OHIO DEPARTMENT OF NATURAL RESOURCES **DIVISION OF WILDLIFE**

OLD WOMAN CREEK NATIONAL ESTUARINE RESEARCH RESERVE

TECHNICAL BULLETIN

No. 3

JULY 2015

HOW IS FISH HABITAT AFFECTED?

LAKE ERIE'S DEAD ZONE

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NATIONAL ESTUARINE RESEARCH RESERVE OLD WOMAN CREEK OHIO DIVISION OF WILDLIFE

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE

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NUTRIENTS, ALGAE, AND LOW OXYGEN

In the late summer, a hypoxic zone, an area with depleted oxygen, develops at the bottom of the central basin of Lake Erie. Massive algal blooms cause opaque green water to cover the surface of western Lake Erie every summer. These algal blooms are fed by agricultural and urban run-off. Nitrogen and phosphorus from fertilizers and waste from distant cities drain into the lake, stimulating growth of algae and other plankton. But not all of the effects of this excess pollution are as visible as green slime.

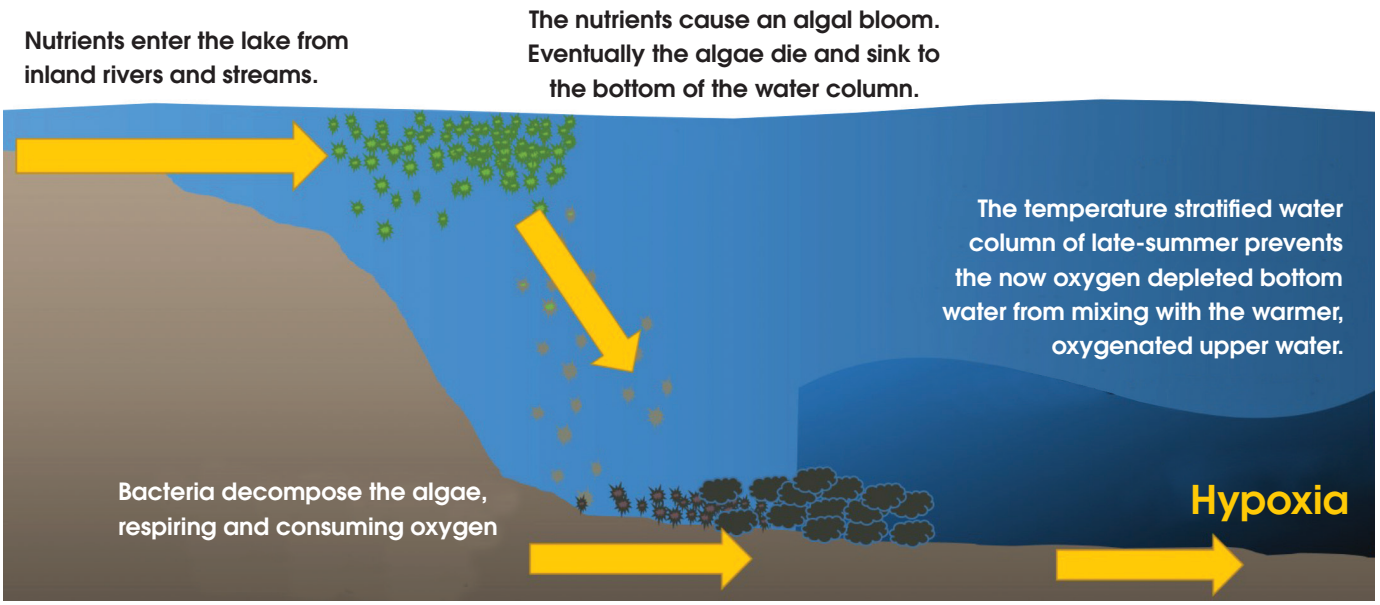
Dead algae settle on the lake bottom where they are decomposed by bacteria. In the process of decomposition, the bacteria respire, consuming oxygen. With such large amounts of algae being decomposed, the oxygen levels become depleted by the bacteria. The oxygen at the bottom of the water column is not replenished because the water column stratifies in the late summer, with warmer, less dense water not mixing with the cooler, denser water below.

LAKE ERIE "DEAD" ZONE

In Lake Erie, the hypoxic zone can be as large as 10,000 square kilometers and alters the lake ecosystem from July to October. These low oxygen areas are often referred to as "dead zones," because many mobile organisms leave the hypoxic zone, and many sessile organisms die without adequate oxygen. Fish are forced to leave the cooler, deeper waters to inhabit new areas with more oxygen, but potentially with different prey and warmer temperatures. The impacts of these novel environments on fish populations and the consequences for local commercial and recreational fishing economies are uncertain.

