Section 10: Assessment and Tracking Progress

10.1 Introduction

Surveillance and monitoring provide essential information about the state of the Great Lakes ecosystem and measure the success of remediation and protection efforts. Annex 11 of the Great Lakes Water Quality Agreement emphasizes the need for surveillance and monitoring in LaMPs and RAPs. The Lake Erie LaMP is responsible for setting goals and identifying management actions to restore and protect the lake, and to track progress towards these goals. Lake Erie Ecosystem Management Objectives have been finalized and, once indicators are developed, wherever possible existing surveillance and monitoring programs will be used to track indicator changes. Where gaps in current programs exist, new programs may be developed.

In 2000, an inventory of monitoring programs in the Lake Erie basin was developed by Environment Canada based on a number of sources of information. Ninety-three independent monitoring programs were underway within the basin (Table 10.1). Some of these monitoring programs are lakewide in nature; others are more localized or created for a single specific purpose. The Lake Erie LaMP will continue to look toward maximizing use of the existing programs to track progress toward achieving LaMP goals.

Table 10.1: Summary of Ongoing Monitoring Efforts in Lake Erie in 2000

Monitoring Category	Number of Programs
Monitoring inputs/outputs of contaminants	19
Ambient contaminant (spatial, temporal, multimedia)	29
Populations (native and exotic) and habitat	34
Health effects monitoring	8
Exotics effects monitoring	10
TOTAL	**93**

In an effort to improve the coordination of binational monitoring throughout the Great Lakes, the Binational Executive Committee in January 2004 approved the development of a Cooperative Monitoring approach according to an agreed-upon rotational cycle of one lake per year. The Cooperative Monitoring approach focuses on coordinating monitoring (and research) for key information needs of the LaMPs and the Lake Huron Binational Partnership (LHBP), one lake at a time, and promoting the sharing of data, information, expertise and technology among agencies. The LaMPs/LHBP identify their information needs and the Cooperative Monitoring Steering Committee (CMSC) then brings together the necessary expertise to develop and implement monitoring programs to address those needs. According to the agreed-upon rotational cycle, Cooperative Monitoring focused on Lake Erie in 2004 and will again in 2009. Support for Cooperative Monitoring has gained momentum among the Great Lakes scientific community.

The preliminary findings of the Lake Erie 2004 study are summarized in Section 10.2. One of the key information needs identified by the Lake Erie LaMP was nutrient loadings from tributaries. The 2004 Cooperative Monitoring year was unsuccessful in launching a project; however, the Cooperative Monitoring Steering Committee undertook a binational tributary phosphorus loading project in 2007. There were three components to this project:

- A pilot project to determine if the nutrient concentrations from the Detroit River varied with depth. The expectation is that the findings will be used to develop a larger program to determine the nutrient inputs from the river to the Western Basin of Lake Erie.

- In conjunction with MOE, two Canadian tributaries and the receiving lake water were sampled intensively. Coupled with an array of sensor mounted buoys, this work should help to determine where the nutrients are going once they reach the lake.
- In order to better understand nutrient loadings to the lake, existing sampling in tributaries was increased.

The results of the work completed in 2007 will inform planning for the Lake Erie 2009 Cooperative Monitoring year. Nutrients will be a major focus of this work.

10.2 Lake Erie Collaborative Comprehensive Survey (ECCS)
(Prepared by: Jan Ciborowski, University of Windsor)

In 2003, the Binational Executive Committee of the Parties to the Great Lakes Water Quality Agreement developed a plan for the U.S. and Canadian agencies to jointly carry out an intensive, coordinated sampling effort on each of the Great Lakes on a 5-year rotating basis. Lake Erie was chosen for investigation in 2004 as the need for intensive sampling was especially important. In the 1990s, the water quality of Lake Erie was under pressure from low water levels coupled with infrequent but intense heavy rainstorms that caused rivers to flood and carry excess sediments and nutrients into the lake. The inadvertent introduction of exotic species such as the zebra mussel was also taking a toll.

Within the lake itself, zoobenthic composition, abundance, and distribution have become dramatically altered either because of, or together with the establishment of non-native zebra and quagga mussels (*Dreissenidae*) beginning in the early 1990s. Dreissenids may be abundant enough in Lake Erie to regulate phytoplankton production, and they are becoming increasingly important in the diet of both sport fish (such as smallmouth bass) and invading species (round gobies). Dreissenids are also affecting the distribution of other benthic organisms, such as aquatic insects, crayfish, and other shallow-water (*Gammarus*) and deepwater (*Diporeia*) crustaceans. These changes are expected to influence the growth of both bottom-feeding and plankton-feeding fish populations.

The water quality models used to predict the amounts of nutrients and concentrations of oxygen in the water are becoming increasingly inaccurate. This may be due to the influence of non-native invasive species, climate change, or the need for better measurements of the way water circulates, mixes, and carries materials to different parts of the lake.

As part of the collaborative effort, a study team of five scientists from Environment Canada, University of Waterloo, Ontario Ministry of Natural Resources and the Great Lakes Environmental Research Laboratory undertook intensive observations of key physical processes and water quality measurements throughout the lake during the ice-free period from April to October 2004. The goal was to obtain time-series observations for surface meteorological components, currents, water temperature and water quality parameters to better understand how weather patterns affect water movement. A total of 26 moorings of current meters, meteorological buoys, water quality recorders, sediment traps and thermistors were deployed at several locations in the lake. Other measurements were made to study nearshore-offshore horizontal exchanges and mixing along the north shore of Lake Erie to understand the mechanisms of upwelling and oxygen depletion, and the impact of storms on resuspension and transport of the material.

Between May and August 2004, a team of 23 scientists from Canadian and US universities and agencies, coordinated through the Lake Erie Millennium Network, collected bottom-dwelling organisms and sediments, and measured water chemistry. A total of 284 nearshore and offshore stations were sampled from 10 different vessels through the cooperative efforts of Environment Canada, Ontario Ministry of the Environment, Ontario Ministry of Natural Resources, NOAA, the USGS, and other cooperators (the Lake Erie Comprehensive Collaborative Study - ECCS). The sample locations were allocated among the three basins, four depth classes, and two substrate types (hard/soft) to permit lake-wide estimates of benthic invertebrate abundance and biomass, especially for zebra and quagga mussels.

Hard substrates were sampled by divers operating air lift samplers. Soft substrates were sampled with a standard Ponar grab. In addition to collecting bottom-dwelling invertebrates, sediment and bottom-associated algal samples were collected at 174 locations where soft sediments were found. The physical and chemical characteristics of these sediments were analysed as were the concentrations of trace metals, organochlorine compounds, and other chemicals of emerging environmental concern.

Funding was provided by U.S. EPA-GLNPO, Ontario Ministry of the Environment, and Environment Canada to process, identify, enumerate and determine the biomass of zoobenthos, especially dreissenids, in benthic samples. The organisms from each station were identified to the genus or species level and enumerated. The biomass of dreissenid mussels was also determined.

Preliminary Results

Lake-wide, quagga mussels were much more common and abundant (mean abundance and density of 2,530 individuals/m^2; 43 g/m^2 dry mass) than zebra mussels (242 individuals/m^2 and 1.9 g/m^2 dry mass). Both species were about equally abundant at shallow depths (<8 m) in the western basin, but zebra mussels were found at only seven of 116 central basin stations, and one of 81 eastern basin locations. Maximum densities were recorded at depths of 3-7 m, 8-12 m, and 8-29 m in the western, central, and eastern basins, respectively. The total density and mass of dreissenids has changed little since 1992, but zebra mussels are now confined almost entirely to the western basin. The density of quagga mussels in the eastern basin may have declined between 2002 and 2004, but biomass was unchanged. Over 75 percent of dreissenid numbers and an even greater percentage of the biomass now occur in the eastern basin. Deepwater amphipods (*Diporeia*), which are an important food for lake whitefish and other bottom-feeding fishes, were collected at only four stations. Taken together, these data suggest that the distribution and abundance of benthic invertebrates in Lake Erie continues to change in concert with the changing aquatic environment and pressures of their predators.

The results of measurements of water movements made in 2004 and additional measurements collected in 2005 are still being interpreted. Preliminary analyses indicate that the average direction of transport was unidirectional and followed the path of prevailing winds from west to east. However, at some times, water near the lake bottom flows from the eastern basin (where most of the dreissenids are located) into the central basin. Further work is needed to determine how much phosphorus associated with dreissenid excretion may be carried by these flows. Water, nutrient, and particle transport movements associated with several severe storm events were recorded and are revealing some unexpected and interesting patterns of circulation.

Throughout the biological and water movement studies, special care was taken to ensure that all data collected and compiled were compatible and suitable for use by other scientists. Ultimately, this information will be incorporated into statistical models that will help us better understand the way in which the lake's physical properties and processes are coupled with biological conditions to affect the Lake Erie food web.

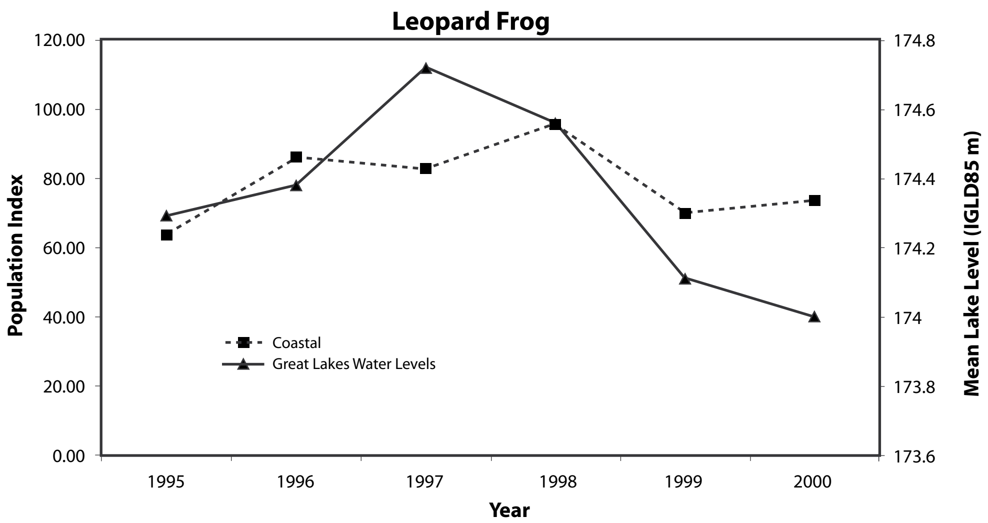
10.3 Marsh Monitoring Program
(Reproduced from Lake Erie LaMP 2002 report)

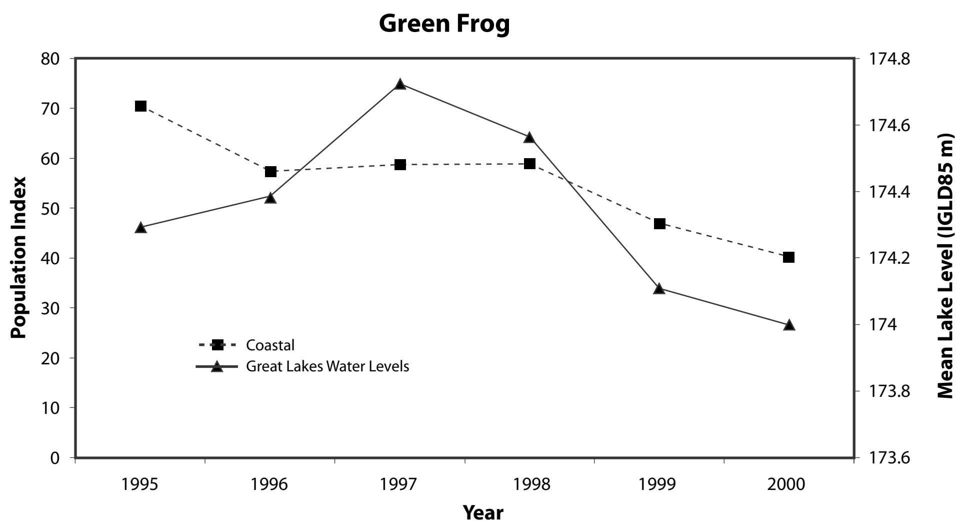
Since 1995, this volunteer based program has engaged both professional and dedicated citizen naturalists throughout the Great Lakes region (including Lake Erie) to record and monitor annual trends in populations of several calling-amphibian (frogs and toads) and marsh bird species in important marshes throughout the basin. Information gathered through the Marsh Monitoring Program is relevant for assessing relative population changes in these species at local, regional and basinwide scales, and can be useful for gauging the status and ecological integrity of marshes at each of these scales.

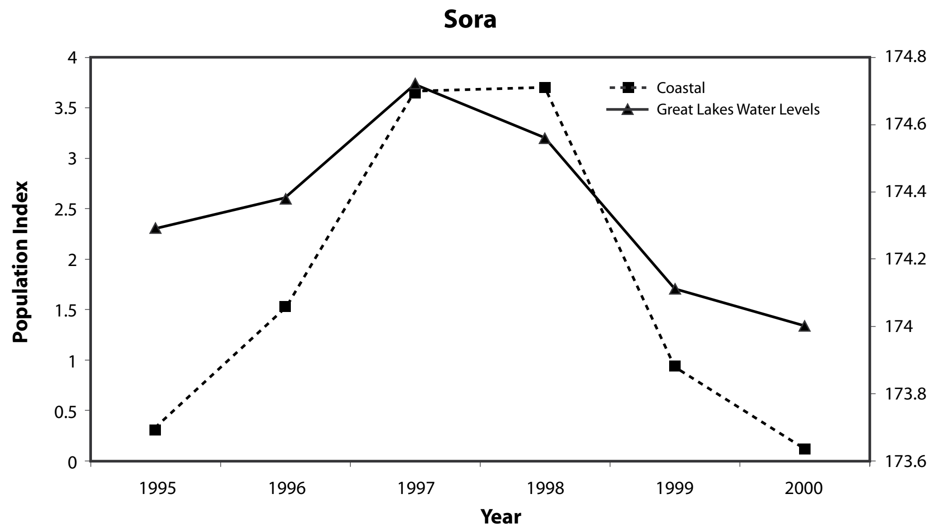
Results (1995-2000) suggest that there appears to be a relationship emerging between population trends of some marsh bird and amphibian species in coastal marshes and the trend in Lake Erie's mean annual water levels, especially since 1997, the year that marked the end of the last sustained high water period. For example, black tern and sora trends at coastal marshes have followed a similar pattern to that of Lake Erie's water levels. Similarly, trends for aquatic amphibian species such as green frog and northern leopard frog have closely reflected the trend in Lake Erie's water levels at coastal marshes. Conversely, trends for certain marsh bird species preferring drier marsh edge habitat have increased at coastal marshes during recent lake level declines. For example, the trend for common yellowthroat (a marsh edge preferring warbler) at coastal Marsh Monitoring Program routes has been inversely related to Lake Erie's water levels (Figure 10.1).

