Using Fish to Evaluate the Ohio River

What can we learn from the fish community?

ORSANCO

Ohio River Valley Water Sanitation Commission

What Is ORSANCO?

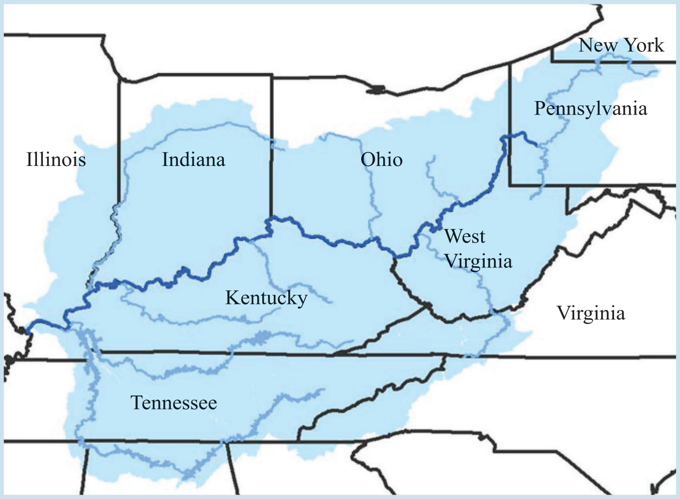
The Ohio River Valley Water Sanitation Commission (ORSANCO) is a water pollution control agency established in 1948 by an interstate compact. The eight member states—Illinois, Indiana, Kentucky, New York, Ohio, Pennsylvania, Virginia, and West Virginia—pledge to cooperate in the control of water pollution within the Ohio River Basin. ORSANCO operates programs for water quality monitoring and assessment, spill response and detection, pollution control standards, and public awareness. Additionally, ORSANCO coordinates activities and facilitates an exchange of information and technology among federal agencies and the water pollution control and natural resource agencies of the member states.

Following its formation in 1948 and as directed by the Compact, ORSANCO made its mission to control and abate water pollution in the Ohio River and its tributaries, ensuring that waters were maintained "in a satisfactory sanitary condition, available for safe and satisfactory use as public and industrial water supplies…suitable for recreational usage, capable of maintaining fish and other aquatic life, free from unsightly or malodorous nuisances… and adaptable to such other uses as may be legitimate." As a result of this Compact directive, ORSANCO has developed a strong monitoring program to ensure that these multiple uses are protected. Specifically, ORSANCO sets pollution control standards, detects spills and harmful organic compounds, and monitors water quality parameters such as toxic metals, dissolved oxygen, and bacteria.

While monitoring chemical and physical parameters is a relatively common and valuable strategy used to determine pollution levels, it is also useful to expand the focus beyond water chemistry and examine the effects of pollution on aquatic life using biological assessment tools. Maintaining the biological integrity of the Ohio River through the protection of aquatic life habitat is a goal of both the Compact and the Clean Water Act. Setting limits on the content and concentration of discharges to the river is one way that ORSANCO's Pollution Control Standards achieve this goal. Additionally, monitoring programs that measure parameters such as dissolved oxygen, bacteria from human and animal waste, and nutrients such as nitrogen and phosphorus can help scientists predict whether or not an aquatic system will support biotic communities. However, factors often act synergistically, increasing the effects when they interact with other factors. Monitoring biological communities can reveal stressors, such as pollution or habitat degradation, which may not be detected by chemical or physical measurements.

Ohio River Basin

The Ohio River flows through or borders six states during the 981 mile trek from its origin in Pittsburgh, PA where the Allegheny and Monongahela rivers meet, to Cairo, IL where it empties into the Mississippi River. The Ohio River watershed, the land area draining into the Ohio River, covers approximately 204,000 mi^2. More than 25 million people, or 10% of the U.S. population, live in the Ohio River Basin. With such a large portion of the population concentrated in this watershed, it is expected that the actions of the population, even in locations as far removed as southwestern New York and Virginia, have the potential to impact the water quality of the Ohio River adversely.