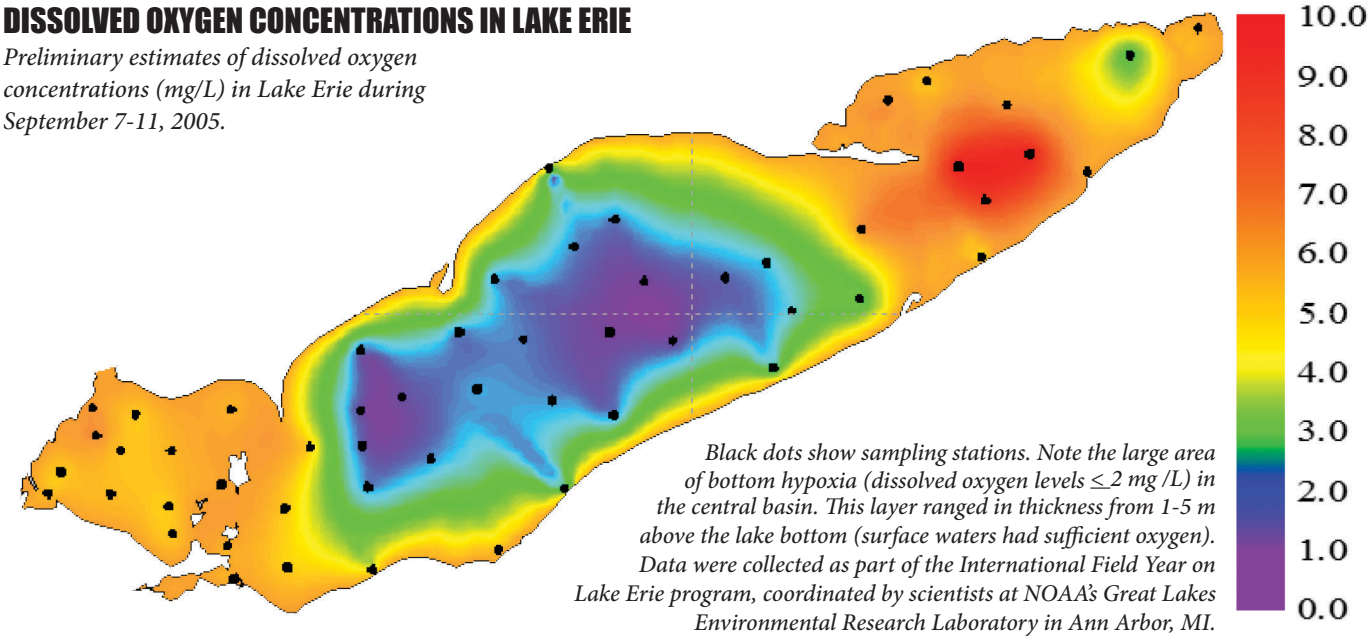
HOW A HYPOXIC ZONE FORMS

How a hypoxic zone, an area of depleted oxygen, forms in the bottom waters of Lake Erie's central basin.



DISSOLVED OXYGEN CONCENTRATIONS IN LAKE ERIE

Preliminary estimates of dissolved oxygen concentrations (mg/L) in Lake Erie during September 7-11, 2005.



Black dots show sampling stations. Note the large area of bottom hypoxia (dissolved oxygen levels ≤ 2 mg /L) in the central basin. This layer ranged in thickness from 1-5 m above the lake bottom (surface waters had sufficient oxygen). Data were collected as part of the International Field Year on Lake Erie program, coordinated by scientists at NOAA's Great Lakes Environmental Research Laboratory in Ann Arbor, MI.