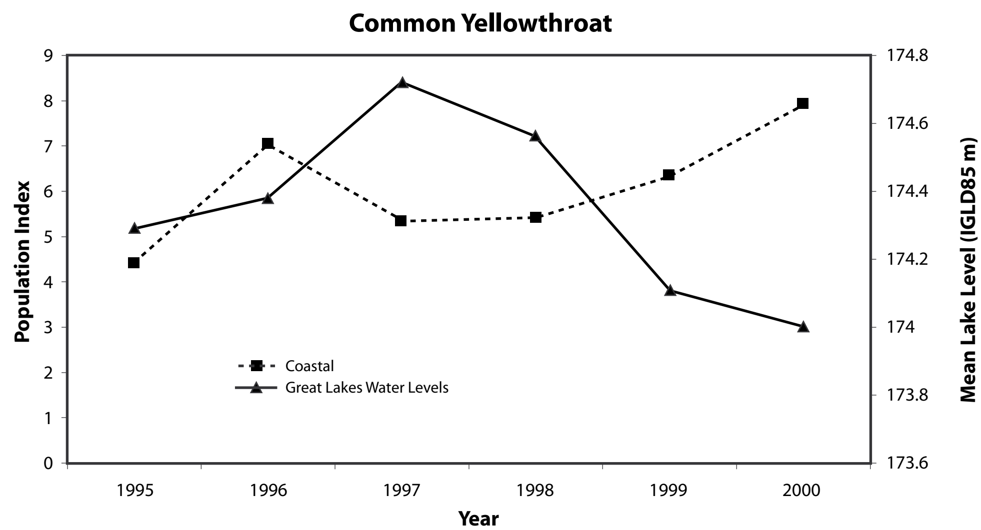
These relations could be explained in part by spatial movement of certain species into or out of Marsh Monitoring Program survey routes. Alternatively, as lake levels declined, if appropriate marsh habitat was not replaced at the rate at which it was lost, and appropriate marsh habitat was either not available elsewhere or was already at its carrying capacity, then declining trends in highly marsh dependent birds and amphibians may well be indicative of overall population declines.

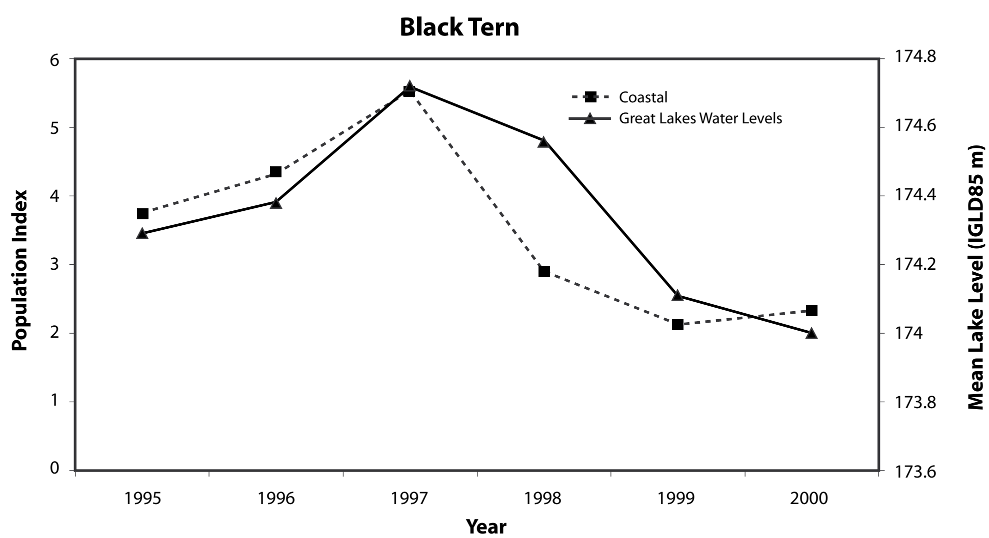
Figure 10.1: Lake Erie basin-wide trends in relative abundance of selected marsh bird and amphibian species compared to mean annual water levels of Lake Erie from 1995 to 2000. For each species, trends are presented for marshes monitored at coastal locations (i.e. within 5 km/3 miles from a lake shore).






Sora
Coastal
Great Lakes Water Levels
Population Index
Year
1995
1996
1997
1998
1999
2000


Common Yellowthroat
Coastal
Great Lakes Water Levels
Population Index
Mean Lake Level (IGLD85 m)
Year
1995
1996
1997
1998
1999
2000


Black Tern
Coastal
Great Lakes Water Levels
Population Index
Mean Lake Level (IGLD85 m)
Year
1995
1996
1997
1998
1999
2000

Although current lake levels are near their long-term lows, because lake levels fluctuate, and trends in certain marsh bird and amphibian species at coastal marshes appear to respond to changing lake levels (positively or negatively), when Lake Erie's levels begin to increase again, these responses should be detected by Marsh Monitoring Program data. Only by taking into account the dynamic nature of coastal marsh habitats can one examine what is really happening to populations of marsh birds and amphibians in the Lake Erie basin.

Bald Eagle Update

Bald eagles continue to be a highly visible indicator of the state of the Great Lakes. Most of the bald eagles nesting in the Lake Erie basin are found in Ohio, particularly in the marshes in the western basin. In 1979, Ohio had only four nesting pairs along the southwestern Lake Erie shoreline and the eagles along Ontario's Lake Erie shoreline produced no young. Exposure to pesticides, particularly DDT and its breakdown product DDE, proved to be the barrier to successful bald eagle reproduction. Reduction in pesticide use slowly decreased the amount of contaminants in the birds. 1980s programs of hacking healthy eaglets in nests in the western basin marshes, and transplanting healthy adult bald eagles to the Long Point area have greatly improved the population status.

The 2000 nesting year was excellent for Ohio Lake Erie eagles with an 83% success rate and an average 1.4 fledglings per nest. 63 nesting pairs produced 89 fledglings (ODNR). In 2000 the Ontario shore of Lake Erie fledged 21 birds from 14 nests, a rate of 1.5 fledglings per nest (Whittam 2000). Eagle populations continue to grow both along the shore and further inland. Younger birds are starting to build nests closer to human disturbance, and more nests are being found further east and inland. In 2002, 107 eaglets fledged from 58 nests statewide in Ohio. In 2003, 88 nesting pairs in 34 (out of 88) Ohio counties produced 105 young. A record-breaking 105 bald eagle nests have been documented in Ohio statewide at the beginning of the nesting season in 2004.

Although populations continue to increase, the inland populations are increasing faster than the Lake Erie based populations. Also, although the reproductive success is improved, the birds are not living as long. Bald eagle pairs generally return to the same breeding territory, and often use the same nest. However, there appears to be a high rate of turnover for breeding birds. Bald eagles can live to be about 28 years old in the wild but the birds in the southern Great Lakes are only surviving for 13-15 years.

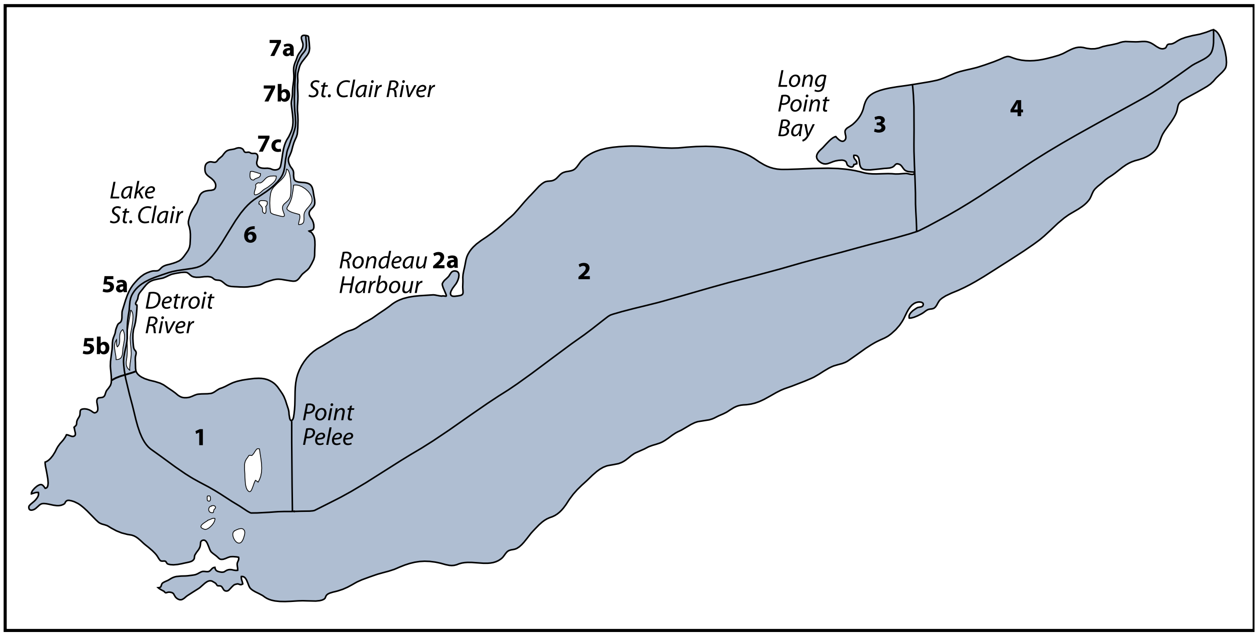
The Ohio Lake Erie Protection Fund provided a grant in 2000 to analyze blood and feather samples collected and archived by the Ohio Department of Natural Resources in the 1990s. PCBs, DDE, chlordane and dieldrin are still found at significant levels (Roe et al. 2004). Elevated levels of mercury and lead have been found in birds in the Long Point area on the Canadian shore. Additional research by Bird Studies Canada and the Ontario Ministry of Natural Resources is being done to track sources of mercury and lead in the bald eagles' diet.

Photo: U.S. Fish & Wildlife Service, Dave Menke

10.4 Trends in Contaminants in Ontario's Lake Erie Sport Fish *(Reproduced from Lake Erie LaMP 2002 report and updated in 2004, prepared by Al Hayton, Ontario Ministry of the Environment)*

Sport fish contaminant monitoring in Ontario is coordinated by the Ontario Ministry of the Environment and conducted in partnership with the Ontario Ministry of Natural Resources. Sport fish from the Canadian waters of Lake Erie have been monitored on a regular basis for contaminants since the 1970s. Size and species-specific consumption advisories for different regions or blocks of the lake (Figure 10.2) are provided to the public in the *Guide to Eating Ontario Sport Fish*.

Figure 10.2: Lake Erie blocks



Consumption advisories, provided as the recommended maximum number of meals per month, are based on health protection guidelines developed by Health Canada. Consumption restrictions in Ontario on Lake Erie sport fish are caused by PCBs (82%) and mercury (18%). In 2002 these percentages were 70% and 30%, respectively. Other contaminants such as DDT and metabolites, hexachlorobenzene, octachlorostyrene, chlordane and lindane are often detected in Lake Erie sport fish, but do not cause consumption restrictions, and concentrations have declined over the years. In recent years, dioxins and furans have been monitored in species expected to have the highest concentrations (e.g. carp, lake whitefish), but have not caused consumption restrictions. Comparing data across the Canadian waters of the Great Lakes, Lake Erie has the lowest proportion of sport fish species with consumption restrictions at 15.7% (in 2002 that number was 17.4%). The proportion of sport fish species with consumption restrictions in the Canadian waters of the other Great Lakes ranges from 21.1% in Lake Huron to 41.1% in Lake Ontario.

In order to report on spatial and temporal trends in contaminants, a "standard size" was selected for each species. The standard size was close to the mean length for the species in the database and typical of the size caught and consumed by anglers. Contaminants in standard size sport fish for the last 10 years were used to evaluate spatial trends. Contaminant data from Block 1 from 1976-2000 were separated into 5-year intervals for temporal trend evaluation. Species selection was based on the availability of data.

Mercury concentrations exhibit no spatial patterns across Lake Erie blocks. Mercury concentrations in 30 cm white bass ranged from 0.09 to 0.15 ppm and in 45 cm walleye from 0.10-0.13 ppm. For both species there was no significant difference across the three major blocks of Lake Erie (Figures 10.3 and 10.4). Block 3 (Long Point Bay) was excluded from the statistical analysis because of the lack of replicate data. Over the past 25 years, mercury concentrations in Lake Erie sport fish have declined. When a comparison was made of the mercury concentrations in white bass in five year intervals between 1976 and 2000 it was found that mean concentrations in 30 cm white bass decreased significantly from 0.22 ppm in the first period (1976-1980) to 0.13 ppm in the last period (1996-2000). The same was found for walleye. Mean mercury concentrations in 45 cm walleye decreased from 0.30 ppm to 0.12 ppm in the same time period (Figures 10.5 and 10.6). Most of the decrease occurred between the 1976-1980 period and 1981-1985. Between 1981-1985 and 1996-2000, there was no significant difference in mercury concentrations in either white bass or walleye. Mercury concentrations in most Lake Erie sport fish are low and only the largest individuals tend to exceed the consumption guideline of 0.45 ppm. White bass and walleye do not exceed the guideline until they exceed 40 cm and 70 cm in length respectively (Figure 10.7).

Analysis of spatial patterns of PCBs for 30 cm white bass suggests that there is little difference in PCB concentrations between blocks in Lake Erie (Figure 10.8). Lower levels found in block 4 are based on only one year of data so statistical significance could not be determined. Over the past 25 years, PCB concentrations in some but not all species of Lake Erie sport fish have decreased. Mean PCB concentrations in 30 cm white bass decreased significantly from 615 ppb in 1976-1980 to 242 ppb in 1996-2000 (Figure 10.9). Most of the decrease occurred between the 1976-1980 and 1981-1985 periods.

