Chapter Four

ECOSYSTEM INTEGRITY: THE CHANGING LAKE ERIE ECOSYSTEM

Introduction

Environmental problems in the Lake Erie ecosystem function as early warning signals for the other Great Lakes. As the shallowest of the lakes, Lake Erie has the shortest water retention time (less than three years), but it also has the largest watershed relative to its size, the highest human population density, the most farm land, and the largest number of major cities. These factors converge to make Erie the Great Lake where ecological disruption often shows up first. If we can develop a detailed understanding of ecological disruption symptoms on Lake Erie, we can perhaps avoid similar problems on the other Great Lakes.

Rapid ecological changes are in fact occurring in the Lake Erie ecosystem, some as puzzling as they are troubling. Evidence now suggests that these changes involve complex and often poorly understood interactions between many factors related to the lake's chemical, physical and biological integrity. From what we know now about the suite of possible problems and their causes, achieving ecosystem integrity in Lake Erie and the other Great Lakes will require greater recognition of the need to address chemical, physical and biological integrity as parts of a unified whole.

Past Successes

Programs created by both countries in response to *Annex 3: Control of Phosphorus* of the *Great Lakes Water Quality Agreement* led to a sharp reduction of phosphorus entering Lake Erie during the late 1970s and the 1980s. These programs, especially those involving improved sewage treatment plants and reformulated laundry detergent, led to a reversal of the lake's eutrophication[1] and water quality improved significantly.[2] The U.S. and Canadian Governments achieved further reductions in phosphorus in subsequent years through a variety of control measures, as recommended by the Commission's Pollution From Land Use Activities Reference Group in 1978. These measures focused on direct or "point" sources of pollution – such as discharge pipes from factories and sewage treatment plants – as well as "nonpoint" sources such as storm water runoff from farm fields or parking lots. The control of eutrophication in Lake Erie is recognized worldwide as a successful model of transboundary cooperation that linked scientific findings with monitoring, resource management, and policy formulation and application.

Recent Trends and Possible Causes

Trends in Lake Erie water and ecosystem quality since the early 1990s are not well understood. Recent research paints a confusing picture of simultaneously positive and negative trends in water and ecosystem quality (Table 5). Considerable year-to-year variations in scientific observations also inhibit identifying cause-and-effect linkages that can guide resource management and policy decision-making. For example:

- Springtime phosphorus concentrations have begun to increase and summertime levels of dissolved oxygen are depleting in the lake's central basin, even though there is no firm evidence of increases in external phosphorus loading.[3] Recent calculations suggest minimal increases of phosphorus from point sources. However, as noted in the Commission's Tenth Biennial Report, uncertainty exists about phosphorus discharges into tributaries because of cutbacks in monitoring programs and less sensitive detection limits of phosphorus in sewage treatment plant discharges.[4]
- An increase in phosphorus should stimulate the growth of phytoplankton (tiny, free-floating plant life), which is a key component of the food web. However, phytoplankton concentrations generally remain low in offshore waters.[5]
- Invasive species continue to enter and become established in Lake Erie, causing economic damage and ecosystem disruptions. Scientists suspect that zebra and quagga mussels and the round goby (Fig. 7) are causing major changes in the Lake Erie ecosystem, perhaps including the springtime increases in phosphorus in lake waters. Non-native species may in

fact be altering the way the natural ecosystem functions, as changes in the food web and rising phosphorus concentrations have coincided with the arrival and population boom of non-native zebra and quagga mussels. Whether there is a relationship between these events or if they are mere coincidences remains unclear.

