

**Ohio Sea Grant  
College Program**

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Sea Grant forms a unique partnership with public and private sectors to combine research, education, and technology transfer for service to the public. Sea Grant provides a national network for universities to meet changing environmental and economic needs in our coastal, ocean, and Great Lakes regions.

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Lake Erie has experienced several decades of accelerated eutrophication and toxic substance contamination. During the latter part of the 1960s, remedial actions were planned, and by the late 1970s, many of these plans were at least partially implemented. In the 1980s, positive signs of recovery are being observed. This fact sheet highlights the environmental changes that have taken place in the past few years and the status of Lake Erie water quality.

**Phosphorus**

- Cultural eutrophication of Lake Erie is being combated by programs to decrease phosphorus loading from all sources. This is the principal focus of lake restoration efforts. Remedial programs for reducing phosphorus loadings from municipal wastewater treatment plants (MWTP) in the Lake Erie Basin have resulted in a substantial decrease in phosphorus loading to the lake. Since 1982, the average loading objective of 1.0 mg/l for all major MWTP has been met, but several individual MWTP exceed the target value. It should be noted that the average loading objective applies only to those plants discharging one million gallons per day or more. The flow-weighted average phosphorus concentration of minor wastewater treatment plants in Ohio is still approximately 4.0 mg/l.
- The 1978 Great Lakes Water Quality Agreement between Canada and the United States contains the basic requirement to reduce the phosphorus concentrations in municipal discharges to 1.0 mg/l in all the Great Lakes Basin. It also calls for other programs or additional requirements needed to reduce point and nonpoint sources in order to achieve target loads of 11,000 metric tonnes/year for Lake Erie (a reduction to this level is expected to eliminate anoxic conditions in the Central Basin hypolimnion). However, if all municipal treatment plants in the Lake Erie Basin were discharging phosphorus at 1.0 mg/l, the total phosphorus load to the lake would still be 13,000 tonnes/year, requiring a further reduction of 2,000 tonnes/year from other sources.
- Total phosphorus loading to Lake Erie from all external sources has declined from a peak of 28,000 tonnes in 1968 to 12,400 tonnes in 1982. This represents a 56 percent decline over the 15-year period. The Detroit River, which supplies about 93 percent of the inflowing water to Lake Erie, has shown a remarkable improvement; phosphorus loadings decreased 60 percent from 1971 to 1980, primarily as a result of improvements to the Detroit municipal wastewater treatment plant.
- In the early 1970s, the concentration of phosphorus in influent wastewater to municipal treatment plants averaged about 10 mg/l within the Lake Erie drainage basin, and the mean effluent concentration was approximately 7 mg/l. By 1980, many plants had installed phosphorus removal systems which resulted in an average effluent concentration of 1.6 mg/l for all Ohio plants and concentrations as low as 0.6 mg/l for the Detroit municipal wastewater treatment plant in 1982.
- In 1981, about half of the 40 major wastewater treatment plants in the Great Lakes Basin did not meet phosphorus effluent requirements of 1.0 mg/l. By 1984, 75 percent of the plants met the requirement. Unfortunately, six of these 10 violators are in the Lake Erie Basin: Wyandotte, MI; Toledo, OH; Akron, OH; Cleveland Westerly, OH; Euclid, OH, and Erie, PA.
- In 1972, the volume-weighted average phosphorus concentrations of wastewater treatment plant effluent to Lake Erie was about 5.7 mg/l. By 1982, this had fallen to slightly below the target concentration of 1.0 mg/l. However, the International Joint Commission (IJC) recommends that special efforts ensure that the six Lake Erie treatment plants which have not achieved the target are brought into compliance.
- Municipal loading of phosphorus to Lake Erie has declined from over 15,000 tonnes in 1972 to about 2,500 tonnes in 1983, a reduction of over 83 percent.
- Phosphorus concentrations in the open waters of Lake Erie are highly variable and have not decreased in a fashion comparable to reductions in phosphorus loadings, except along the north shore of the Western Basin. Here, in response to reduced loadings from the Detroit River, concentration of phosphorus in Ontario waters decreased approximately 40 percent in the ten-year period from 1970 to 1979. Similarly, in the 15-year period from 1968 to 1982, the annual mean phosphorus concentrations in the Central Basin epilimnion have fallen from 21.3 to 12.0 µg/l (44 percent decline). Elsewhere phosphorus released from sediments through wave resuspension and anoxic regeneration keep levels high.
- All of the Great Lakes jurisdictions have enacted legislation to control the amount of phosphorus permitted in household detergents as a component of their phosphorus management strategies for the Great Lakes.