Why Use Biology?

In the 1900s, miners took canaries into the coal mines to serve as early indicators of toxic gases. The canaries were particularly sensitive to toxic gases such as carbon monoxide and therefore could alert the miners to low levels of these gases, giving them enough time to leave the area safely. Biologists recognize that other organisms also can serve as environmental indicators, or bioindicators. They act as early warning systems, indicating disturbances to habitat or the presence of toxins in the environment before humans can feel or see the effects. For example, frogs, because of their permeable skin and high rate of moisture exchange with the environment, are sensitive to pollution and UV radiation. This enables them to serve as indicators of environmental degradation from acid rain or ozone depletion. Similarly, fish species may be particularly sensitive to certain types of water pollution or disturbances affecting water resource integrity.

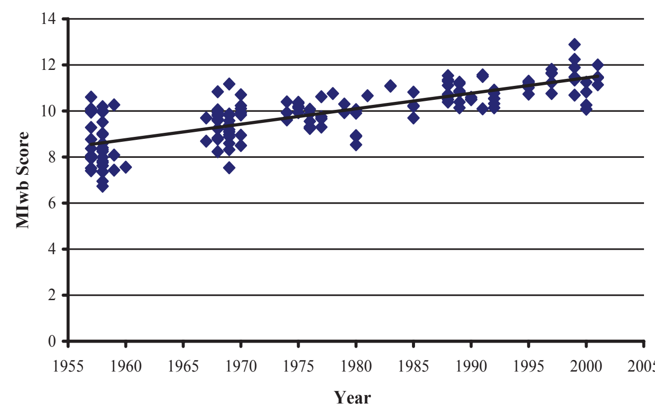
Because living organisms respond to changes in the environment, they also can be used to track environmental changes over time. As humans become more aware of the impacts they have on the environment, there is an increasing interest in tracking the results of such actions. By monitoring trends in the populations of living organisms, it is possible to determine if efforts to improve the environment have been successful.

ORSANCO uses data based on fish populations to monitor the Ohio River. According to the United States Environmental Protection Agency (USEPA), fish are practical for biological monitoring because, unlike other organisms such as turtles, frogs, and some macroinvertebrates (organisms such as aquatic insects and snails), they live in the water all of their lives and feel the effects of water quality changes throughout their life cycles. In addition, fish species differ in their tolerance to amounts and types of pollution, are easy to collect with the appropriate equipment, live for several years, and are easy to identify in the field. They provide an accurate assessment of stream health because most species stay in the same area during the summer sampling season, recover rapidly following disturbance, have large ranges lessening the effects of small-scale habitat changes, and vary in their sensitivity to water quality changes. Public interest in fish as a recreational resource further increases their utility as an indicator of the river's health.

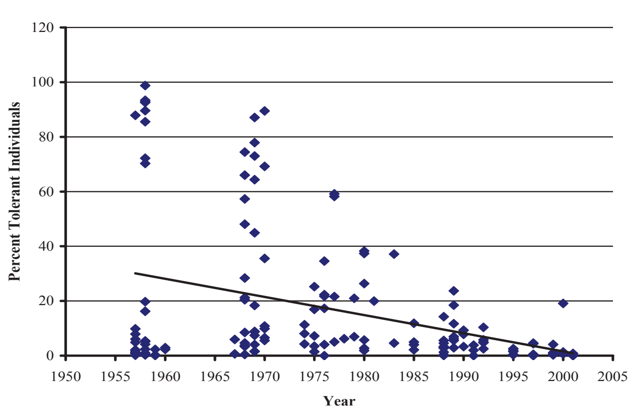
Is Ohio River Water Quality Improving?