PCB concentrations in channel catfish appear to have decreased (Figure 10.10) but lack of replicate data for some periods prevented statistical confirmation. The highest PCB concentrations were found in 1981-1985 (3225 ppb). By the 1996-2000 period mean PCB concentrations had declined to 1143 ppb. PCB concentrations in carp do not appear to have declined over the period of sampling and in the most recent period (1996-2000) were still in excess of 2000 ppb (Figure 10.11). Differences among species may be due to the residual effects of sediment-bound PCBs. Pelagic species such as white bass would be less affected by sediment-bound PCBs than benthic-feeding species such as carp. Although PCB concentrations are low in most Lake Erie sport fish, high lipid species such as channel catfish and carp exceed the consumption guideline of 500 ppb even in relatively small individuals (Figure 10.12).

The Ontario Ministry of the Environment, through the Sport Fish Contaminant Monitoring Program, continues to monitor Lake Erie sport fish for trends in contaminant concentrations and provides consumption advice to anglers.

Figure 10.3: Mercury concentrations in 30 cm (12 inch) white bass across Lake Erie 1990-2000

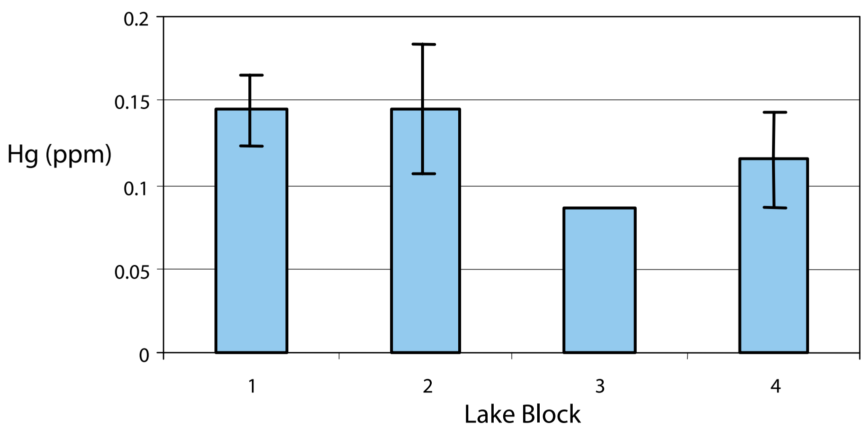


Figure 10.4: Mercury concentrations in 45 cm (18 inch) walleye across Lake Erie 1990-2000

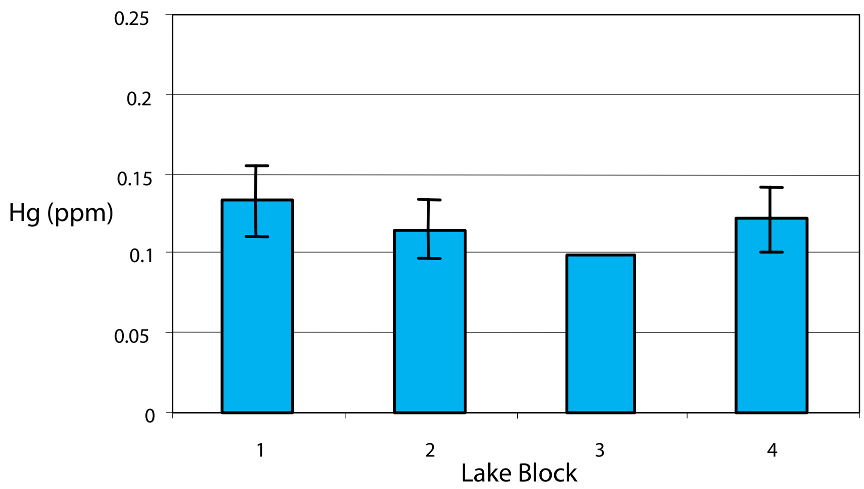


Figure 10.5: Mercury concentrations in 30 cm (12 inch) white bass over time in Lake Erie block 1

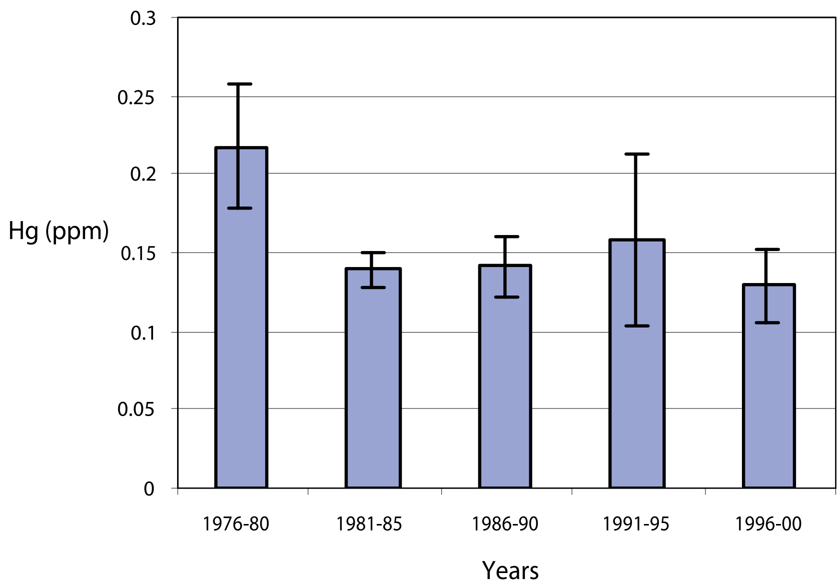


Figure 10.6: Mercury concentrations in 45 cm (18 inch) walleye over time in Lake Erie block 1

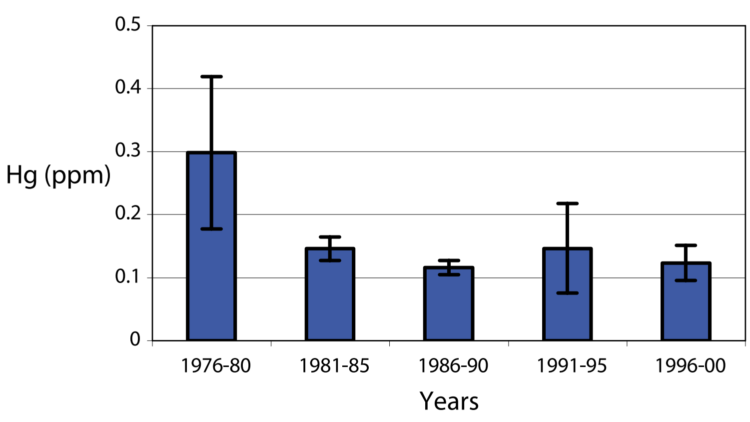


Figure 10.7: Mercury concentration vs. length in walleye and bass from Lake Erie block 1

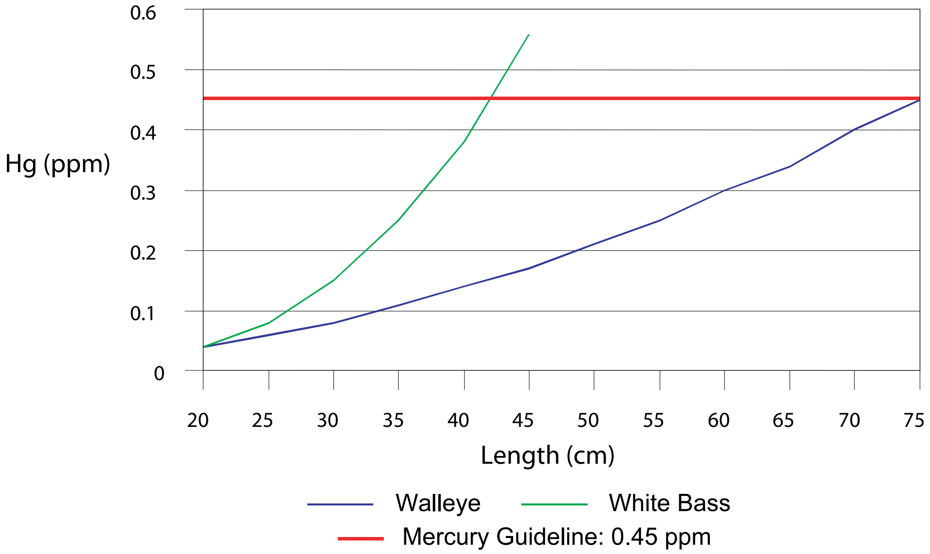


Figure 10.8: PCB concentrations in 30 cm (12 inch) white bass across Lake Erie 1990 - 2000

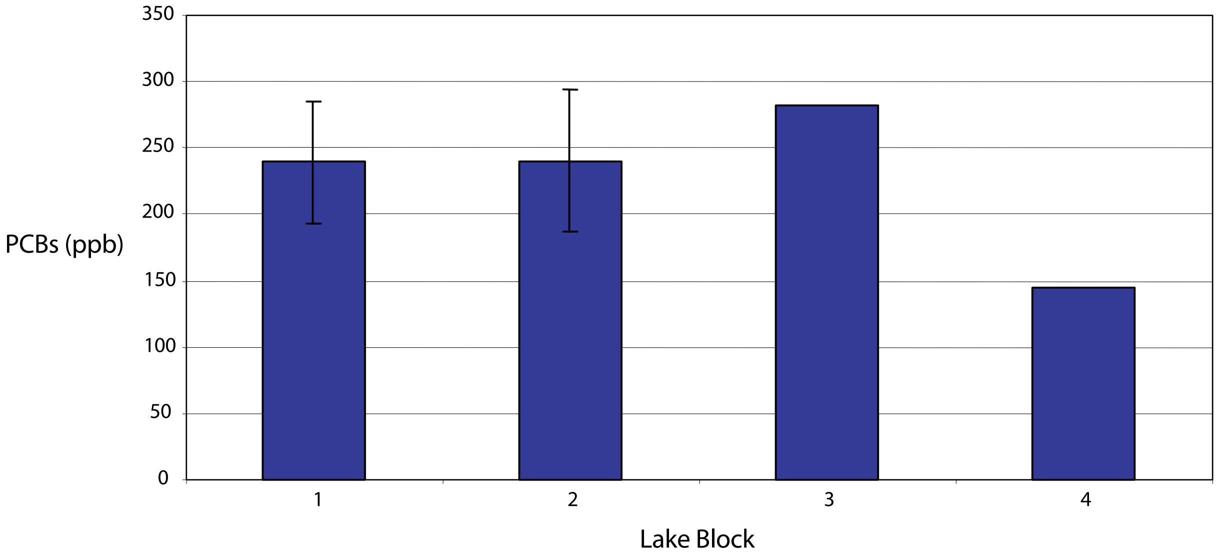


Figure 10.9: PCB concentrations in 30 cm (12 inch) white bass over time in Lake Erie block 1

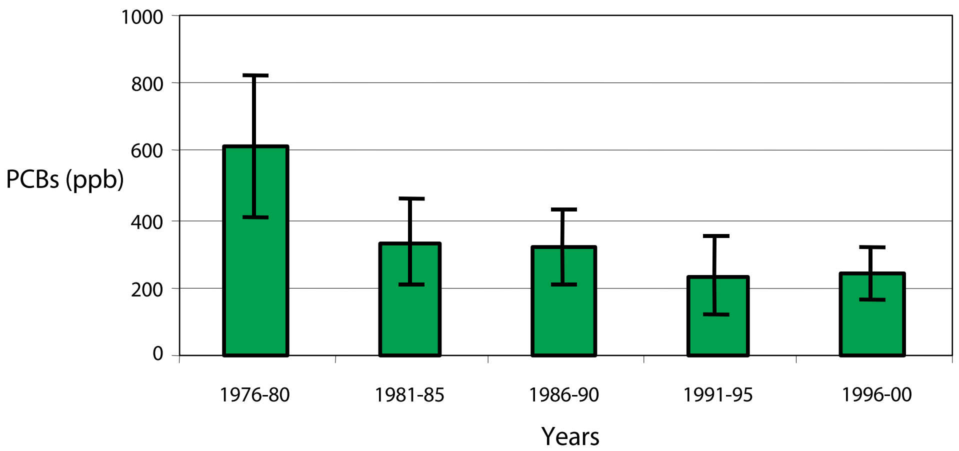


Figure 10.10: PCB concentrations in 45 cm (18 inch) channel catfish over time in Lake Erie block 1

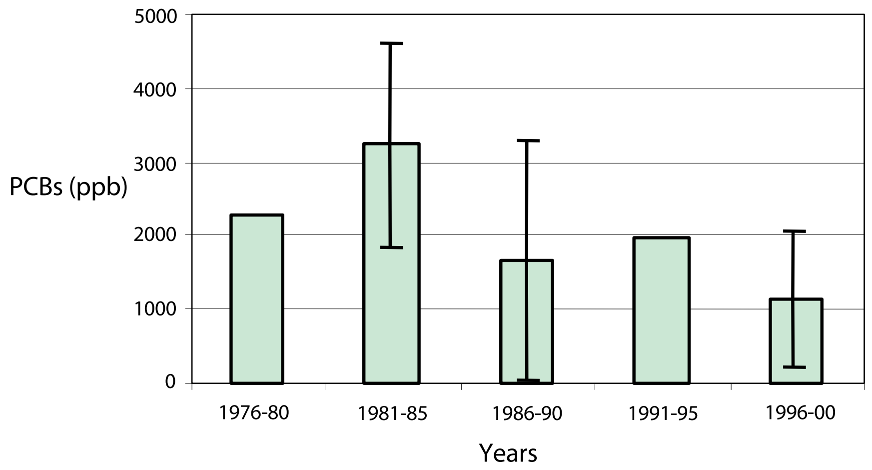


Figure 10.11: PCB concentrations in 65 cm (25 inch) carp over time in Lake Erie block 1