- Agricultural cropland phosphorus is estimated to account for 65 percent of the phosphorus entering Lake Erie from nonpoint sources. To achieve the target loading of 11,000 tonnes/year, Ohio's portion of the goal is a reduction of 1,385 tonnes, of which about 900 tonnes is assigned to cropland phosphorus reduction. Many programs are attempting to reduce loads through comprehensive land treatment, residue management, fertilizer management, and livestock waste management. Although these programs are resulting in steady increases in conservation tillage acreage and increased knowledge of fertilizer management, they will not be enough to meet the target load reduction. Current estimates indicate that conservation tillage will reduce phosphorus 71 tonnes by 1988. Existing erosion and animal waste control programs (other than cropland management) will reduce phosphorus loads by another 120 tonnes. Because only 14 percent of the goal can be achieved using existing erosion control and water quality protection programs, the vast majority of the reduction must be met with new programs and funding. The Ohio Environmental Protection Agency estimates that nearly 2,000,000 acres of cropland must utilize conservation tillage to meet the phosphorus reduction goal.

## Dissolved substances

- Records for the period 1900 to 1960 in nearshore waters of central Lake Erie show dramatic increases in conductivity, chloride, calcium, sulfate, sodium, and potassium. From 1966 to 1980 conductivity values indicate a decline in the total amount of dissolved substances in central Lake Erie, falling approximately eight percent during this period. Chloride shows a more dramatic improvement, dropping about 26 percent from a concentration of 25.0 mg/l in 1966 to 18.4 mg/l in 1979. Much of this decline can be attributed to elimination of waste brine pollution from the Grand River near Painesville, Ohio in the early 1970s. In the Eastern Basin, Presque Isle Bay at Erie, Pennsylvania has experienced a marked decrease in alkalinity (largely bicarbonate ions), falling from 96 ppm in 1945 to 87 ppm in 1978. Other conservative ions (e.g. calcium, sodium, and sulfate) have ceased to increase in the lake and have remained relatively stable over the past decade.
- Nitrogen is the only major dissolved constituent in the waters of Lake Erie which has shown a dramatic increase in the past decade. Increased use of chemical fertilizers and precipitation from the atmosphere of gaseous emissions of nitrogen compounds within the lake's drainage basin are major causes. Combined nitrate and nitrite loading from the Detroit River more than doubled in the period 1967 to 1979.

## Algae

- Blooms of planktonic blue-green algae, such as *Microcystis*, *Aphanizomenon*, and *Anabaena* in western Lake Erie, and massive growths of attached filamentous green algae, such as *Cladophora* which were prevalent in the mid-1960s, decreased in intensity and number during the 1970s. No blooms have been reported in recent years.
- Water levels in Lake Erie during the past decade have averaged two feet above the 1960-1970 levels. The dilution effect of more upper Great Lakes water flowing into Lake Erie, coupled with greater submergence of algal attachment sites, is thought to be partially responsible for the absence of basin-wide algal blooms.
- Open-lake phytoplankton decreased in total biomass and shifted toward more oligotrophic species. Eutrophic species, such as *Melosira granulata*, *Stephanodiscus tenuis*, and *S. niagara*, were less abundant in 1979 than in 1970, and oligotrophic species, such as *Dinobryon divergens* and *Ochromonas scintillans*, were once again observed in 1979.

## Dissolved oxygen

- The Central Basin hypolimnion (lower layer of water) has suffered seasonal anoxic conditions for at least 40 years. Taking into account natural variability in oxygen depletion rates due to meteorological factors, the highest oxygen depletion rates occurred during the 1960s and 1970s, when Lake Erie was most influenced by cultural eutrophication, exhibiting the highest phosphorus concentrations and algal biomass. From 1980 to 1984 oxygen depletion rates have decreased and are less variable.
- The Central Basin's rate of hypolimnetic oxygen depletion more than doubled between 1930 and the mid-1970s. In 1930, the volumetric rate has been estimated at 0.05 mg/l/day; in 1974 it was 0.13 mg/l/day. During the same period the area of the basin subjected to anoxic conditions increased from 300 km<sup>2</sup> in 1930 to 10,250 km<sup>2</sup> in 1974. Studies conducted from 1980 to 1982 show that the demand rate has dropped to an average of 0.10 mg/l/day and the area of anoxia has been reduced to 4,870 km<sup>2</sup>. This improvement in bottom water quality can be attributed to decreased amounts of sedimented organic material due to nutrient reduction.