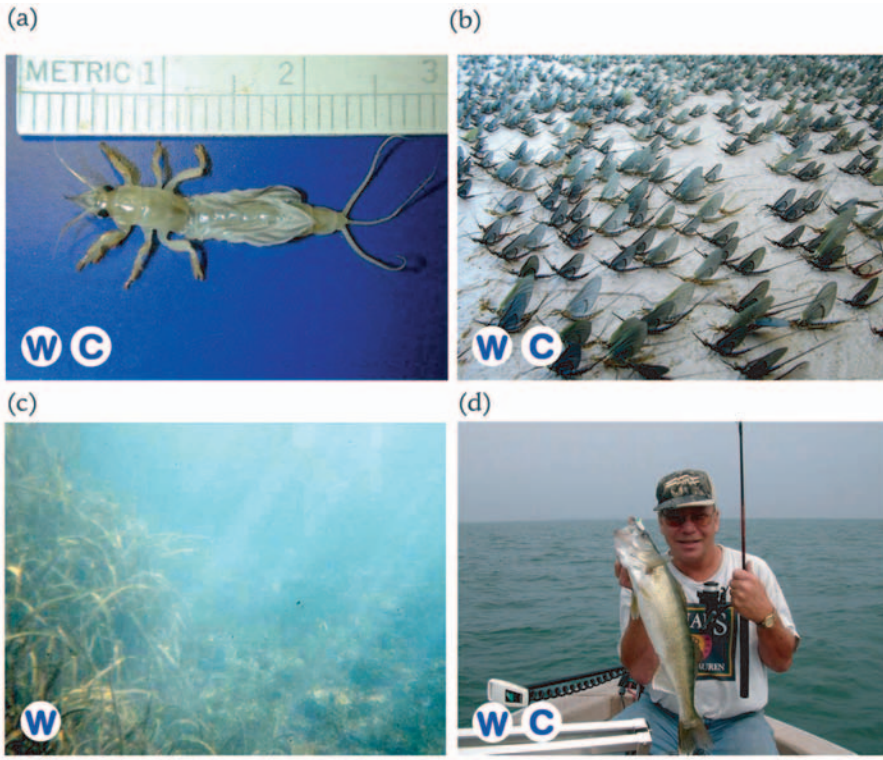
- The walleye population recovered dramatically during the 1980s and developed into one of the most financially important sport fisheries in North America (Fig. 6). However, walleye and other fish populations (such as rainbow smelt) have declined in recent years, raising concerns among sport fishers and the fishery management community that changes in phosphorus and the food web may be responsible.[6] Again, the causes for these changes are unclear.

Table 5. Summary of Recent Trends in Lake Erie Ecosystem Quality

Positive Trend
Increased water clarity
Re-establishment of rooted aquatic plant communities
Burrowing mayfly recovery
Walleye recovery
Lake whitefish recovery - central basin

Negative Trend
Lake whitefish decline - eastern basin
Phosphorus increase in water column
Phytoplankton decline in offshore waters
Blue-green algae blooms
Cladophora shoreline accumulations
Establishment of invasive species
Diporeia decline
Fish and wildlife die-offs from botulism

Figure 6. Positive Changes in Lake Erie Ecosystem Quality, and Lake Erie Map



(a) Aquatic and (b) adult burrowing mayfly, *Hexagenia*; (c) rooted aquatic plants improve habitat diversity; and (d) walleye