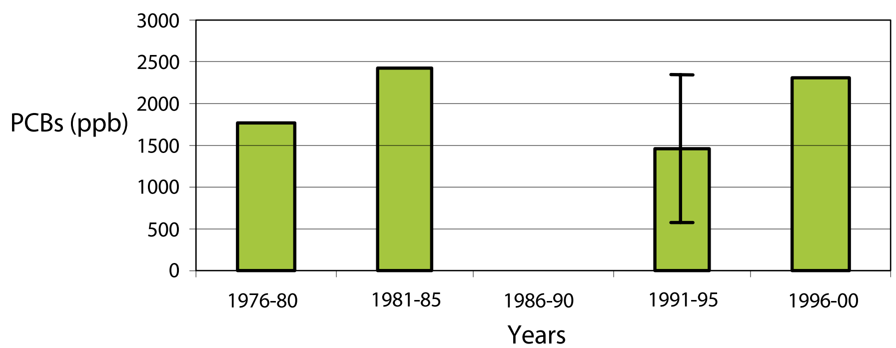
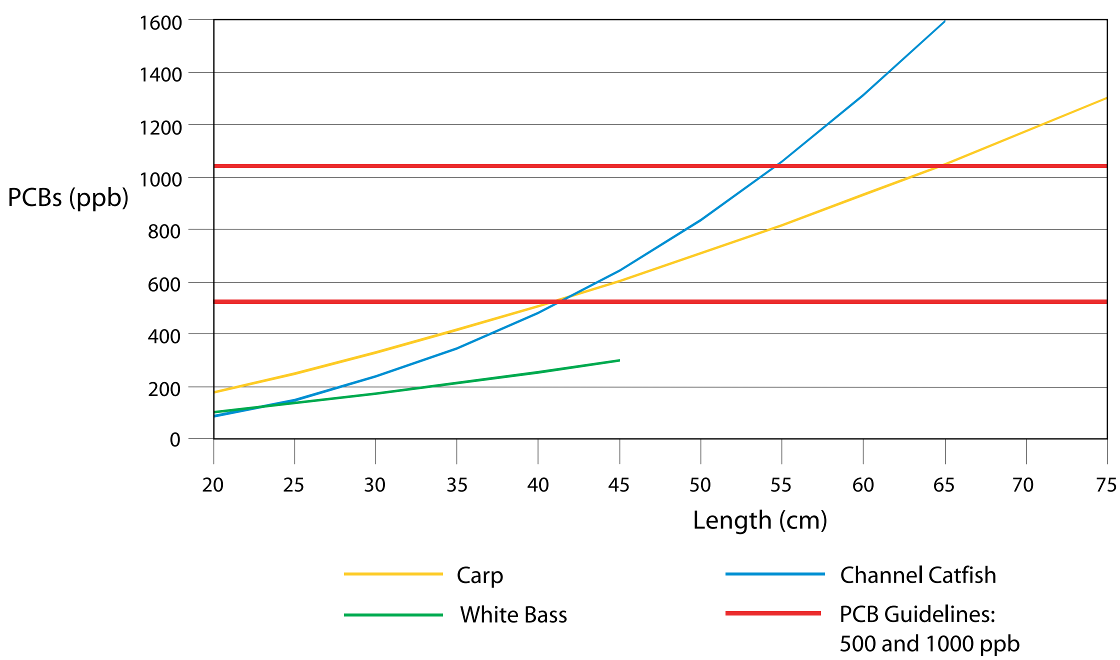


Figure 10.12: PCB concentration vs. length in fish from Lake Erie block 1



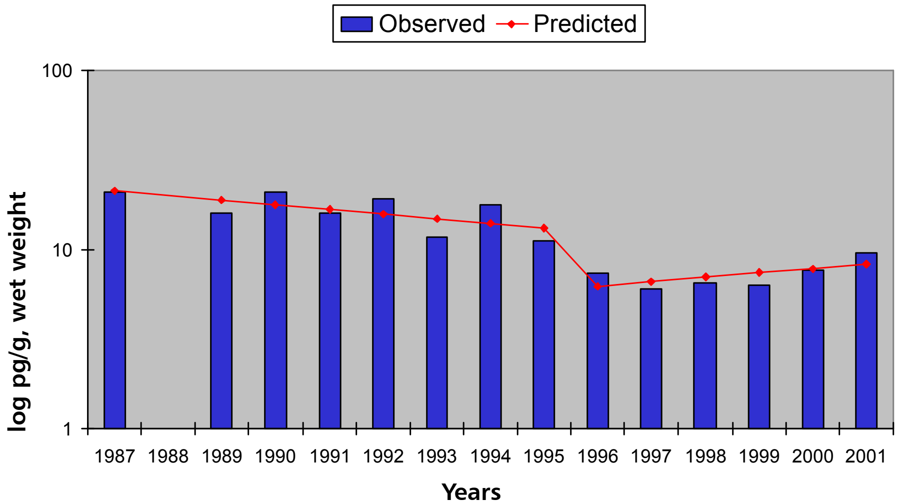
10.5 Trends in Contaminant and Population Levels of Colonial Waterbirds *(Reproduced from Lake Erie LaMP 2002 Report, prepared by Chip Weseloh, Environment Canada - Canadian Wildlife Service)*

The Wildlife Toxicology Section of the Canadian Wildlife Service (Ontario Region) maintains two wildlife-monitoring programs on the Great Lakes: contaminants in herring gull eggs and population levels of breeding colonial waterbirds. The former program was last reported on for the two Lake Erie sites, Middle Island and Port Colborne Breakwall, in 1999. The latter program is only conducted in its entirety once every decade and the most recent report is now available.

Contaminant levels in herring gull eggs do not change very much from year to year, and year-to-year changes do not necessarily have much meaning in long-term trends. Significant changes in long-term trends are usually only seen over several years. For example, Figure 10.13 illustrates an increase in 2,3,7,8 TCDD (dioxin) in herring gull eggs at Middle Island over the last three years but, compared to longer-term observations, there is not an increasing or decreasing trend. Figure 10.14 likewise shows an increase in PCB in herring gull eggs at the Port Colborne site in 2001, but the overall long-term trend is downward. The overall changes in concentrations of the other contaminants measured under this monitoring program (DDE, hexachlorobenzene, mirex, heptachlor epoxide and dieldrin) were variable over the last three years, but the overall trend is significantly downward.

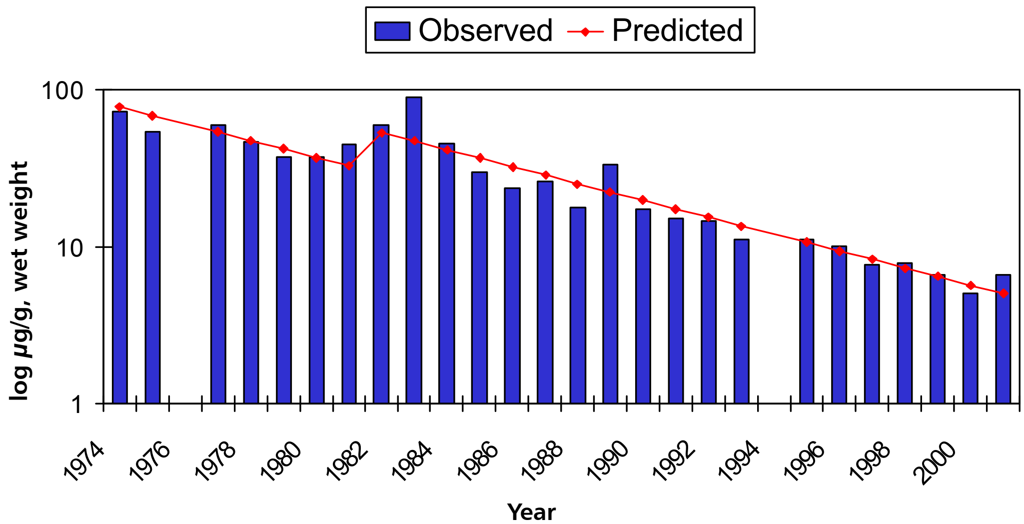
Breeding populations of colonial waterbirds on Lake Erie were surveyed in the late 1970s, 1980s and the 1990s. During the last two decades, populations of herring and ring-billed gulls, and common terns have declined from 14.7 to 18.3%. This is consistent with similar patterns for these species in the other Great Lakes. The number of breeding gulls has declined probably as a result of artificially high population levels in the 1980s, when forage fish populations were larger. Common terns have declined probably as a result of ongoing nest site competition with ring-billed gulls. Double-crested cormorant populations in Lake Erie have increased 211% since the late 1980s. Their populations have been increasing in each of the Great Lakes since the late 1970s. Great black-backed gulls and Caspian terns have just started nesting in Lake Erie (at Mohawk Island at the mouth of the Grand River) and have not yet established themselves there on an annual basis.

Figure 10.13: 2378-TCDD in herring gull eggs - Middle I., 1987-2001



Model shows a significant decline before the change point year in 1996 and a non-significant trend after the change point.

Figure 10.14: PCB 1:1 in herring gull eggs - Port Colborne, 1974-2001



Model shows the same significant rate of decline before and after the change point in 1982.

10.6 Ohio Lake Erie Quality Index

In 1998, the Ohio Lake Erie Commission released the Ohio State of the Lake Report. For this report ten indicators were developed to measure environmental, economic and recreational conditions as related to the quality of life enjoyed by those living near or utilizing the Ohio waters of Lake Erie. Each indicator is composed of several metrics that were selected because they had measurable goals or endpoints against which progress could be measured and, in most cases, some regular monitoring was already being done. These indicators, called the Lake Erie Quality Index, will be updated in 2004. The ten indicators developed in 1998 are presented in Table 10.2.

Table 10.2: Ohio Lake Erie Quality Index Indicators

Indicator	Rating
Water Quality	Good
Pollution Sources	**Fair**
Habitat	**Fair**
Biological	Good
Coastal Recreation	Good
Boating	Good
Fishing	Excellent
Beaches	Good
Tourism	Excellent
Shipping	Fair

Additional analysis over the past five years has somewhat altered the metrics used to determine several of the indicators. The Water Quality Indicator has been split into two indicators: one that addresses ambient conditions (water chemistry, water clarity, contaminants in bald eagles, and contaminated sediment) and one that addresses human exposure risks (fish consumption advisories, beach closings and drinking water). The biological indicator has been expanded to include an index of biological integrity (IBI) for shoreline and tributary fish, offshore fish, offshore plankton, key indicator species and coastal wetlands. Tourism and shipping have been combined into one indicator titled Economy.

Photo: Scott Gillingwater

10.7 State of the Lakes Ecosystem Conference (SOLEC)

In response to a reporting requirement of the Great Lakes Water Quality Agreement, in 1994 U.S. EPA and Environment Canada initiated the State of the Lakes Ecosystem Conference, more universally known as SOLEC. It provides a forum for the exchange of information on the ecological condition of the Great Lakes and surrounding lands. SOLEC focuses on the state of the Great Lakes ecosystem and the major factors impacting it, rather than on the status of programs needed for protection and restoration, which is more of the LaMPs' role. In 1998, SOLEC began an effort to develop standard indicators that could be used to better report out on the status of the Great Lakes in a more consistent manner. SOLEC reviewed a number of possible indicators and is currently refining a list of 80 for their potential utility in measuring conditions across the Great Lakes. The work of the SOLEC team will be utilized wherever possible as the Lake Erie LaMP develops the indicators that it will use to track Lake Erie LaMP progress. In 2004, SOLEC will focus on indicators of physical integrity.

10.8 Trends in Contaminants in Lake Erie Whole Fish (1977-2004) *(Prepared by: Elizabeth Murphy, U.S. EPA GLNPO; D. Michael Whittle and Michael J. Keir, DFO, Great Lakes Laboratory for Fisheries and Aquatic Sciences; and J. Fraser Gorrie, Bio-Software Environmental Data)*

Long-term (>25 yrs), basin-wide monitoring programs measuring whole body concentrations of contaminants in top predator (lake trout and/or walleye) and forage fish (smelt) are collected by the U.S. EPA's Great Lakes National Program Office (GLNPO) and Fisheries and Oceans Canada (DFO) to develop trend data on bioavailable toxic substances in the Great Lakes aquatic ecosystem. DFO reports contaminant burdens annually in similarly-aged fish, while GLNPO reports contaminant burdens annually in similarly-sized fish. For Lake Erie, DFO samples walleye, lake trout and smelt 4 to 6 years old, while GLNPO samples walleye 450 to 550 mm in length. Since the late 1970s, concentrations of historically regulated contaminants, such as PCBs, DDT and mercury, have generally declined in most monitored fish species throughout the Great Lakes. Several other contaminants, currently regulated or unregulated, have demonstrated either slowing declines or increases in selected fish communities. These changes are often specific to a particular Great Lake and relate both to the characteristics of the substances involved and the biological conditions of the fish community surveyed.

The GLWQA criterion for PCBs states that, "The concentration of total polychlorinated biphenyls in fish tissues (whole fish, calculated on a wet weight basis), should not exceed 0.1 microgram per gram for the protection of birds and animals which consume fish." The GLWQA criterion for DDT and metabolites states that, "The sum of the concentrations of DDT and its metabolites in whole fish should not exceed 1.0 microgram per gram (wet weight basis) for the protection of fish-consuming aquatic birds". The GLWQA criterion for mercury states that, "The concentration of total mercury in whole fish should not exceed 0.5 micrograms per gram (wet weight basis) to protect aquatic life and fish-consuming birds". Tables 10.3 and 10.4 define the percent change over time compared to the highest recorded concentration, for GLNPO and DFO sampling, respectively.

Table 10.3: Percent Change in Total PCB/ΣDDT Concentrations for GLNPO Fish Collections (Walleye: 450-550mm)

Contaminant	GLWQA Criterion (µg/g)	Species	Highest Recorded Concentration		Most Recently Measured Concentration		% of Highest Recorded Concentration
			Year	Value (µg/g)	Year	Value (µg/g)	
Total DDT	1.0	Walleye	1977	0.51	2000	0.085	17%
Total PCBs	0.1	Walleye	1977	2.64	2000	1.241	47%

*All concentrations based on whole fish samples, wet weight

Table 10.4: Percent Change in Total PCB/ΣDDT/Mercury Concentrations for DFO Fish Collections (Age 4 to 6 year old range)

Contaminant	GLWQA Criterion (µg/g)	Species	Highest Recorded Concentration		Most Recently Measured Concentration		% of Highest Recorded Concentration
			Year	Value (µg/g)	Year	Value (µg/g)	
Total DDT	1.0	Walleye	1977	0.90	2003	0.06	7%
		Lake Trout	1989	0.83	2003	0.07	8%
		Smelt	1980	0.12	2003	0.01	8%
Total PCBs	0.1	Walleye	1979	3.11	2003	1.08	35%
		Lake Trout	1990	1.75	2003	0.70	40%
		Smelt	1990	0.76	2003	0.08	11%
Mercury	0.5	Walleye	1977	0.37	2003	0.12	32%
		Smelt	2002	0.05	2003	0.02	40%

*All concentrations based on whole fish samples, wet weight.