## Benthos

- The composition of the benthic macroinvertebrate communities of western Lake Erie has improved since 1967. Samples taken in 1979, when compared with 1967 data, showed that the bottom is still dominated by pollution tolerant tubificid worms including *Limnodrilus hoffmeisteri*, *L. cervix*, and *L. maumeen* - *sis*. However, other less tolerant taxa of tubificids such as *Pelosclex* spp. were also common.

- A modest reestablishment of the burrowing mayfly (*Hexagenia limbata*) has been observed at the mouths of the Detroit and Maumee rivers in western Lake Erie. This species was extirpated from the Western Basin in the mid-1950s following periods of anoxia in this normally unstratified portion of the lake. Prior to 1953, bottom sediments supported about 400 nymphs per square meter in the Bass Islands region. Following the catastrophic kills of the 1950s, no *Hexagenia* nymphs were found in Lake Erie sediments for over 20 years.

## Areas of Concern

- In the past decade there has been considerable improvement in the environmental quality in the Great Lakes Areas of Concern, particularly with respect to problems associated with conventional pollutants (e.g., BOD, suspended solids, oil and grease) and to some extent heavy metals (e.g., mercury). The severity and extent of problems, such as low dissolved oxygen levels, oil slicks, and fish kills, have been reduced as a result of remedial actions taken in compliance with restrictions enacted under the National Pollution Discharge Elimination System (NPDES) and the Construction Grants program of the Clean Water Act.
- A total of 42 Areas of Concern have been identified by the IJC in the Great Lakes Basin. These areas exhibit various water quality problems resulting from various sources. Ten of these Areas of Concern are located on Lake Erie and its connecting waterways (see table).
- Causative factors are known for the four Areas of Concern in Ohio, and remedial action plans are being developed. Some remedial measures have been implemented. (FS-041, available from Ohio Sea Grant, contains more information about these four Areas of Concern.)
- Sediment cores taken at the mouth of the Detroit River and in western Lake Erie in 1971 yielded surface mercury concentrations up to 3.8 ppm and generally decreased exponentially with depth to background concentrations of less than 0.1 ppm. High surface values were attributed to waste discharge during the period 1950 to 1970 from chlor-alkali plants on the Detroit and St. Clair rivers. In 1977, several years after these plants ceased operations, the area was again cored. Analyses showed that recent deposits were covering the highly contaminated sediment with a thin layer of new sediment that had mercury concentrations approaching background levels, thus the contaminated are being isolated and removed from the aquatic environment.
- Mercury in fish of Lake St. Clair and western Lake Erie was a major contaminant problem in the early 1970s. Levels of total mercury in walleye (*Stizostedion v. vitreum*) collected from Lake St. Clair

## Areas of Concern

Location	Problem Codes	Source Codes
Detroit River	1,2,3,4,5,6,7,8,9	1,2,3,4,5,6
River Rouge	1,2,3,4,6,7,9	1,2,3,4,5,6
Raisin River	1,2,4,6,7,9	1,2,3,4,5,6
Maumee River	1,2,3,4,5,7,9	1,2,3,4,5,6
Black River	1,2,3,4,6,7,9	1,2,3,4,5,6,8
Cuyahoga River	1,2,3,4,7,9	1,2,3,5,6
Ashtabula River	1,2,3,4,6,7	2,3,6
Wheatley Harbour	1,2,3,4,5,6	1,2,6,9
Buffalo River	1,2,3,4,6,7	1,2,3,5,6,8
Niagara River	1,2,3,4,6,7	1,2,3,5,6,8

Code		Code	
No.	Type of problem	No.	Sources of problems
1.	Conventional pollutants (e.g., bacterial, nutrient, solids, etc.)	1.	Municipal point sources
2.	Heavy metals	2.	Industrial point sources
3.	Toxic organic substances	3.	Urban nonpoint sources
4.	Contaminated sediments	4.	Rural nonpoint sources
5.	Eutrophication	5.	Combined sewer overflows
6.	Fish consumption advisory	6.	Inplace pollutants
7.	Biota impacted	7.	Atmospheric input
8.	Beach closings	8.	Waste disposal sites
9.	Aesthetics (fish tainting)		

have declined from over 2 µg/g in 1970 to 0.5 µg/g in 1980. In western Lake Erie, 1968 levels of mercury were 0.84 µg/g as compared to only 0.31 µg/g in 1976. The rapid environmental response subsequent to the cessation of the point source discharges at Sarnia, Ontario and Wyandotte, Michigan can be attributed to rapid flushing of the St. Clair-Detroit River system and the high load of suspended sediment delivered to western Lake Erie, which, once deposited, covers the contaminated sediments greatly reducing the entry of mercury into the Lake Erie food chain.

