Lake Erie

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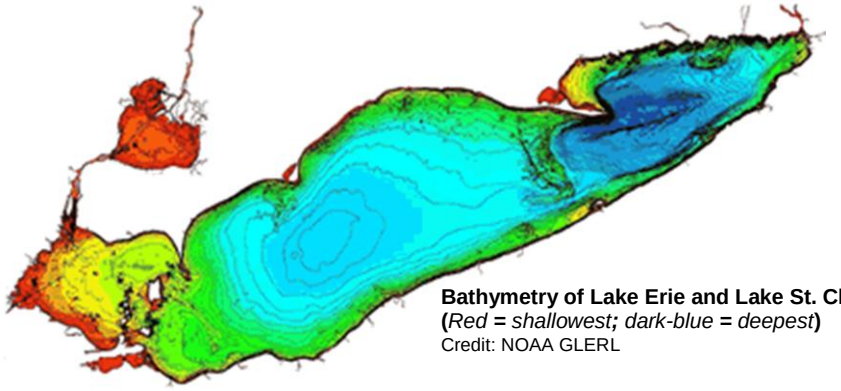


Bathymetry of Lake Erie and Lake St. Clair
(*Red = shallowest; dark-blue = deepest***)**
Credit: NOAA GLERL

Lake Erie is the smallest (by volume) and shallowest of the Great Lakes. Although it does not hold as much water as the other four lakes, Lake Erie is considered the most productive of the Great Lakes. Its productivity is related to the large number of fish species (over 120), the abundant forage base (small prey fish) and the number of diverse habitats found in the lake, including wetlands and embayments. Lake Erie is the southernmost of the Great Lakes and its location and volume contribute to it being the warmest, as well. It is the only Great Lake that typically freezes over from shore to shore, although recent warm winters are making that occur less frequently.

Lake Erie was formed by huge glaciers that advanced and retreated across the area, carving out the lake and creating its shorelines and formations. The early Erigan River helped to create the east-west position of Lake Erie as the glaciers moved across the region. Proof of glacial activity is evidenced today in the ridges, sand dunes and glacial grooves that can be found in spots along the shore.

Water enters Lake Erie through the Detroit River to the west and empties through the Niagara River in the east. The waters cascade over Niagara Falls before reaching Lake Ontario and the St. Lawrence River, where the water eventually flows to the Atlantic Ocean. The lake has many important tributaries including the Buffalo River, Maumee River, Grand River, Sandusky River, Huron River and the infamous Cuyahoga River, that brought national attention to its environmental degradation when it burned in 1969. Today, the Cuyahoga River, like many of the other tributaries, has benefitted from years of environmental stewardship and pollution controls.

Two engineered canals played an important part in the development of Lake Erie and its role as a significant shipping area. The Erie Canal, links the Great Lakes to the Atlantic Ocean and the Welland Canal, provides a water link between Lake Ontario and Lake Erie and safe passage for ships around the natural barrier of Niagara Falls. Even today, international ships use the Welland Canal to reach the upper Great Lakes as they journey through the St. Lawrence Seaway from the ocean.

Due to its west-to-east orientation, Lake Erie is prone to seiches. A seiche is a sloshing back and forth of lake water that is caused when strong and steady winds push the water from one shoreline to the other. Due to strong Westerlies-- the winds that blow across the lake--water is often pushed from Toledo towards Buffalo. As lake levels increase on one end of the lake, the levels on the other end decrease, often dramatically. During a seiche, the water sloshes back and forth until it returns to normal.

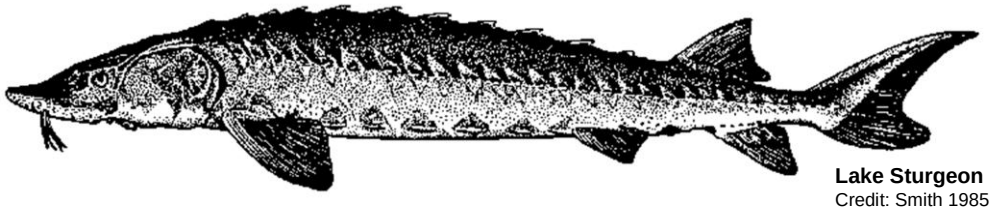
The three distinct basins of Lake Erie make it unique among the Great Lakes. Lake Erie has: 1.) a shallow Western basin with an average depth of less than 30 feet; 2.) a Central basin with an average depth of 60 feet; and 3.) a cold, deep Eastern basin which bottoms out at over 200 feet deep. These distinct basins, with their particular temperature ranges, provide appropriate conditions for warm water and cold water fishes, helping to provide the great diversity of fish species that Lake Erie is known for.