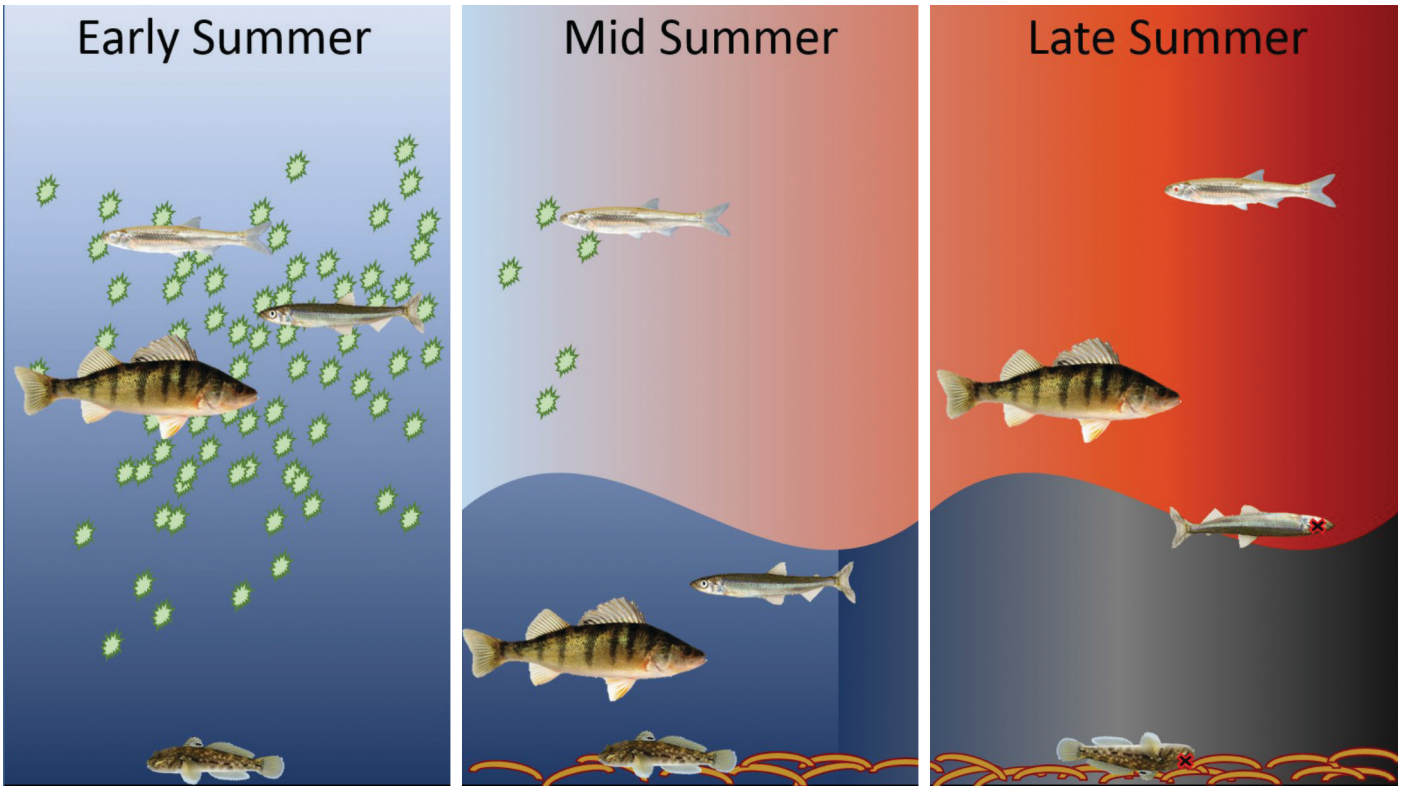
Source: IFYLE program, NOAA-GLERL

HOW DOES LOW OXYGEN AFFECT FISH?

Because hypoxic zones do not typically kill fish directly through suffocation, their negative effects on fish can be difficult to understand. The most significant way hypoxic zones affect fish is by decreasing the amount and quality of habitat available. For habitat to be of good quality, it must meet the oxygen and temperature requirements of a fish. The habitat must also provide a fish with enough light to detect prey and enough prey to consume so that the fish can survive and grow. Because prey such as zooplankton have their own oxygen, temperature, and light needs, high quality habitat for fish only occurs where these suitable habitat features overlap.

IMPACT ON HABITAT QUALITY

Depiction of a column of water in Lake Erie's central basin throughout the summer and approximate locations of fish based on modeled habitat quality.



Temperatures continue to warm as spring becomes summer, but stratification has not occurred yet. Pelagic prey have their peak abundance.

Thermal stratification of the water column has occurred. Pelagic water temperatures are becoming quite warm and prey number in this zone decline. Below the thermocline, water is still cool and benthic prey are increasing in abundance.

The upper part of the water column is too warm for many fish species, but it remains well oxygenated. Hypoxia has developed in the bottom of the water column, preventing fish from occupying cooler bottom waters where benthic prey are abundant.