## Beaches

- In 1967, 11 Lake Erie bathing beaches on the United States side of the lake were posted unsafe because of high bacterial contamination; another 12 beaches were questionable because of moderate bacterial pollution; and 27 were considered generally safe with only slight pollution (only three beaches were found to be uncontaminated throughout the swimming season). By 1981, only four beaches were closed throughout the year, eight were open for restricted use, and 76 were open as safe, uncontaminated beaches. Records show continued improvement in public swimming areas.

## Fishery

## Ohio Sea Grant Extension: Bringing Lake Erie research to the public

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- The annual sport angler harvest of fish in the Ohio waters of Lake Erie has increased from 1.4 million pounds in 1976 to 10.1 million pounds in 1982, an increase of 621 percent. During this eight-year period, yellow perch (*Perca flavescens*) harvests rose from 8.2 million to 12.2 million fish, while walleye (*Stizostedion v. vitreum*) production jumped from 112,000 to 3.1 million fish. The increased walleye production has been attributed to good young-of-the-year recruitment and international management of sport and commercial harvests. The abundance of walleye within western Lake Erie also increased dramatically from 1970 to 1982. During the 1960s and early 1970s the "fishable" population of walleye (14.5 inches in length and larger) was estimated at or below two million individuals. Since 1982, the fishable population in western Lake Erie has averaged over 20 million walleye.
- Levels of PCB and DDT in spottail shiners (*Notropis hudsonius*) sampled in Canadian waters have declined in the past decade, illustrating a system-wide response to controls on production and use of these compounds. PCB levels in shiners at Point Pelee dropped from 844 ng/g in 1975 to 150 ng/g in 1980 while during the same period DDT fell from 92 to 21 ng/g.
- In 1983, mean concentrations of DDE, DDT, dieldrin, HCB, Mirex, and total PCB in herring gull (*Larus argentatus*) eggs from two Lake Erie colonies (Middle Island and Port Colborne) were lower than they had been during any year since the monitoring program began in 1974.
- Data from 1977 through 1983 indicate the mean concentrations of total PCB in walleye exceed the Canada-United States Water Quality Agreement objective of 1.0 ppm for whole fish samples. But the mean concentrations are under the U.S. Food and Drug Administration limit of 2.0 ppm for human consumption.
- Observations of increased incidence of tumors and other malformations in fish collected from areas such as the Cuyahoga and Black rivers are indicative of localized sources of toxic organic compounds but may also be indicative of a larger problem throughout the lake.
- In eastern Lake Erie and the Buffalo River, high percentages of tumors have been reported in fish. Correlations between sediment polynuclear aromatic hydrocarbons (PAH), tumors in fish, and induction of tumors in bullheads by exposure to extracts of polluted sediment, support the hypothesis that some of these fish tumors result from exposure to carcinogenic chemicals in the environment.
- Two-year-old brown bullhead (*Ictalurus nebulosus*) from the Black River at Lorain had a liver tumor rate

of 1.2 percent, those three years and older had a 33 percent rate. In contrast, none of the brown bullhead from a control lake had liver tumors. The high tumor rate for older bullheads in the Black River correlated with high body burdens of PAH. It was concluded that because the Black River differed from the control site principally in the levels of PAH contamination, this contaminant was most likely the causative factor of elevated liver tumors in brown bullhead.

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This fact sheet presents a snapshot of the water quality of Lake Erie during a specific time period. Since the late 1980s, with reductions in phosphorous and the presence of zebra mussels, the Lake Erie ecosystem has dramatically changed. For more information about Lake Erie, subscribe to *Twine Line/North Coast Newsletter*, Ohio Sea Grant's eight-page newsletter and the Lake Erie Commission's four-page newsletter. These bimonthly newsletters are published jointly and are available for \$4.50 for six issues from the Sea Grant office in Columbus. For additional resources, request a publication brochure for Sea Grant.