Lake Erie Fishes

Fish species include small prey fish like minnows, shiners and dace, to large predatory fish like lake trout and muskellunge. Walleye (*Sander vitreus*) and yellow perch (*Perca flavescens*) are the two economically important fish species in Lake Erie, with great harvest efforts made by both recreational anglers and Canadian commercial fishermen

The largest and most distinctive fish found in its waters is the lake sturgeon *(Acipenser fulvescens*). These large, primitive, prehistoric-looking fish survive on a diet of small invertebrates, like aquatic insect larvae and crayfish, yet can grow to lengths exceeding six feet. As a group of fishes, sturgeons date back to the age of dinosaurs-- several 100 million years ago.

Before being over-fished for their flesh, eggs (caviar) and isinglass--a substance used as a clarifier of glue, jellies and even beer-- sturgeon populations were stable. Currently, in New York waters the lake sturgeon is considered a threatened species by the New York State Department of Environmental Conservation. The fact that it takes over 20 years for a female lake sturgeon to reproduce and 12 years for a male to become sexually mature, helps to slow down population growth of these fish. Both males and females rarely spawn every year, which also reduces reproduction rates. No other fish in Lake Erie can top lake sturgeon for longevity, with some living over a century and most sturgeon living 40-50 years.



Lake Sturgeon
Credit: Smith 1985

Lake Erie is not only diverse biologically, but also in its habitat types. The lake contains wetlands, beaches, bays and even islands that are found in its Western basin. The largest island is Pelee Island, located in Canadian waters and situated in a major flyway, making the island an ideal spot for birding enthusiasts. The U.S. islands include the Bass Islands and Kelleys Island, which are popular summer tourist destinations. Tourism and fishing, both recreational and commercial fishing (primarily along the Canadian shore) are important elements of the economy of Lake Erie.

During the 1960s, Lake Erie was declared a “dead lake” due to eutrophication and pollution. The children’s book, *The Lorax*, written by Dr. Seuss, actually included the following line referring to fish: “They will walk on their fins and get woefully weary in search of some water that isn’t so smeary. I hear things are just as bad in Lake Erie.” Fortunately, as the conditions in Lake Erie improved, the line was removed from future editions of the book.

Dead Zones

Although no longer considered a dead lake, during the summer the central basin of Lake Erie often develops anoxic areas (oxygen depleted) spots referred to as "dead zones." These dead zones develop as the water temperature increases in the warm, upper layers (epilimnion) of the lake and increased bacterial activity is using up oxygen in the colder, lower layers (hypolimnion) of the lake. This stratification of lake water is due to the different densities of water with temperature change. The bacterial activity increases as dead algae and other materials settle to the bottom of the lake. Since the hypolimnion is much smaller than the upper layers, the oxygen can be depleted during the summer. These dead zones have been studied for many years and change in size and duration over the years. Some researchers believe that invasive mussels and phosphorus loadings play a role in the formation of dead zones in the central basin.

Lake Erie has the shortest retention time of all of the Great Lakes, just 2.6 years. According to the US Environmental Protection Agency, retention time is a measure based on the volume of water in the lake and the mean rate of outflow. Also known as residence time, it provides an idea of how long it would take to flush the lake's waters. Since the water is replenished more frequently than the other lakes, pollution and contaminants can be discharged more readily and Lake Erie can benefit from remediation efforts more quickly than the larger lakes.