The Ohio River has changed significantly since it was named "oyo" by the Iroquois, translated by the French to "La Belle Riviere" or "the Beautiful River". Beginning in 1885, the river underwent drastic modifications as the U.S. Army Corps of Engineers (USACE) installed dams for navigational purposes. At the time of the Industrial Revolution, the Ohio River was used as a place to dump sewage and industrial wastes, resulting in severe water quality problems. To measure the effects that changes in water quality had on the fish community, ORSANCO, along with state agencies, began conducting extensive fish surveys along the Ohio River in 1957. Biologists originally selected lockchambers, which are used by boats to bypass the dams, to trap fish so they could be netted, identified, and weighed. Although ORSANCO currently uses more advanced, less invasive methods for fish collection, this historical record is essential when investigating trends in the Ohio River, helping to answer the common question—**Is the Ohio River getting cleaner?**

Our studies indicate that water quality has improved over the past 40 years. This has been shown using the Modified Index of well-being (MIwb), which enables biologists to measure overall fish community health. The MIwb is a biological tool that is comparable to an air quality index. In the same way that an air quality index measures multiple components of the air to assess air quality, the MIwb combines several measures of the fish community to produce a single score. The MIwb incorporates the number of species along with the number of individuals and their weights into each measurement. Scores can be used to track changes in these communities over time. ORSANCO has applied the MIwb to fish community data collected from lockchamber surveys between 1957 and 2001. **Since 1957, MIwb scores from samples in the Ohio River have increased over time indicating an improvement in the fish community.**

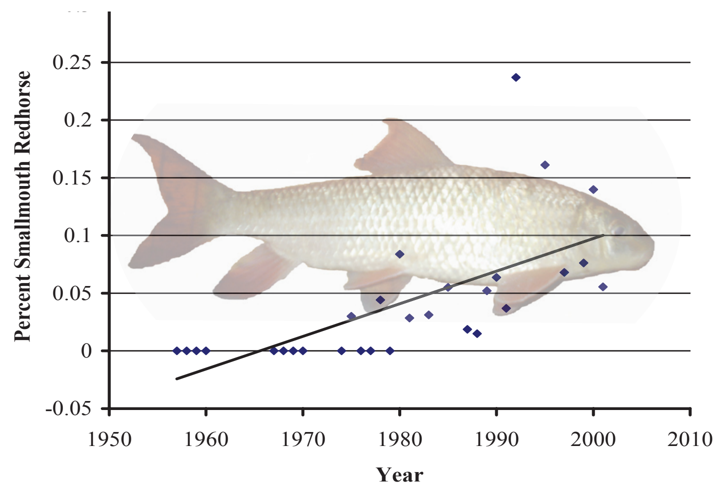


Increasing MIwb scores between 1957 and 2001 indicate improvements in the fish community and water quality.



The percentage of pollution tolerant individuals in the Ohio River has declined since 1957.

There are other trends in the data collected between 1957 and 2001 that show water quality is improving. The occurrence of tolerant species has declined significantly since the lockchamber surveys began. Tolerant individuals are species that can withstand higher levels of pollution. When pollution levels are low, less tolerant species are able to outcompete the more tolerant species. The decline in tolerant individuals in the Ohio River indicates that water quality has improved, preventing pollution tolerant species from dominating the community.

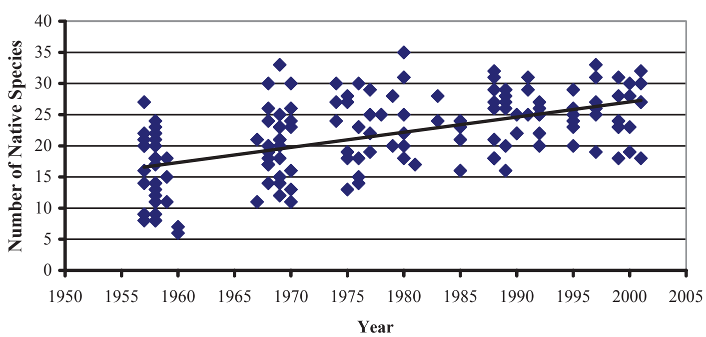


Since 1957, the percentage of smallmouth redhorse suckers collected during lockchamber surveys has increased. The return of these pollution-intolerant species is a sign of improving water quality.