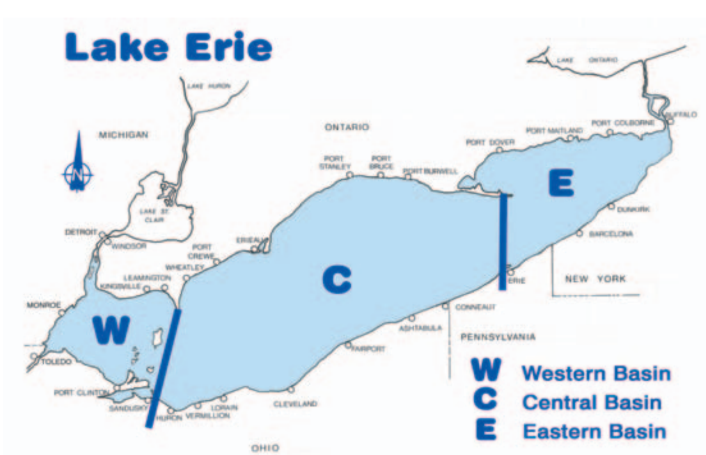
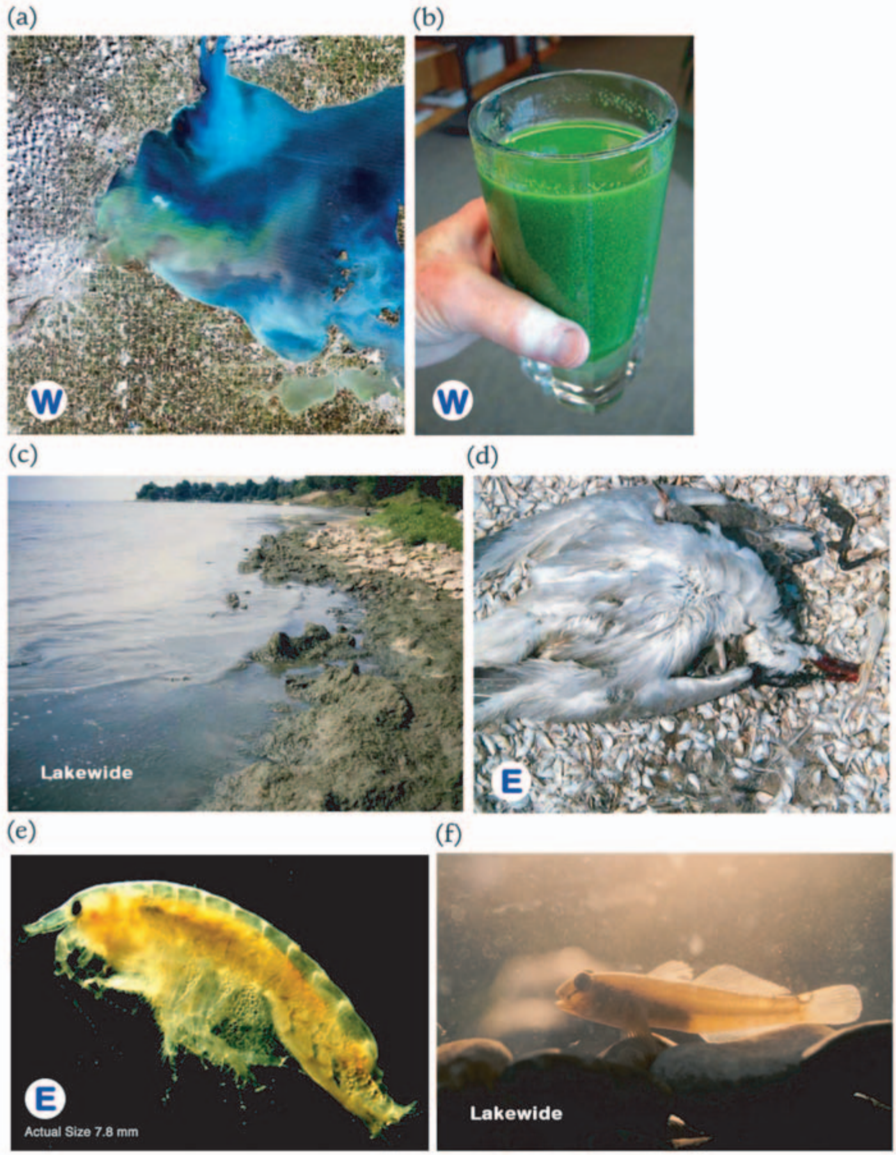


Figure 7. Negative Changes in Lake Erie Ecosystem Quality, and Lake Erie Map



(a) and (b) Blue-green algae blooms; (c) the macro-algae, *Cladophora*, fouling beaches; (d) fish and fish-eating birds dying of botulism poisoning; (e) the declining native invertebrate, *Diporeia*; and (f) another invasive species, the Round Goby