Photo: U.S. EPA Great Lakes National Program Office

Total DDT

All monitored species in Lake Erie displayed a similar pattern of DDT contamination (see figures below). Each species displayed a fair degree of year-to-year variability but the overall trend is decreasing. Since the late 1970s, concentrations showed a steady decline followed by a sharp increase in the late 1980s. After 1989, concentrations again declined with some year to year variability. Figure 10.15 presents DDT in rainbow smelt (DFO), Figure 10.16 displays DDT in DFO-collected walleye, and Figure 10.17 depicts DDT in GLNPO-collected walleye. Both DFO and GLNPO walleye data follow the pattern of annual concentration increases in the late 1980s, linked to changes in the zebra mussel population (Morrison et al. 1998, Morrison et al. 2000), followed by generally declining concentrations after 1989. DFO walleye collected in Lake Erie represent primarily conditions in the western and central basins of the lake. Fall DFO collections occur in the western basin but fish migrate between the western and central basins at points during each year. Fall GLNPO walleye collections demonstrate similar characteristics. DFO lake trout and smelt data trends also follow the fluctuating concentration pattern influenced by zebra mussel infestation (Morrison et al. 1998.) It is important to note that DFO lake trout collections in Lake Erie were only initiated in 1985. Therefore, the limited number of samples available in the selected age cohort over time makes rigorous temporal trend assessment difficult. Lake trout primarily represent conditions in the eastern basin of the lake as their movement is restricted by generally higher water temperatures prominent outside the eastern basin. GLNPO and DFO recorded concentrations of total DDT in Lake Erie walleye have never exceeded GLWQA criteria. DFO recorded concentrations of total DDT in lake trout and smelt have never been above GLWQA criteria.

Figure 10.15: Total DDT levels in Lake Erie Rainbow Smelt, 1977-2004 (μg/g +/- S.E. wet weight, whole fish). (Source: DFO-GLLFAS unpublished data) GLWQA criterion is 1.0 μg/g.

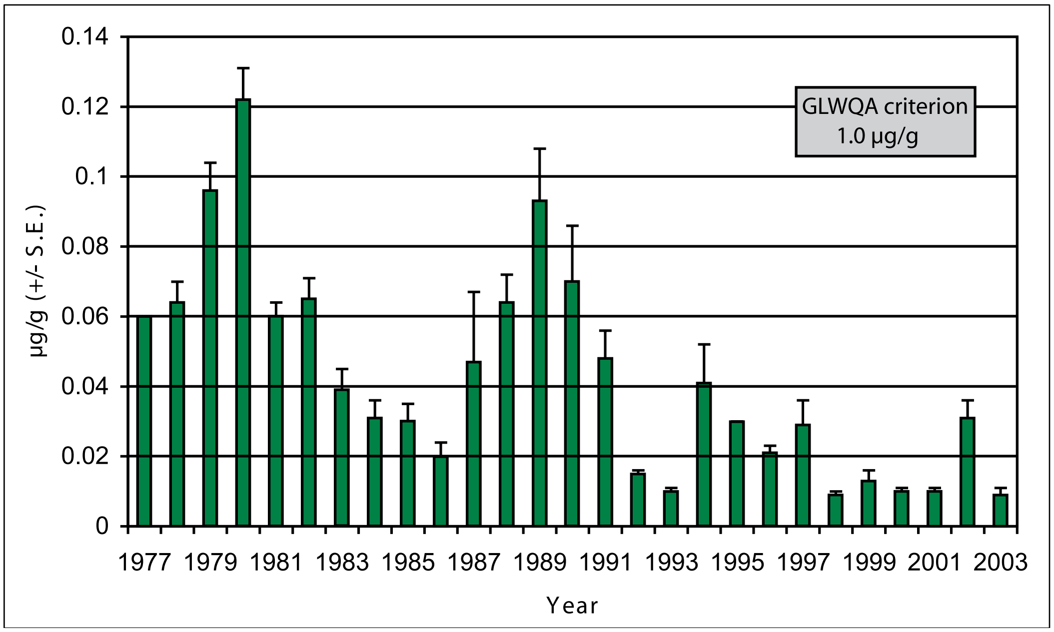


Figure 10.16: Total DDT Levels in Lake Erie Walleye, 1977-2003 (µg/g +/- S.E. wet weight, whole fish ages 4-6). (Source: DFO-GLLFAS, unpublished data)

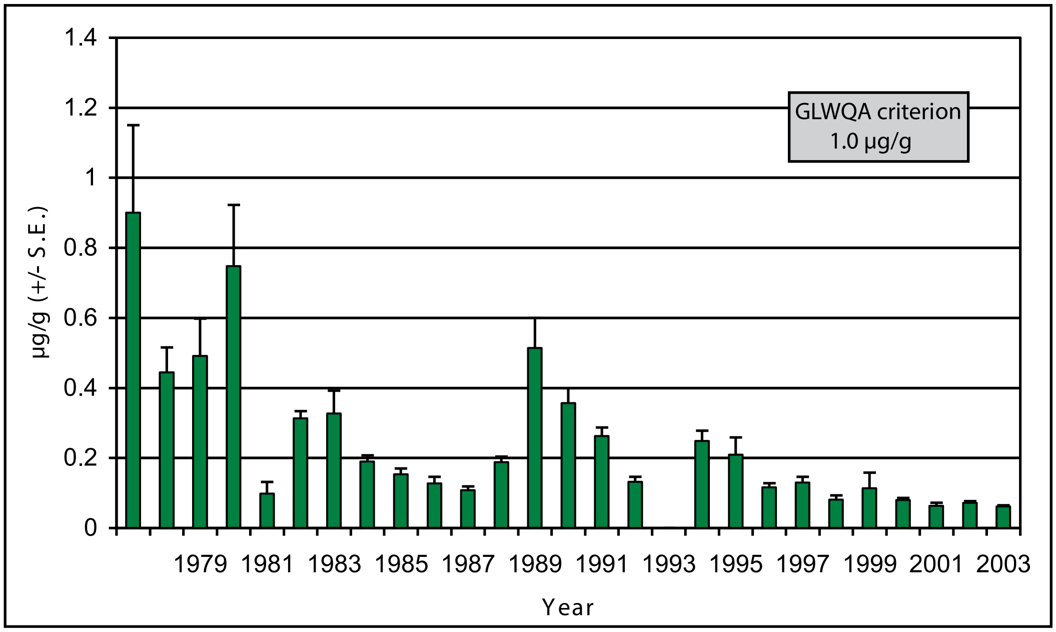
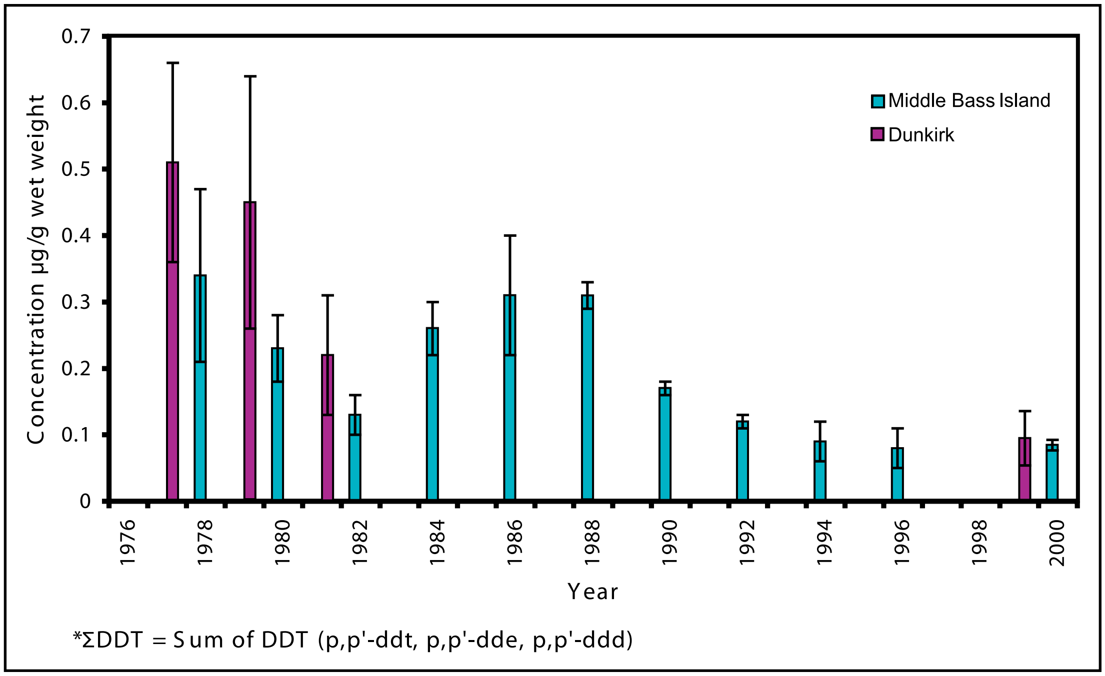


Figure 10:17: ΣDDT levels in whole Walleye (450 - 550 mm size) in Lake Erie, 1972 - 2000 (µg/g wet weight +/- 95% C.I., composite samples). (Source: EPA-GLNPO)



Total PCBs

The introduction of zebra mussels also affected contaminant trends of PCBs (Morrison et al 1998). GLNPO walleye demonstrate a period of increase in concentration from the late 1980s through the early 1990s, followed by a sharp decline in the early 1990s and a fairly stable concentration since then (Figure 10.18). DFO walleye demonstrated a similar period of annual increases from 1985 through 1993 associated principally with the proliferation of the zebra mussel population, followed by a decline in PCB concentration, and then remained relatively steady over the past four years through 2003 (Figure 10.19). DFO lake trout data show a decrease in concentration between 1990 and 2001, followed by a slight increase in concentration through to 2003 (Figure 10.20). DFO smelt data show a decline in concentration between 1990 and 2001, followed by a sharp increase in 2002 and an 80% decrease in 2003 (Figure 10.21). GLNPO and DFO recorded PCB concentrations in Lake Erie walleye and lake trout are above GLWQA criteria. DFO measured Lake Erie smelt PCB concentrations have exceeded GLWQA criteria, but there are also years where concentrations are below 0.1 µg/g.

Figure 10:18: Total PCB levels in whole Walleye (450 - 550 mm size range) in Lake Erie, 1972-2000 (µg/g wet weight +/- 95% C.I., composite samples). (Source: EPA-GLNPO)

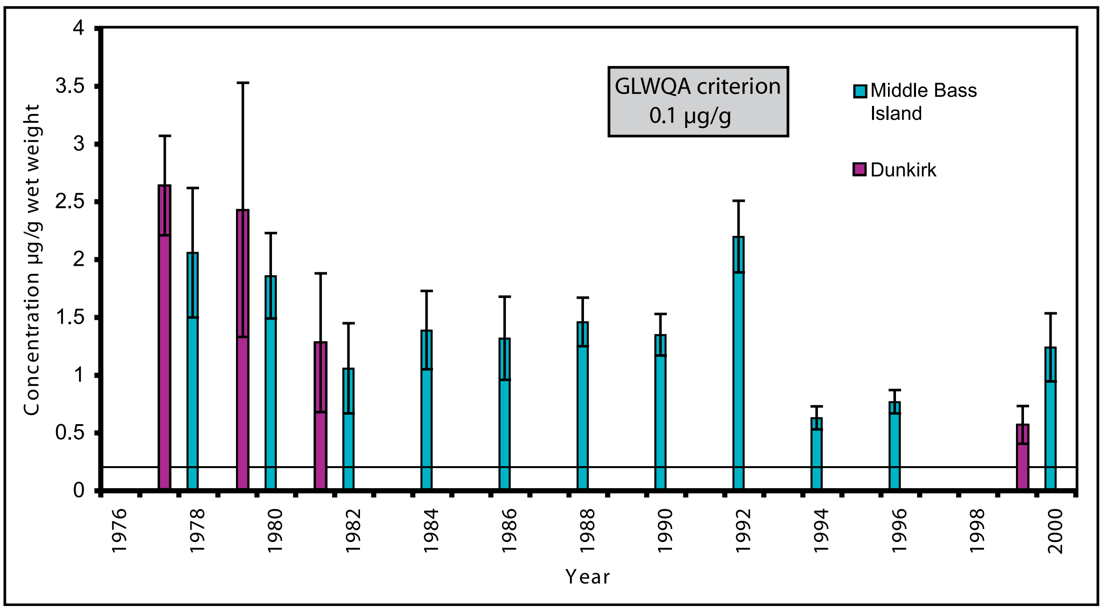


Figure 10:19: Total PCB Levels in Lake Erie Walleye 1977-2003 (µg/g +/-S.E. wet weight, whole fish, ages 4-6). (Source: DFO-GLLFAS unpublished data) GLWQA criterion is 0.10 µg/g.