Since 1957, fish surveys indicate improving water quality in the Ohio River with increasing numbers of pollution intolerant and native species.

In contrast to the decline of tolerant species, intolerant species, or those most sensitive to pollution, have returned to the Ohio River fish community. For example, the intolerant smallmouth redhorse (pictured above), a type of sucker, was not seen in the first lockchamber surveys. However, it reappeared in 1975 and has increased in numbers since that time. Other intolerant species, such as sauger, paddlefish, and blue suckers, also have increased their numbers since the surveys began. This suggests that pollution levels have decreased and the habitat needed by these native species has improved.

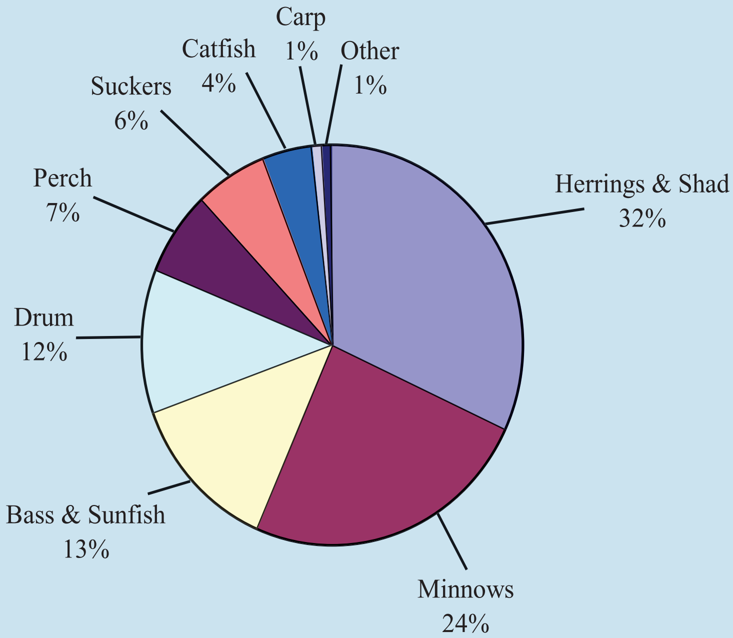
Other native species have also returned to the Ohio River fish community. Native species are important pollution indicators because they are adapted to the conditions that existed before humans altered the river ecosystem. The number of native species found in the lockchamber surveys has increased, indicating that conditions have become more favorable for these species. The increase in native species tells biologists that environmental regulations and habitat restoration projects have been successful in improving the water quality of the Ohio River.



A variety of native species, or species historically found in an area, have re-established populations in the Ohio River.

Fish of the Ohio River

Currently, 126 species of fish have been collected by ORSANCO from the Ohio River. Members of the herring family such as gizzard shad and skipjack herring are the most commonly encountered species in the Ohio River. They are followed by minnows, freshwater drum, and catfish such as the channel, flathead, and blue catfish. Bass species collected in the river include smallmouth, largemouth, and spotted bass. The perch family is represented by sauger, walleye, and darters. The diversity of fish found in the Ohio River suggests that pollution levels are not nearly the issue they have been in the past.



What Is Electrofishing?

In 1992, the focus of ORSANCO's biological assessment shifted from lockchamber surveys to a method called electrofishing. Electrofishing is a mobile alternative that provides a more representative sample of the fish community by allowing biologists to sample a variety of habitat types rather than limiting surveys to lockchamber locations.