YELLOW PERCH


RAINBOW SMELT


EMERALD SHINER


ROUND GOBY


PELAGIC PREY


BENTHIC PREY

CHANGES TO FISH HABITAT QUALITY

In order to identify how hypoxia alters the inter-actions between high quality habitat features in central Lake Erie, I worked with Dr. Tomas Höök and Dr. Timothy Sesterhenn to adapt a computer model developed by Dr. Kristi Arend that determines habitat quality for specific fish species. Our model quantifies how suitable a certain area of habitat is, given the physical characteristics and amount of prey found there. For yellow perch, rainbow smelt, emerald shiner, and round goby, we determined how the hypoxic zone altered habitat from 1987 to 2005. Additionally, we used our model to forecast how habitat may change for those fish in the central basin if nutrient loading increases or decreases.

Our model showed that during the late summer, when temperatures are warmest, most fish thrive at the bottom of the lake. In the cool, deep water, fish use less energy and can feed on bloodworm larvae. Unfortunately, at that time of year this area of high habitat quality becomes hypoxic, causing fish to move to other habitats, which might be of poorer quality. For our forecast scenarios, warmer water temperatures and more nutrients increase the amount of prey available and overall habitat suitability early in the year. However, our preliminary results show that the benefits early in the summer do not counteract the strong negative effects of a longer lasting and larger hypoxic zone during late summer.

THE FUTURE PROGNOSIS

Although farmers and cities are working to reduce the amount of nutrient pollution added to Lake Erie, we are unlikely to fully reverse the changes in climate. Our model allows for a better understanding of the impact of nutrient loading on Lake Erie's fish community. These types of predictive models can help managers anticipate what species may thrive in Lake Erie's central basin in the future.

ABOUT THE AUTHOR

Zoe Almeida is a graduate student in the Department of Forestry and Natural Resources at Purdue University. Her research examines the effects of hypoxia on fish in Lake Erie. She is studying the way hypoxia affects fish physiology as well as fish populations through laboratory experiments and computer modeling.

GLOSSARY

BENTHIC:
associated with the bottom of a body of water

HABITAT:
the physical (temperature, oxygen, light, etc.) and biological (prey densities) components of a specific area of water

HYPOXIA:
low dissolved oxygen concentration often defined as below 2.0 mg/L

PELAGIC:
associated with open water

STRATIFICATION:
a separation of water layers, in this case due to a difference in temperatures

THERMOCLINE:
the zone between the warmer upper part and the cooler lower part of the water column where there is rapid temperature change

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OLD WOMAN CREEK NATIONAL ESTUARINE RESEARCH RESERVE

Old Woman Creek National Estuarine Research Reserve (OWCNERR) is managed as a cooperative partnership between the Ohio Department of Natural Resources Division of Wildlife and the National Oceanic and Atmospheric Administration (NOAA). OWCNERR is one of 28 coastal reserves connected nationally through NOAA to address state and regional coastal management needs through research, education, and stewardship. The National Estuarine Research Reserve System uses its network of living laboratories to help understand and find solutions to crucial issues facing America's coastal communities.

The mission of OWCNERR is to improve the understanding, stewardship, and appreciation of Great Lakes estuaries and coastal wetland ecosystems. Integrated Reserve research, education, and stewardship pro-grams address threats to Great Lakes coastal wetland ecosystems including nonpoint source pollution, aquatic invasive species, habitat loss, and climate change. OWCNERR provides laboratories for ecological research and education and training to support decisions and actions that benefit Lake Erie ecosystems.

OWCNERR publishes the OWCNERR Technical Reports series to provide constituents with information derived from Great Lakes coastal research, management, education, and outreach projects conducted in partnership with and/or at OWCNERR.

Financial assistance provided under award number NA12NOS4200138 from the National Oceanic and Atmospheric Administration, U.S. Department of Commerce through the Old Woman Creek National Estuarine Research Reserve, administered by the Ohio Department of Natural Resources, Division of Wildlife.

The Old Woman Creek National Estuarine Research Reserve is part of the National Estuarine Research Reserve System, (NERRS), established by Section 315 of the Coastal Zone Management Act, as amend-ed. Additional information about the system can be obtained from the Estuarine Reserves Division, Office of Ocean and Coastal Resource Management, National Oceanic and Atmospheric Administration, US Department of Commerce, 1305 East West Highway – N/ORM5, Silver Spring, MD 20910.

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