Invasive Species

Non-native species such as zebra mussels (*Dreissena polymorpha*) and quagga mussels (*Dreissena rostriformis bugensis)*, round gobies (*Apollonia melanostomus*) and spiny waterfleas (*Bythotrephes longimanus)* have all had significant impact on the ecosystem of Lake Erie. These invasive species entered the Great Lakes through ballast water exchange during the late 1980s and early 1990s, causing dramatic changes in the food web of Lake Erie.

Round goby.
Credit: David Jude, Michigan Sea Grant

Originally, zebra mussels colonized Lake Erie, followed by quagga mussels several years later. Quagga mussels can be found in the deeper, colder waters of the lake and they have colonized the lake in greater numbers than zebra mussels. Today, in many portions of the lake it is difficult to find living zebra mussels, but quagga mussels are quite prolific. Each female mussel of both species can produce approximately one million offspring in a season, helping to keep populations high. Both Dreissenid mussel species have reduced the amount of much needed plankton in the lake with their filtering activities. The reduction of plankton has created increased water clarity in the lake. Sometimes people erroneously believe that the filtering of mussels has "cleaned up" the lake, since they can see the bottom at greater depths than in the past. The filtering activity has "cleared up" the lake by increasing visibility, but this does not necessarily mean the lake is healthier. Dreissenid mussels take in contaminants as they filter the water and, if eaten by other organisms, these contaminants can move up the food chain.

Spiny waterfleas have changed the composition of zooplankton communities through predation on smaller planktonic animals, while being protected from predators by their long, spiked tails. Capable of asexual reproduction, spiny water fleas can increase their populations rapidly and later summer abundances of these invertebrates are common in Lake Erie.

Round gobies, a benthic or bottom-dwelling fish, eat the eggs and fry (young) of other fish species and displace native fishes with their aggressive behavior. The gobies also feed on zebra and quagga mussels, using pharyngeal or throat teeth to deal with the shells of these bivalves. Although they eat mussels readily, their feeding activities cannot control the mussels due to their high reproductive rates. Unlike many other fish species in Lake Erie, round gobies can spawn several times per year, helping to increase their populations. Fortunately, larger fishes and even birds like double-crested cormorants (*Phalacrocorax auritus*) have added round gobies to their diets, helping to control populations of this prolific invader.

Lake Erie

Harmful Algal Blooms

One of the most pressing issues today in Lake Erie, especially in the shallow western basin, is harmful algal blooms (HABs) that have changed the once clear waters into a bright green soup.

Satellite image showing *Microcystis* bloom
Credit: NASA Earth Observatory

(Inset) *Microcystis* sample
Credit: NOAA GLERL

Although single celled organisms, including algae, are an important part of the food web, some blooming organisms can contain toxins or noxious chemicals. Many algal blooms are harmless, but blooms of cyanobacteria (blue-green algae) like *Microcystis aeruginosa, Anabaena circinalis, Anabaena flos-aquae and Aphanizomenon flos-aquae* can contain toxins including nerve toxins (neurotoxins), liver toxins (hepatotoxins) and toxins that cause skin irritation.

Harmful algal blooms are not new to Lake Erie. During the 1960s and 1970s, the lake had massive cyanobacteria (blue-green algae) blooms due to eutrophication enhanced by human activities (cultural eutrophication), such as the use of excessive fertilizers. As the lake was cleaned up, these blooms seemed to diminish until the mid- to late-1990s. Since then, the lake has seen significant numbers of HABs and some recent blooms have been much more widespread than those of the past.

These harmful algal blooms are linked to the amount of phosphorus available in the lake. Phosphate from agricultural runoff is a common source of phosphorus to the lake. Along with farm runoff, phosphorus from wastewater treatment plants and septic systems in the basin can increase the severity of the blooms. In extremely wet seasons, runoff increases and fuels the bloom of harmful algae. Research is underway to determine practices and actions that could be used around Lake Erie to reduce these blooms that pose a threat to people and their pets using the lake.

Although small in volume, Lake Erie is a thriving, productive environment. It has survived challenges brought about by pollution, over-fishing, eutrophication, invasive species and harmful algal blooms. Future changes from climate change may pose new threats, but somehow Lake Erie continues to be a resilient ecosystem, providing drinking water, a strong fishery, recreational opportunities and adding to the economies of its surrounding communities.

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