To use this method, electricity is generated on an 18-foot jon boat and flows into the water through a negatively charged electrode (the anode), which sits just below the surface of the water. This electricity, approximately 3,000 watts of pulsed direct current (DC), passes through the water as it moves toward the positively charged boat hull, which serves as a cathode. Fish swimming near this electrical field are stunned by the electricity. While they are disoriented, biologists stationed on the front of the boat collect the stunned fish with a net and place them in an aerated livewell on the boat (pictured below).

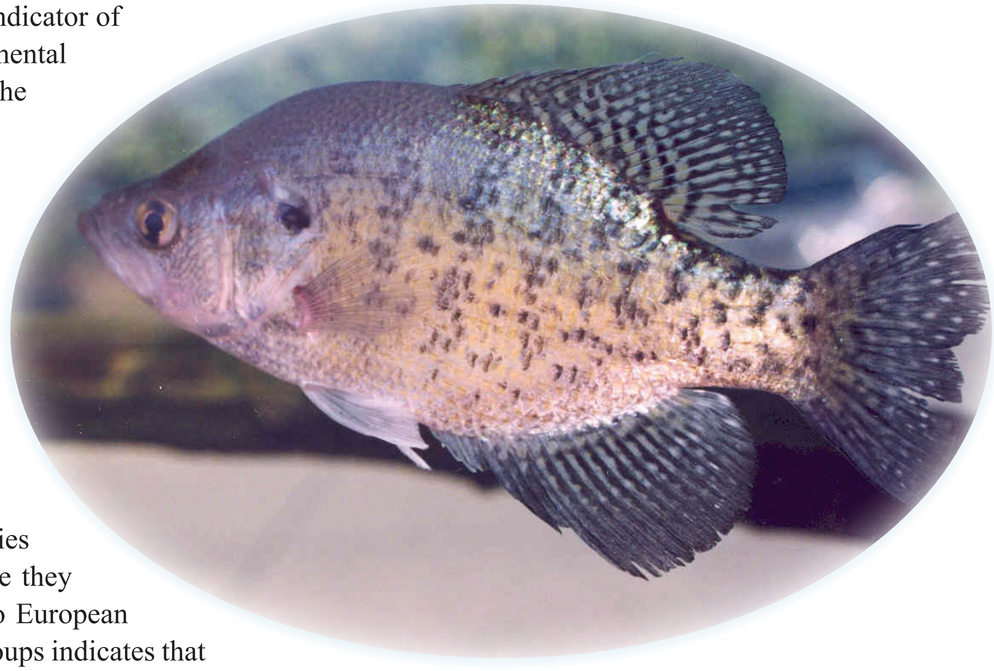
Between the months of July and October, ORSANCO biologists collect fish samples to assess the quality of the Ohio River based on its fish population. Using the electrofishing method, fish are collected from a 500 meter length of shoreline. Electrofishing on the Ohio River is limited to the shoreline because the electrical current only extends to a depth of 15 to 20 feet. Fish sampling is conducted after sunset when fish are most active and species normally dwelling in deeper water move to the shoreline to feed. Following collection, fish are identified, weighed, measured and returned to the river unharmed. The information collected on the size and condition of the fish, as well as the species composition of the fish community enables biologists to assess the health of the fish community and draw conclusions about the current condition of the Ohio River.

How Can We Evaluate the Fish Community?

Much of the information gained from biological monitoring depends on how the data are analyzed and interpreted. In recent years, biological monitoring programs have shifted toward an integrated, metric approach for biological assessment. This type of assessment focuses on species assemblages rather than target species and uses a variety of metrics as surrogate measures of more complicated processes. Using the original Index of Biotic Integrity (IBI) as a model, ORSANCO developed the Ohio River Fish Index (ORFIn) to examine the fish community data that are collected from the Ohio River. Although more complex, the ORFIn, like the MIwb (see page 4), combines various measures of the fish community to produce a single score that is easily understood. The ORFIn assesses the fish community by examining the number of species, the types of species and the ecological structure of the fish community at a site. This is done by looking at 13 attributes of the community, called metrics, and comparing them to expected values. The 13 metrics selected for the ORFIn were chosen based on their sensitivity to changes in water quality. A score (of zero, one, three, or five) is given for each of the 13 metrics based on how the site compares to conditions found at the least disturbed locations available. The higher scores indicate a more desirable fish community that is reflective of improved water quality; a perfect score would consist of 13 scores of five for a total of 65. The total score is compared to an expected score, which is determined by the available habitat.

