing water quality due to their ubiquity and ease of collection and identification.
- They are attractive to agencies and organizations seeking practical means of evaluating water quality in streams.

Using Benthic Macroinvertebrates to Assess Biological Conditions

- WAB uses the Index of Biotic Integrity (IBI) as a tool to extract and understand information from benthic macroinvertebrate samples.
- IBI is a summary score composed of biological indicators known as metrics.
- Metrics are characteristics of the biological community that change predictably with increases in human disturbance.
- Species richness, also known as diversity, is a commonly used component metric of IBIs.
- Species richness generally decreases as human disturbance increases.
- IBI is a valuable tool for assessing the impact of human activities on benthic macroinvertebrate communities in aquatic environments.

<https://dep.wv.gov/WWE/getinvolved/sos/macros/Pages/Benthic.aspx>

FRESHWATER MUSSELS OVERVIEW

Many people when fishing, swimming, or simply dreaming away the hours watching the water flow by, never see or are even aware of a fascinating group of creatures known variously as mussels, clams, or bi-valves. In fact, North America has the richest freshwater mussel fauna in the world. Two hundred and twenty-five species have been reported in North America, with 130 reported from the Ohio River System alone. Today, in many unpolluted streams in WV, the trained observer can usually spot 20 to 30 different kinds of freshwater mussels.

Mussels live in a variety of aquatic habitats, but all require areas where the running water has a high oxygen content and supplies a rich food source of organic particles and micro-organisms (single-celled animals, bacteria and diatoms). The constant flow of water also removes waste materials that would be toxic to the mussels. The best substrate for fresh-water mussels is a combination of silt, sand, gravel or cobble with little sedimentation. Some bi-valves exist in the stiller waters of natural lakes and ponds. However, they are almost never found in impoundments. This is due to sedimentation, recirculation of waste toxic to mussels, and the high concentrations of carbon dioxide and carbonic acid which dissolves their calcareous shells.

According to Paul Parmalee in *The Freshwater Mussels of Illinois*, all mussels possess a soft body enclosed by two separate shells hence the common name of "bivalve." The adult lives its entire life partly embedded in the substrate, active only in warm months. Mussels move by extending the foot out from between the shells and wedging it into bottom material. The body is then pulled along by contraction of the muscles within the foot. Mussels feed and derive oxygen by drawing in water through the in-current siphon and transferring the material to the stomach and gills, respectively. Wastes are expelled through the excurrent siphon.

The life cycle of the freshwater mussel is a complex and fascinating phenomenon. Four distinct stages occur: 1) the fertilized egg, 2) the young or glochidium in the brood sac of the female mussel, 3) the glochidium in the parasitic stage on a fish or salamander and 4) the adult, free-living stage with a shell.

Mussels are either male or female, although a few species are hermaphraditic. In many species the two sexes can be told apart by the shape of the shell. The male sex cells are released into the water and are taken into the female's body through the in-current siphon. They are then transported to the gills where the eggs are fertilized. The gills now serve as brood pouches as well as respiratory organs. Next, the eggs develop into glochidium, possessing only partially developed organs. At this point they are discharged from the female through the excurrent siphon into the water column. If they are to survive, they must be taken into the mouth of a passing fish and attach themselves to its gills. The glochidium remain embedded for 1 to 6 weeks in the tissues of the host fish, not increasing in size, but developing adult structures. Some species of mussels parasitize only one species of fish, while others are not as particular. This parasitism usually does not harm the host fish.

At the end of the third stage the young clam dislodges itself from the fish and falls to the bottom. If a suitable substrate is encountered, the young will survive and grow to adult-hood.

Mussel shells are composed of 3 layers, the outer two being formed by glands at the edge of the mantle, and the inner, pearly iridescent or nacre layer is secreted by the entire mantle surface. The shell grows in area by the addition of material at the margin, and in thickness by successive deposits of nacre across the shell's entire inner surface. In general, mussels that inhabit rivers or streams with a fairly fast current develop thicker shells than those found in shallow, quiet areas.

Mussels have been and are currently extremely important to man in several different ways. Native Americans used them as a food source, and shell heaps or middens may be found at many sites. These middens are important to malacologists – those who study mollusks-as they can indicate past abundance and species composition of an area. Many kinds of mussels now extinct or very rare have been found in the middens. Indians also valued the pearls found in nearly all kinds of freshwater mussels for ornamentation.

The late 1800's witnessed the birth of the button industry which produced buttons from mussel shells. The soft bodies of the millions of clams harvested for this purpose also provided food for livestock. However, the development and refinement of plastics after World War II spelled doom for this industry.

In the 1960's an unusual need for the shells developed that continues today as a multi-million-dollar industry mainly overseas. Pellets cut from the mussel shell, called baroques, are used to seed oysters in order to produce cultured pearls.

Freshwater mussels are an important food source for muskrat and other furbearers, waterfowl, and fish (especially the freshwater drum). Bivalves can also be used as fish bait. Besides their aesthetic appeal, mussels are very important indicators of water quality. Because freshwater mussels are filter feeders, often dependent on one species of fish for reproduction, and are basically sedentary and quite long lived, they are adversely affected by long-range water quality problems (pollution), physical barriers such as dams and locks, and changes in the abundance of fish, algae and other microorganisms.

Populations of all freshwater mussels have been drastically reduced in our streams and waterways, many to the point of extinction. West Virginia has six federally endangered mussels, the pink mucket pearly mussel (*Lampsilis orbiculata*), tubercled-blossom pearly mussel (*Epioblasma torulosa torulosa*), James spinymussel (*Canthyria collina*), Fanshell (*Cyprogenia stegaria*), Northern riffleshell (*Epioblasma torulosa rangiana*) and Clubshell (*Pleurobema clava*). The reasons for their decline are many, and all related directly to man's activities. Impoundments, dams, or other activities associated with these facilities create: excess sedimentation, which covers their siphons and suffocates them; physical barriers that isolate populations and separate them from host fishes; increased metals and other pollutants; and fluctuations in water flow that decreases nutrient and oxygen availability and prohibits toxic waste removal. Perhaps even more damaging because entire beds are destroyed are the activities of commercial sand and gravel dredging, navigation maintenance dredging, and barge handling associated with permanent loading and unloading facilities.

Because of their importance in the ecosystem and extent of their decline, freshwater mussels warrant further study as to distribution, relative abundance, species diversity and population

stability. Some of the methods to accomplish this include handpicking in shallow water and along the shoreline (especially muskrat- middens), water scoping, snorkeling or general shallow diving, scuba diving and brailing. The latter two methods are essentially the same as used by commercial harvesters. In brailing, an individual stands at the end of a flat-bottomed “John” boat, lowering an apparatus known as a mussel brail with attached hooks. The hooks are dragged across the bottom as the boat drifts with the current. When a prong of a hook enters the partially open shells and touches or becomes embedded in the soft parts of mussels, the valves instantly clamp shut on the hook.

Studies such as these have been conducted by biologists of the WV Division of Natural Resources, Water Resources Division and the U.S. Fish and Wildlife Service in order to learn more about mussels and make recommendations on water project and policy development. This will ensure better protection of these rapidly dwindling, valuable and fascinating creatures.