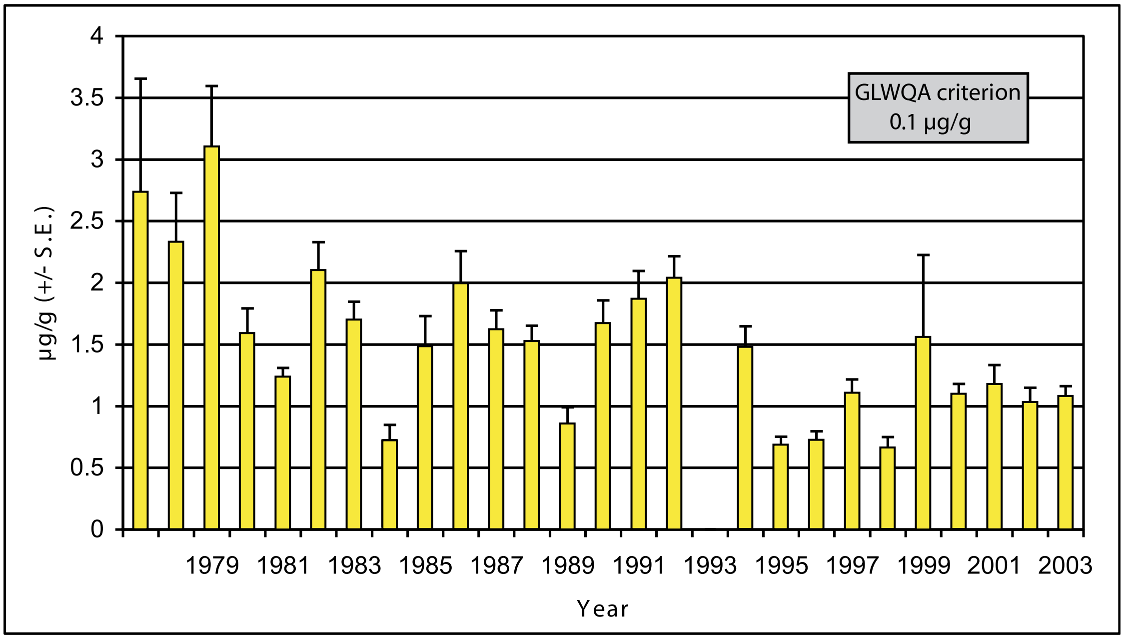


Figure 10:20: Total PCB levels in DFO collected Lake Erie Lake Trout 1985-2003 (µg/g +/- S.E. wet weight, whole fish ages 4-6). (Source: DFO-GLLFAS unpublished data) GLWQA criterion is 0.10 µg/g.

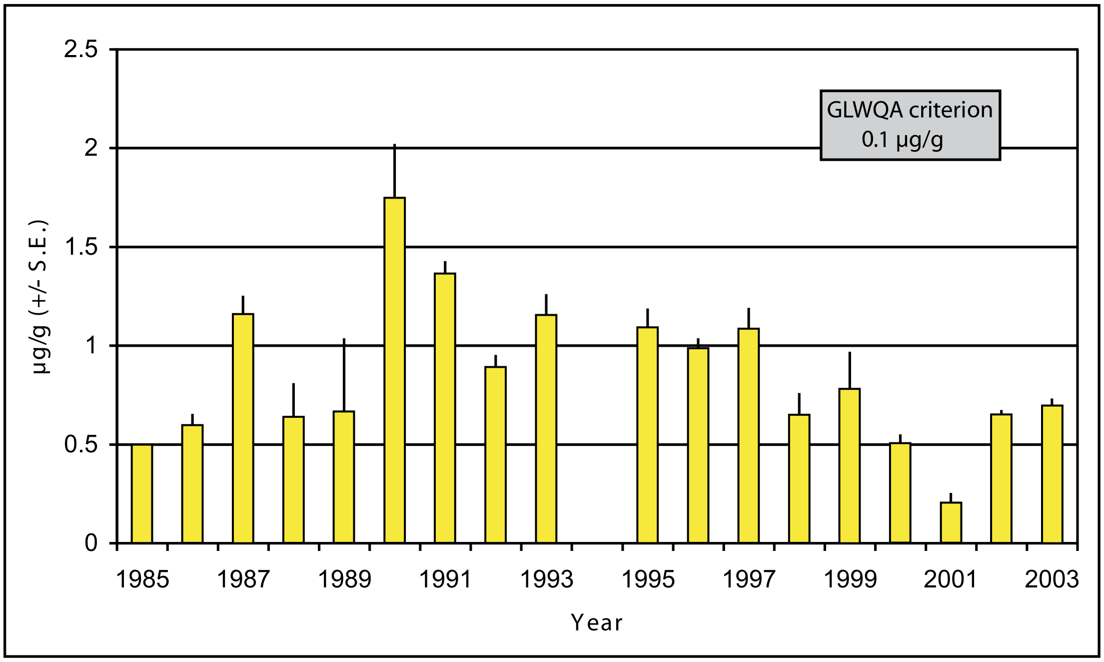
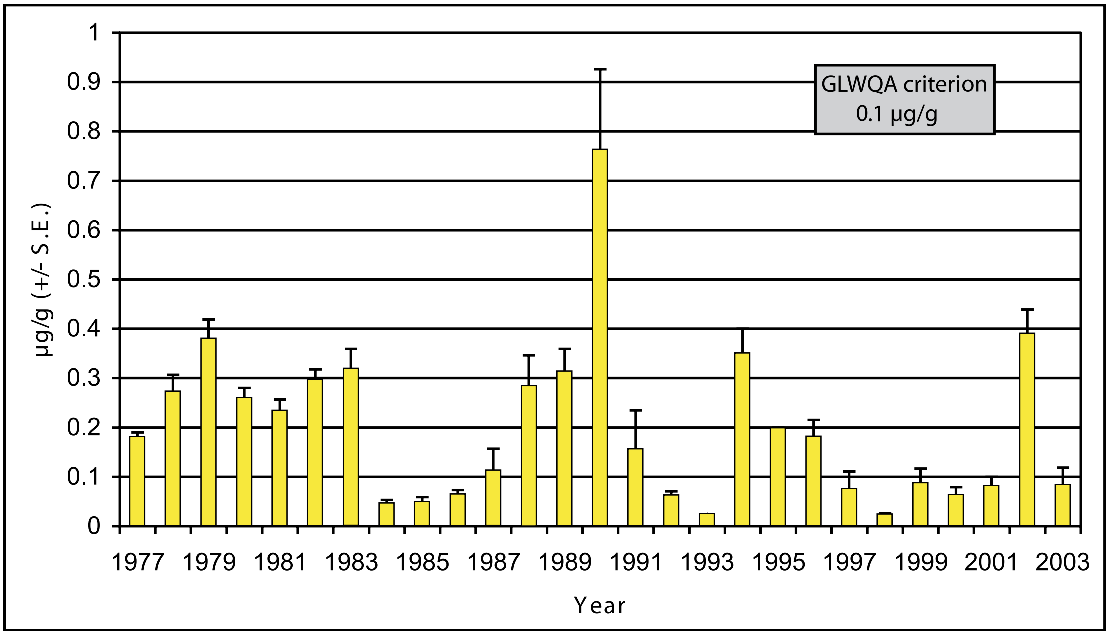


Figure 10:21: Total PCB levels in Lake Erie Rainbow Smelt 1977-2003 (µg/g +/- S.E. wet weight, whole fish). (Source: DFO-GLLFAS unpublished data) GLWQA criterion is 0.10 µg/g.



Mercury

After a period of rapid decline from 1977 through 1983, mercury concentrations in Lake Erie walleye have remained steady. After 1996, the frequency of annual measurements of mercury burdens in walleye by DFO was reduced. The mean of two recent measurements made in 1999 and 2003 was ~ 15% greater than the 5 year mean of the period 1992 through 1996 (Figure 10.22). DFO recorded mercury levels in walleye are less than the GLWQA criteria of 0.5µg/g. DFO smelt data show that concentrations of mercury measured in samples collected in 2002 had the highest concentrations reported since the whole lake survey was initiated in 1977. Subsequently, the 2003 concentrations were the second lowest concentration reported since 1977. DFO recorded concentrations of Lake Erie smelt are below GLWQA criteria (Figure 10.23).

Figure 10:22: Total Mercury levels in Lake Erie Walleye 1977-2003 (µg/g +/-S.E. wet weight, whole fish ages 4-6). (Source: DFO-GLLFAS unpublished data) GLWQA criterion is 0.50 µg/g.

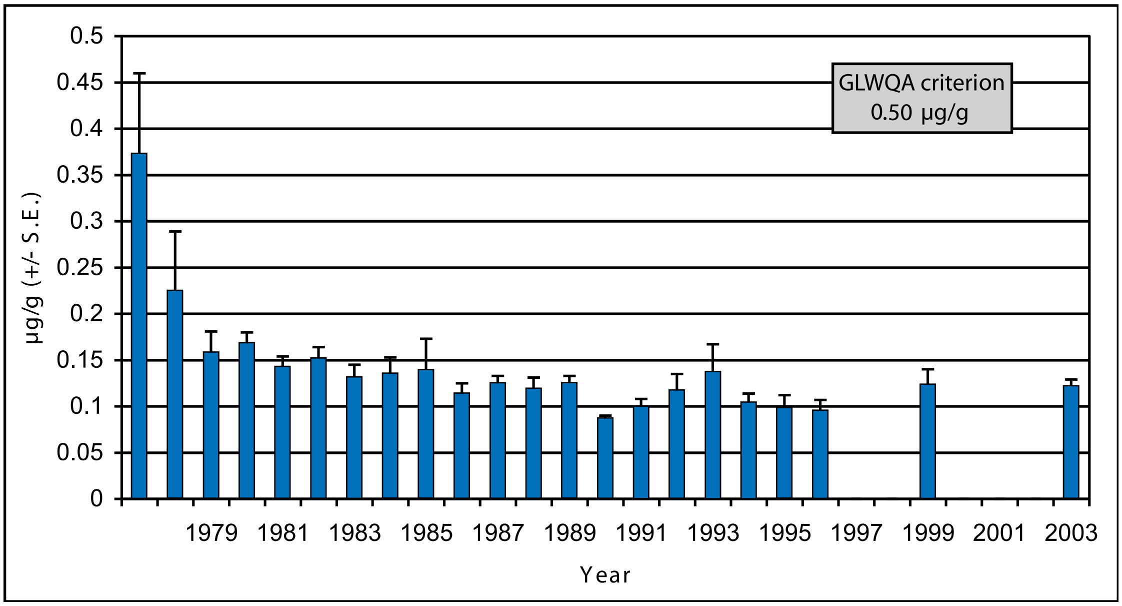
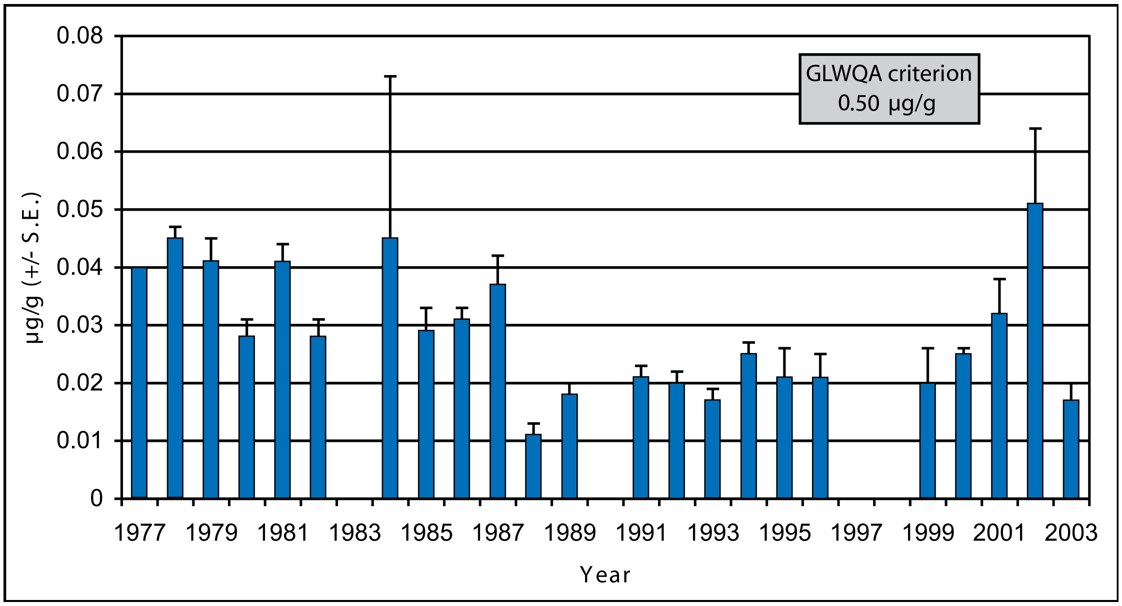


Figure 10:23 Total Mercury levels in Lake Erie Rainbow Smelt, 1977-2003 (µg/g +/-S.E. wet weight whole fish) (Source: DFO-GLLFAS unpublished data). GLWQA criteria is 0.50 µg/g.



Chlordane

Total chlordane is made up of five components: trans-nonachlor; cis-nonachlor; trans-chlordane; cis-chlordane; and oxychlordane. Trans-nonachlor is the most prevalent of the chlordane compounds. Lake Erie walleye were lower in trans-nonachlor concentrations than were lake trout in the other Great Lakes (Swackhamer 2004).

Dieldrin

Concentrations of dieldrin in Lake Erie appear to be declining. Concentrations of dieldrin in Lake Erie walleye were the lowest measured in all the Great Lakes.

10.9 International Field Years on Lake Erie (IFYLE) Program *(Prepared by Drs. Stuart A. Ludsin and Stephen B. Brandt, NOAA Great Lakes Environmental Research Laboratory, Ann Arbor, MI)*

To improve the ability to provide reliable ecosystem forecasts for Lake Erie, the NOAA Great Lakes Environmental Research Laboratory initiated the integrated (multi-agency), multidisciplinary "International Field Years on Lake Erie" (IFYLE) Program in 2004. This program primarily seeks to: 1) quantify the spatial extent of hypoxia across the lake, and gather information that can help forecast its onset, duration, and extent; 2) assess the ecological consequences of hypoxia to the Lake Erie food web, including phytoplankton, bacteria, microzooplankton, mesozooplankton, and fish; and 3) identify factors that control the timing, extent, and duration of harmful algal bloom (HAB) (including toxin) formation in Lake Erie, as well as enhance our ability to use remote sensing as a tool to rapidly map HAB distributions in the lake.