How Does the Ohio River Fish Index Work?

Each metric of the ORFIn assesses a unique attribute of the fish community to provide information about the biological integrity of the Ohio River. For example, the *number of species* measures native species diversity, which is expected to be higher at locations with better water quality. A loss of native species is a good indicator of environmental disturbances that are detrimental to those species and the overall stability of the ecosystem. *Sucker species*, which comprise a large portion of the Ohio River fish population, are sensitive to degradation of both habitat and water quality. The *number of bass and sunfish (centrarchid) species* is sensitive to high levels of suspended sediment, also called turbidity, and increased water temperatures. *Great river species*, those expected to thrive in the largest of rivers, respond to loss of critical floodplain habitat. Together suckers, bass, sunfish, and great river species are all important to the Ohio River because they are the fish that inhabited the river prior to European settlement. A decline in any one of these groups indicates that human activities are putting too much stress on these fish populations. *Intolerant species* are those most sensitive to changes in the ecosystem and are useful in identifying the highest quality areas since they are the first species to be affected by declining water quality. In contrast, the *percent of tolerant individuals* metric, a measurement of those species that can withstand higher levels of pollution, is meant to discriminate between poorer sites at the lower end of the water quality spectrum.



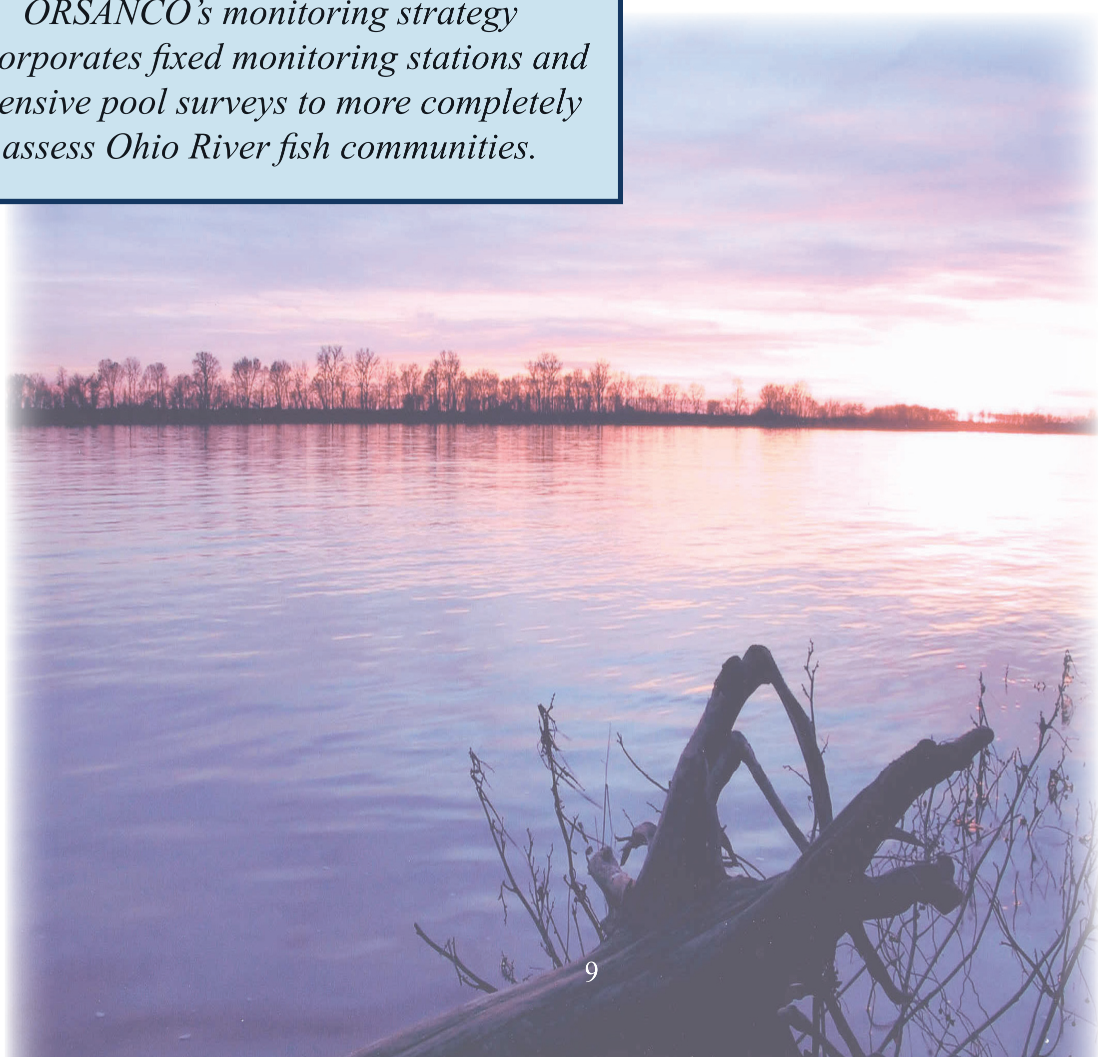
Other metrics, such as the *percent simple lithophils,* look at ecological components. Simple lithophils, fish species that spread their developing eggs over gravel beds, require clean coarse substrates for reproduction and are therefore sensitive to the effects of siltation. The *percentage of non-native individuals* is used to measure the degree to which outside species have affected the ecosystem. Fish species that are *detritivores* feed on small organic particles, and are more