The IFYLE Program has become the largest international, multidisciplinary research effort of its kind in Lake Erie's history, costing approximately $5 million and involving more than 40 scientists from NOAA, US and Canadian universities, and federal, state, and provincial agencies. Vessel support comes primarily from NOAA Ship Support, U.S. EPA-GLNPO, and NOAA-GLERL, whereas funds for external researchers were provided by the National Sea Grant College Program and the Ohio and New York Sea Grant College programs. Environment Canada deployed several moorings to collect physical data in collaboration with this program, while the US Army Corps of Engineers provided continuous dock space for NOAA vessels. In addition, the project has been offered in-kind support (e.g., historical data, technical assistance with aging fish, vessel support) from all of the state and provincial fishery management agencies on the lake, including the Ohio Department of Natural Resources, the New York State Department of Environmental Conservation, the Michigan Department of Natural Resources, the Pennsylvania Fish and Boat Commission, and the Ontario Ministry of Natural Resources.

The 2005 field program centered on determining the factors regulating the distribution of oxygen concentrations and HABs in Lake Erie and the consequences of low oxygen on the abundance, distribution, and condition of fish and their prey. The remainder of 2005 and all of 2006 will be devoted to sample processing, data analysis, testing and refining hypotheses, and building models that can be used for both understanding and forecasting purposes. During 2007, it is expected that another intensive field season will be conducted, with more focused sampling objectives.

For more information on the IFYLE program, see www.glerl.noaa.gov/ifyle/, or contact Dr Stuart A. Ludsin (Stuart.Ludsin@noaa.gov) and Dr Stephen B. Brandt (Stephen.B.Brandt@noaa.gov), co-coordinators of the IFYLE program.

10.10 Trends in Sediment and Nutrients in Major Lake Erie Tributaries, 1975-2004 *(Prepared by R. Peter Richards, National Center for Water Quality Research (NCWQR), Heidelberg College, Tiffin, Ohio)*

In the last decade or so, in-lake concentrations of phosphorus have been on the increase, though the trend is not statistically significant. Hypoxia in the central basin appears to be more extensive and occurring earlier in the summer. Extensive blooms of *Microcystis* and other undesirable algae have been observed in some recent years that are comparable to those of the 1970s. These signs all suggest that Lake Erie is out of trophic balance once again.

Most hypotheses that attempt to explain these observations implicate zebra and quagga mussels in processes that enhance in-lake recycling of nutrients or shunt them from nearshore to offshore or from the western basin to the central basin. However, during the last decade, increasing concentrations and loads of sediment and nutrients have been observed at many of the NCWQR tributary monitoring sites. This section documents these trends. We are unable to assess their importance relative to in-lake processes, but any efforts to understand the renewed problems in the lake must take these trends into account as well.

Photo: Jeff Schmaltz, MODIS Rapid Response Team, NASA/GSFC, April 6, 2004

Data and Approaches

The NCWQR maintains automated sampling stations on the Grand, Cuyahoga, Sandusky, and Maumee Rivers in Ohio, and on the River Raisin in Michigan. The data presented here deals only with the Ohio tributaries, but results for the River Raisin are similar. On each river, the sampling station is located at a USGS flow gauging station as far downstream as possible while remaining upstream of seiche-induced flow reversals. Samples are collected three times per day. All three samples are analyzed during periods of high flow, and one sample per day is analyzed at other times. This program produces 400-450 samples per station per year. Samples are analyzed for sediment, nutrients, and major ions, and a subset is analyzed for currently used pesticides and metals. Relevant information about each station is presented in Table 10.5. Further information about the tributary monitoring program and its results can be found at www.heidelberg.edu/WQL/publish.html#reports.

Table 10.5: Station Locations for NCWQR Sampling Sites

Station and USGS Number	Location	Drainage area (square miles)	First year of operation	Total number of samples
Raisin 04176500	Above Monroe, MI	1042	1982	7051
Maumee 04193500	Waterville, OH	6330	1975	12,965
Sandusky 04198000	Above Fremont, OH	1253	1969	13,863
Cuyahoga 04208000	Independence, OH	708	1981	10,331
Grand 04212100	Painesville, OH	686	1988	6686

For trend analysis, raw data were converted to daily values by calculating a flow-weighted mean concentration for each day with more than one sample. Concentrations were converted to daily loads by multiplying them by the daily average flow reported by USGS, and expressed as metric tons per day. No attempt was made to fill in values for days on which no samples were obtained.

Trends are displayed as LOWESS (Locally Weighted Scatterplot Smoother) smooths of the raw data. In all cases a 20% bin width was used. The position of the smoothed trend at any point in time is computed using the 10% of the data immediately before that point in time, and the 10% of the data immediately after it, with the greatest weight given to the points that are closest in time. This technique allows a general trend to be extracted from very "noisy" data, without imposing severe restrictions such as the assumption that the trend must be a straight line.

For statistical assessment, trends were computed with a two-slope analysis of covariance (ANCOVA) model that divides the data into two periods, before and after January 1, 1995. A separate linear trend is computed for each period. This approach was chosen because an initial trend analysis reported results for the period 1975-1995, and because many parameters show a strong change in trend occurring somewhere about 1995. The model uses log-transformed flow and concentration, and sine and cosine terms in time are used to model seasonality. Results are reported as percent change in average daily load per decade.

Results

LOWESS trends are depicted for the four Ohio tributaries in Figures 10.24-10.27. The graphs cover the period of record (through the end of the 2004 water year) except that the Sandusky River plots begin at the beginning of the 1975 water year. The trends for the Grand River are shorter, for example, because the station did not begin operation until 1988.

Values are reported as loads in metric tons per day. In comparing the results for different stations, remember that the Maumee watershed is much larger than the rest, and consequently the loads will also be larger, other things being equal. Also note that the plots cover the range of the trend values, but do not extend to zero. Plotting the trends in this fashion makes them appear more dramatic than they would if they were plotted on a scale that extended to zero. Conversely, if plotted in the context of the total range of the data, the trends would appear quite modest. However, the impact of these changes on the lake is more a function of gradual changes over time than of day-to-day fluctuations, and the curves as displayed portray these gradual changes well.

Flow

Since loads are determined by the product of concentration and flow, a trend in loads may reflect a trend in concentration, a trend in flow, or a trend in both. Conceivably, an upward trend in concentration could be negated by a downward trend in discharge, resulting in no trend in loads. The flow trends (Figure 10.24) are provided primarily as background for use in interpreting the load trends. However, substantial trends in flow are a cause for concern in and of themselves, particularly for possible negative impacts on riverine ecosystems. A striking aspect of the flow trends is the strong increase in flow in all tributaries except the Maumee, beginning about 2000. This increase in flow is reflected in increased loads as well. The Maumee also shows increased flow, but it appears to begin somewhat earlier and the increase is not as pronounced.

Suspended Sediment

Suspended sediment (SS) is important as a pollutant in its own right, particularly in the bays, harbors and nearshore zone of the lake. SS is also important because many pollutants of concern are carried attached to it. This is particularly true of phosphorus and some forms of nitrogen (as well as metals and many organics, which are beyond the scope of this report). Studying trends in SS (Figure 10.25) may help identify causes of trends in other parameters. Sediment load trends are obviously influenced by flow trends, though the patterns differ in detail, reflecting the fact that there are changes in concentration as well. The Maumee shows a strong and persistent downward trend in sediment loads. Given the dominance of the Maumee as a source of sediment and nutrients to western Lake Erie, this is an important and gratifying trend.

Total Phosphorus

Total Phosphorus (TP) is the nutrient parameter chosen as the indicator of trophic status for the remediation of Lake Erie. As such it is a very important parameter from a management standpoint. Most of the TP in transit in Lake Erie tributaries is attached to sediment particles, but the percent of TP that is particulate varies from one tributary to another and from season to season, and has changed significantly over time. The load trends for TP (Figure 10.26) are similar to those for SS, especially for the Sandusky and Grand Rivers. Increasing loads since approximately 2000 characterize all tributaries except the Maumee, which, while not increasing, is no longer showing declining trends.

Dissolved Reactive Phosphorus

While total phosphorus is the parameter by which Lake Erie eutrophication is managed, dissolved reactive phosphorus (DRP) is also of great importance because it is highly bioavailable. Thus increases in DRP can have disproportionately large impacts on the Lake Erie ecosystem. Increasing trends in DRP loads (Figure 10.27) in the recent past characterize all four tributaries, and are particularly pronounced for the Sandusky and Grand. These increasing trends follow a period of strong decreasing trends for all tributaries except the Grand, for which the period of record is perhaps too short to have captured such a trend. The onset of increasing trends is earlier than for the other parameters discussed, and occurs sometime between 1990 and 1995, depending on the tributary. While these load trends are influenced by trends in flow, there are also strong parallel trends in concentration, indicating other causes for these trends than just changes in flow.

Results of ANCOVA Analysis

Linear trends for the periods of time before and after 1995 are presented in Table 10.6. These results clearly show that the overall pattern of change before 1995 was one of improvement (i.e. reduced loads), while the overall pattern since 1995 is one of deterioration (i.e. increased loads). For technical reasons, assessments of the level of statistical significance of these trends are not presented. Other forms of analysis indicate that most of the trends are statistically significant, particularly those that exceed 10% per decade. In evaluating these results, which often involve reversals of trends, it is well to remember the asymmetry of percentages of change: If one starts with a value of 100, and reduces it to 40, that is a 60% decrease, but the return to the original value of 100 from 40 represents a 250% increase. The net change is not 190% but 0%.

Table 10.6: Percent Change per Decade in Daily Loads, Before and After 1995

Parameter	Maumee		Sandusky		Cuyahoga		Grand	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Flow	13	36	8	56	-17	41	-8	19
Suspended Sediment	8	-5	-6	34	-32	202	-93	5
Total Phosphorus	-11	29	-20	79	-69	61	-76	32
Dissolved Reactive Phosphorus	-50	199	-55	341	-88	212	-59	226

Two things stand out in these results. One is the uniformly large reversals in trends of DRP; in general the loads at the end of 2004 are nearly as high as or higher than they were at the beginning of the period of record. The other is the consistency of trend reversals. For the three water quality parameters (excluding flow), 11 of 12 trends pre-1995 were downward, but 11 of 12 trends post-1995 are upward.

Causes

Little definitive can be said about causes at this point. Certainly increased flows have contributed to increased loads. But concentration trends show similar patterns of recent increase. There are a large number of plausible causes, including: demographic changes, especially exurbanization; increased numbers of farm animals increasingly confined to small areas; and possible retrenchment of conservation tillage or reduced effectiveness of conservation tillage because of nutrient concentration at the surface. Data on many possible causes is difficult or impossible to obtain. Evaluation of causes may require development of highly sophisticated models that link watersheds with tributary systems, the lake, and its biota.

Figure 10.24: Trends in flow, 1975-2004. Units for flow are cubic feet per second.

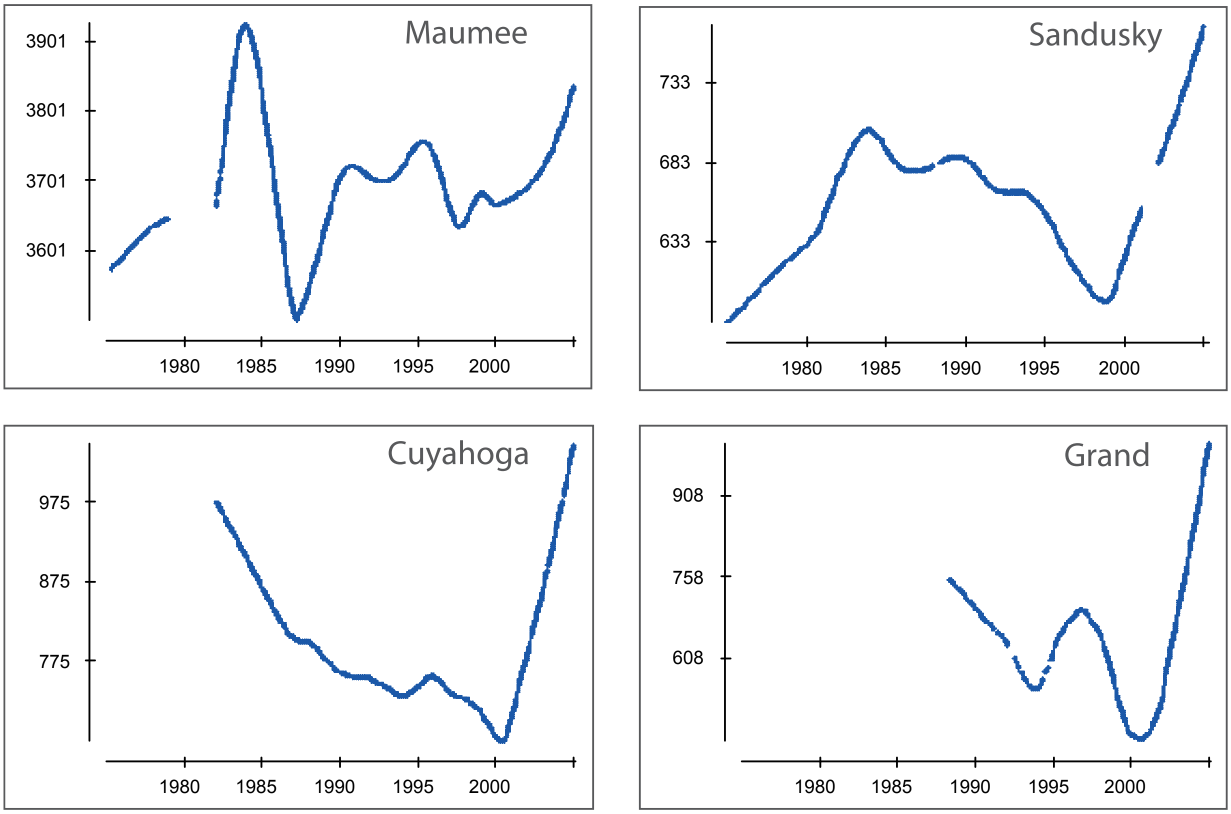


Figure 10.25: Trends in suspended solids, 1975-2004. Units for SS are metric tons per day.

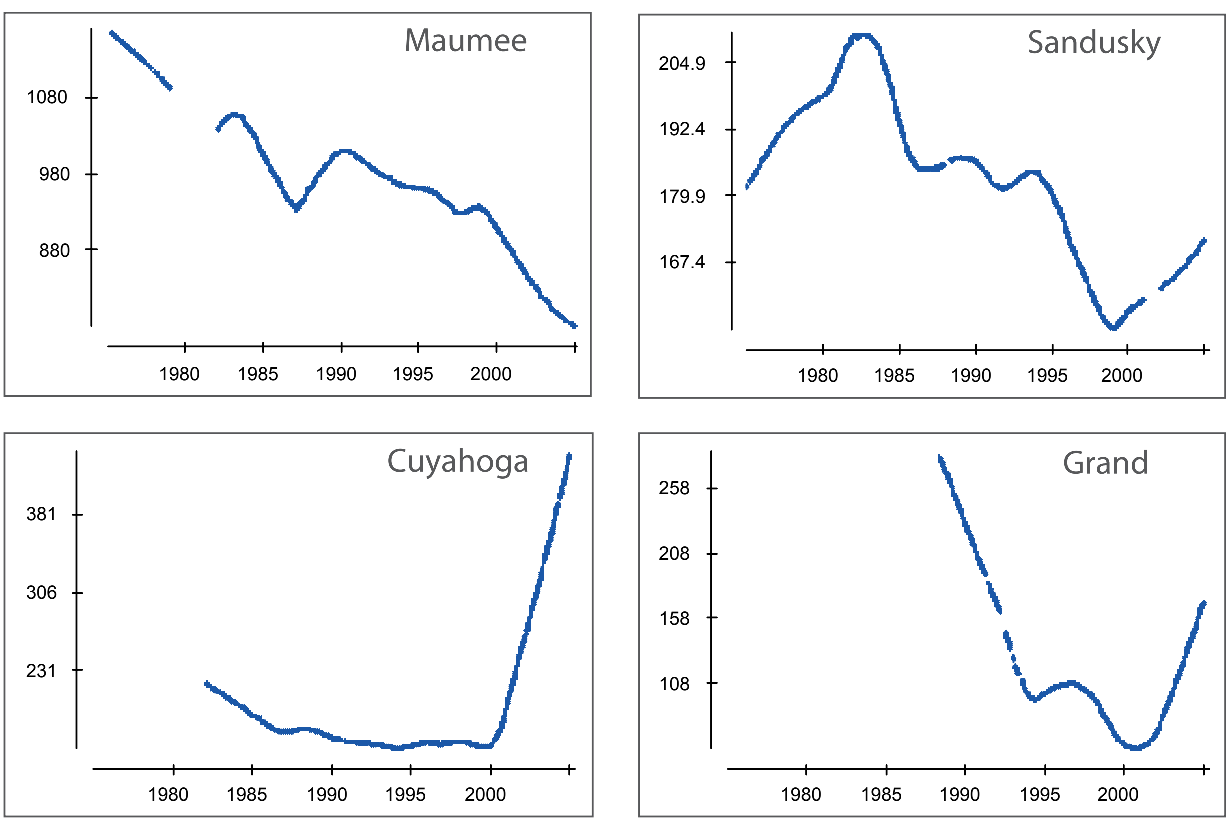


Figure 10.26: Trends in total phosphorus, 1975-2004. Units for TP are metric tons per day.

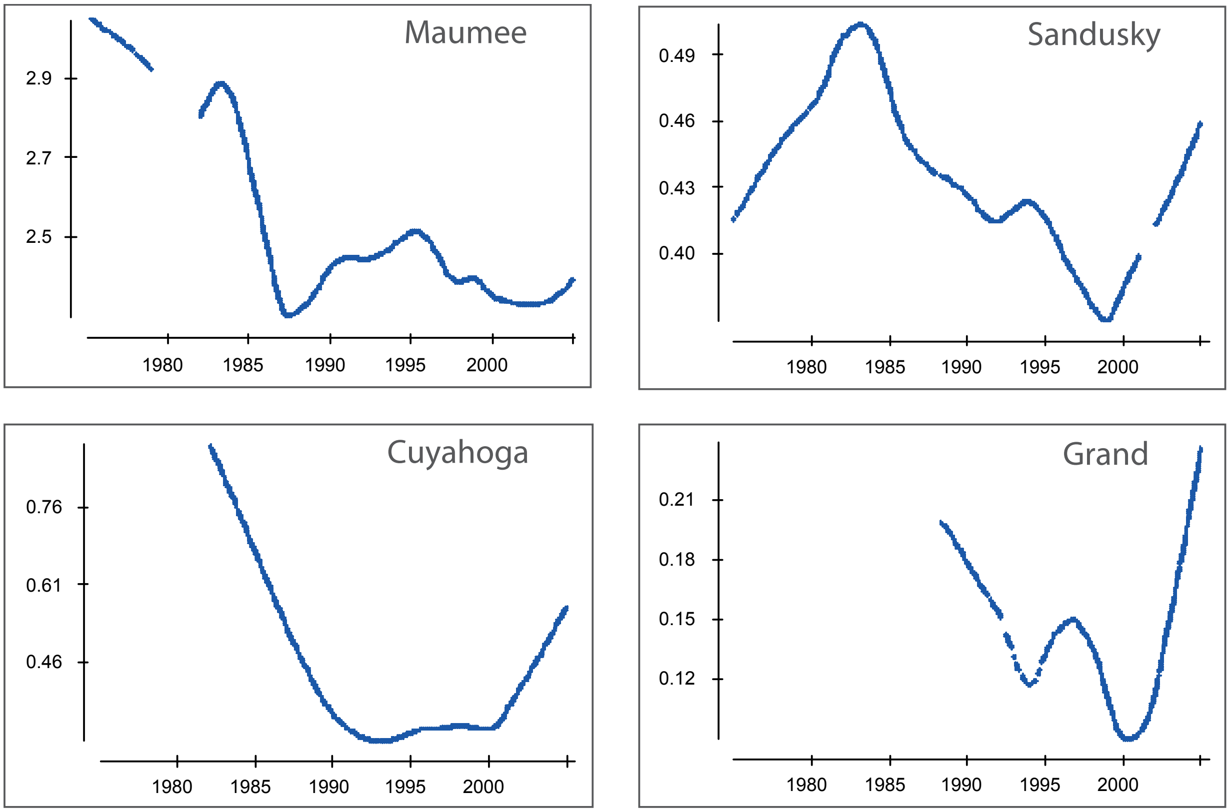
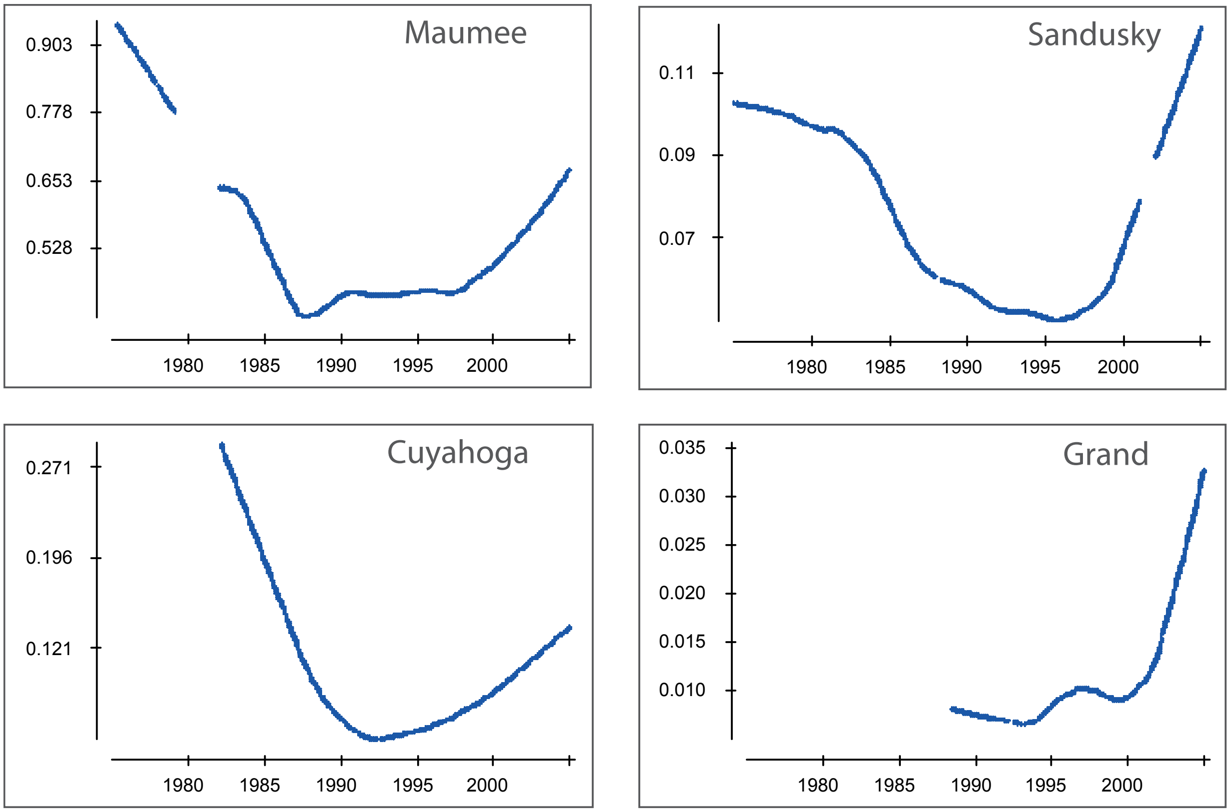


Figure 10.27: Trends in dissolved reactive phosphorus, 1975-2004. Units for DRP are metric tons per day.



10.11 Focus on Increasing Trends of Dissolved Reactive Phosphorus

The relationship between external phosphorus loading to Lake Erie and in-lake conditions determined in the 1980s was based on total phosphorus loading to the lake. Although most of the point source phosphorus was bioavailable, substantial portions of the nonpoint load were not considered to be bioavailable. Therefore, total phosphorus may not be the best parameter to set controls for loadings to the lake. Most nonpoint-derived phosphorus is attached to suspended sediments and only about 25-30% of this particulate phosphorus is available for supporting algal growth. Furthermore, portions of this particulate phosphorus may be physically removed from possible biological uptake as it settles into the bottom mud. In contrast, the dissolved reactive phosphorus component of nonpoint runoff is 100% bioavailable and is delivered directly into Lake or bay water during storm runoff events.

Recent reviews of phosphorus loading to Lake Erie from Ohio tributaries have shown that trends in dissolved reactive phosphorus (DRP) loading differ greatly from trends in particulate phosphorus loading. Nonpoint phosphorus control programs focused on reducing particulate phosphorus loading through erosion control measures and use of buffer strips to trap sediments. These programs have been effective in reducing particulate phosphorus. Dissolved reactive phosphorus loading decreased even more rapidly than particulate phosphorus up through the mid-1990s. Since that time, however, dissolved reactive phosphorus loading has increased dramatically to the point where it now approaches the same loads as in the late 1970s and early 1980s. Algal trends in Lake Erie appear to match the trends in dissolved reactive phosphorus loading much more closely than they match the trends in either total phosphorus or particulate phosphorus loading.

To look more closely at the trend of increasing DRP loads, Ohio EPA established the Ohio Lake Erie Phosphorus Task Force in March 2007. The goal of the Task Force is to understand increases in DRP loads to Lake Erie by identifying all potential sources, determining the relative magnitude of each source, and recommending management or policy options to effect DRP load reduction to Lake Erie. Many stakeholders interested in phosphorus management and effects are represented on the group.

Because agriculture is the predominant land use in much of the Ohio Lake Erie watershed, the group initially chose to delve into presentations relating to agricultural sources. Meetings of the Task Force have aided greatly in the overall understanding of how phosphorus is introduced to, interacts with and is released from soil to surface waters. Moreover, such discussions have also revealed there is much more data needed to understand the relative magnitude of agricultural nonpoint pollution associated with soil release of phosphorus. For example, there are very limited sub-watershed scale data with respect to: fertilizer and nutrient additions to soil; usable soil test data; stratified soil test data; and runoff chemical data from a watershed where all variables are accounted for. Other point and nonpoint sources are also being investigated and the Task Force is working on a recommendations report to be released in spring 2008.

To further investigate the causes of the increasing DRP load from agricultural lands, Heidelberg College National Center for Water Quality Research (NCWQR) received a $940,000 grant from the Great Lakes Protection Fund to lead an effort to reduce dissolved phosphorus runoff from the Sandusky River watershed into Sandusky Bay and Lake Erie. One goal of this project is to achieve at least a 30% reduction in dissolved phosphorus runoff during the next five years. Another goal is to export the lessons learned in the Sandusky watershed to other agricultural areas around the Lake Erie Basin, as well as to the other Great Lakes.

The increase in dissolved phosphorus runoff from cropland comes at the same time farmers have made major progress in reducing particulate phosphorus runoff from their fields. Particulate phosphorus is attached to eroded soil particles and runoff has been reduced through farmer adoption of various erosion control techniques, such as reduced-till and no-till crop production. However, one of the causes of increased dissolved phosphorus runoff is apparently the same no-till and reduced-till cropping practices that reduce particulate phosphorus runoff. With no-till and reduced till, phosphorus accumulates at the soil surface.

Photo: Upper Thames River Conservation Authority

Part of the accumulation is associated with surface applications of phosphorus fertilizers and manures. In addition, crop roots take up phosphorus from deeper in the soil. When the stems and leaves are left on the soil surface to protect the soil from erosion, they eventually decay, depositing their phosphorus at the soil surface. In the past, plowing the soil would have buried this phosphorus deeper into the soil. With no-till and reduced-till, the soil is no longer inverted so that phosphorus continues to accumulate at the soil surface. The phosphorus concentration at the soil surface determines dissolved phosphorus concentrations in surface runoff.

Preliminary results of a pilot study have confirmed that phosphorus builds up in the top two inches of soil. In standard soil tests, a sample of the top eight inches is tested. Much of the Great Lakes Protection Fund grant funding will subsidize stratified soil testing in the Sandusky satershed to split and examine the eight inch soil column into three portions: 0-2 inches, 2-4 inches, and 4-8 inches, with separate testing for each portion.

The NCWQR researchers have assembled a 34 member project team to help address the problem. The team is composed of local farmers, certified crop advisers, fertilizer dealers, and representatives of local soil and water conservation districts, soil testing labs, extension offices, state and federal agencies, and the Ontario Ministry of Agriculture, Food and Rural Affairs, as well as faculty from Ohio State University, the University of Wisconsin, and Michigan State University.

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