commonly found where sand and fine substrates (siltation) have decreased habitat quality. The *percentage of invertivores* assesses the proportion of fish feeding on bottom-dwelling, aquatic insects, which may decline as disturbances affect those insects. *Top piscivores*, predators that eat other fish, rely on a stable fish population for food, and their absence reflects a lack of suitable habitat for the overall fish community. *Catch per unit effort*, or the number of fish caught at each site, is a measure of the productivity of the particular site. A high *number of DELT anomalies* (Deformities, Eroded fins, Lesions, and Tumors) is indicative of stress on the population due to poor water quality and/or habitat degradation.

The Ohio River Fish Index (ORFIn) combines 13 measures of fish community health into a single score that is easily understood. As expected, ORFIn scores decrease significantly at locations influenced heavily by human activity and are higher at less-impacted sites.

Description of metrics used in determining Ohio River Fish Index (ORFIn) Scoring

Metric	Description
Number of Species	Species diversity, excluding hybrids and exotics
Number of Sucker Species	Members of Catostomidae family (suckers such as redhorse and buffalo)
Number of Centrarchid Species	Sunfish and black bass species
Number of Great River Species	Species dependant upon great rivers and associated floodplains
Number of Intolerant Species	Species that are sensitive to pollution
Percent of Tolerant Individuals	Individuals that are not sensitive to pollution
Percent of Simple Lithophils	Fish that require silt-free gravel beds for spawning
Percent of Non-native Individuals	Non-indigenous (introduced and invasive) and hybrid species
Percent of Detritivores	Individuals that feed on detritus (particulate organic matter)
Percent of Invertivores	Individuals that feed on insects and other arthropods
Percent of Top Piscivores	Individuals at the top of the food chain that feed on other fish
Catch Per Unit Effort	Number of fish caught excluding tolerant, hybrid, and non-indigenous fish
Number of DELT Anomalies	Irregularities such as Deformities, Eroded fins, Lesions, or Tumors

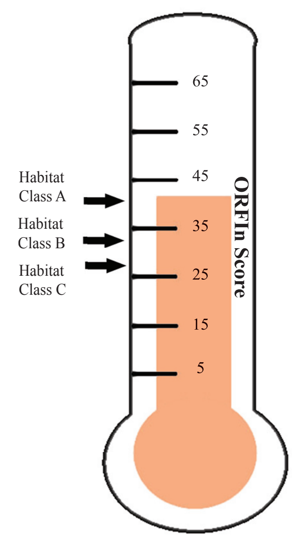
ORSANCO's monitoring strategy incorporates fixed monitoring stations and intensive pool surveys to more completely assess Ohio River fish communities.



Does Habitat Affect ORFIn Scoring?

Habitat heavily influences the fish that inhabit a particular site. The fish community is generally more numerous and diverse at sites where a complex habitat provides food and cover from predators. ORSANCO has identified three distinct habitat classes, which are designated as A, B, and C. Each class has a different expectation on the ORFIn scale, depending on the habitat composition. Biologists first record critical habitat data from a site and then assign it to one of three habitat classes. Habitat A sites, those with coarse substrates such as boulders and cobble, provide the most cover and food and therefore score the highest. Habitat C sites have smaller substrates such as sand, are less attractive to fish, and usually score at the lower end of the ORFIn scale. Habitat B sites have a combination of sand, cobble, and other substrates. Although habitat classes are based on substrate types, other factors such as woody cover and water depth may also affect the fish community present and the ORFIn score. By classifying the habitats and then collecting fish, biologists can determine if the fish community present meets the expectations for that site.

Identifying habitat classes enables biologists to assess the fish community found at a specific site in the river more accurately. Expectations for low quality sites are not as high as sites offering more complex habitat.



Habitats are classified as A, B, or C. There are different expectations from the fish community depending on the habitat class.

ORSANCO's Monitoring Program

In 2004, ORSANCO initiated a new biological monitoring strategy that continues to use electrofishing data to evaluate the Ohio River water quality. The plan consists of surveys of pools created by dams and annual monitoring at select, fixed locations throughout the river. This dual approach strategy was designed to enable ORSANCO to report on the condition of the individual pools, locate problem areas, and track long-term trends.

The pool surveys will allow ORSANCO to get a detailed look at four of the 20 navigational pools (the area of river between two dams) in the Ohio River each year. After a five-year cycle, a detailed examination of the entire river will be complete and a new monitoring cycle begins. Each pool survey will consist of a minimum of 15 random, computer-selected sites. Through the use of randomly selected locations, biologists can extrapolate results, providing an unbiased look at the entire pool. If a certain number of sites within a pool fail to meet expectations, follow-up studies can be conducted to pinpoint the location, cause, and severity of the problems. The results from the pool surveys also can be used to compare the pools to each other, allowing ORSANCO to identify and focus on the areas with the greatest water quality problems.

The use of fixed monitoring stations was initiated so that annual differences in the river biota could be monitored. This approach consists of 18 standard electrofishing sites that are distributed throughout the entire river. By repeating the sampling at these sites every year, ORSANCO can track trends over time to identify improving or worsening water quality, similar to comparisons made with the lockchamber studies.

In addition to the new fixed station and intensive survey approach, ORSANCO continues to expand the focus of the biological monitoring program. Collaborating with EPA and state agencies, ORSANCO plans to determine if the ORFIn can be adapted for application to other large river systems such as the Wabash, Kanawha, and Monongahela rivers. Work is currently underway to develop a multiple metric index for the Ohio River macroinvertebrate community providing another investigative tool for measuring water quality. These new initiatives, in combination with the current monitoring program, will ensure that the high standards for water quality and multiple use protection outlined in the Compact are achieved and protected.

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