- In some nearshore waters, especially around the western Lake Erie islands, greater water clarity has resulted in a dramatic increase in rooted aquatic plants.[7] This has improved habitat diversity for such fish as the smallmouth bass. (Fig. 6)[8] Concurrently, blue-green algae (cyanobacteria) blooms periodically erupt in the open waters of western Lake Erie, causing a soupy, green scum on surface waters. Closer to shore, sheets of *Cladophora*, macro algae, are growing at excessive rates on rocks and other hard surfaces, sloughing off in wind and waves, then dying and rotting on beaches. (Fig. 7)[9] These conditions prevailed when eutrophication was at its worst in the late 1960s and early 1970s, yet phosphorus levels in the western Lake Erie basin do not suggest eutrophication is occurring.[10]

- *Hexagenia*, a large burrowing mayfly, serves as an important indicator of high water and sediment quality. This once-abundant insect spends its immature (nymph) stage in the lake and emerges only briefly as an adult, when it serves as a food source for many fish. This species disappeared from the lake during the 1950s, presumably due to oxygen depletion, but has recovered dramatically in the western and near shore portions of the central and eastern basins of Lake Erie since the early 1990s. Its reappearance after four decades — sometimes in great clouds of adults — can be hailed as an indicator that the Lake Erie ecosystem is recovering. (Fig. 6)[11]

- The predominant bottom-dwelling organism in the deeper, colder waters of the eastern basin of Lake Erie has been the deepwater amphipod, *Diporeia*, a small shrimp-like organism. It also is an indicator of good water quality and an extremely important food source for fish. *Diporeia* populations declined dramatically in the late 1990s (Fig. 7), and the species is now virtually absent.[12] The lake whitefish, once the mainstay of the Lake Erie fishery during the 19th and early 20th centuries but a minor part of the fish community for decades thereafter, had undergone a recovery in the eastern basin during the 1990s. One of its main sources of food is *Diporeia*, and as that prey species declined, so did the short-lived recovery of the lake whitefish in the eastern basin. However, the lake whitefish population is still rebounding in the central basin and occurs in the western basin during the colder months of the year.[13]

- Episodic die-offs of bottom-feeding fish and fish-eating birds from botulism poisoning are being reported, mainly in the eastern basin of Lake Erie, with lesser outbreaks noted in the western and central basins as well as in lakes Huron and Ontario. During and after the die-offs, rotting fish and bird carcasses litter beaches and shorelines (Fig. 7). Toxins from the bacterium *Clostridium botulinum* and specifically Type E botulism, which is found in fish-eating birds in the Great Lakes, cause these die-offs. Type E botulism is one of seven botulism types identified with the letters A through F, each characterized by the neurotoxin it produces. The last substantial Type E botulism outbreak occurred in Lake Michigan during the 1960s. The neurotoxin is produced in the absence of oxygen and with suitable temperature and nutrient conditions. It remains unclear which factors trigger the bacterium to produce the neurotoxin and the ensuing fish and wildlife die-offs. However, Type E botulism outbreaks have occurred as the round goby population, another invasive species, has increased. Researchers are looking for clues that triggered the botulism outbreak in Lake Erie, the source of the toxin, and its transfer among fish and other aquatic organisms, waterfowl, and fly maggots on carcasses.[14]

- Two other factors may be influencing or contributing to Lake Erie's ecosystem alterations, perhaps in similar or different ways on the other Great Lakes. Both short-term storms and long-term climate change may be influencing the ecosystem's dynamics. As already discussed in previous chapters, the same changes in land use, shoreline hardening from buildings, roads and parking lots, and wetland loss also may be triggering changes.

Understanding Lake Erie's Complexity

Because of their complex nature, addressing the overlapping and interacting issues affecting Lake Erie today requires a greater level of binational communication and cooperation than ever before.

Nevertheless, significant information gaps remain, making it difficult for policymakers to determine what actions can and should be taken to improve the lake's ecological integrity. Because the ecosystem is undergoing dynamic changes, scientists need to conduct more comprehensive biological investigations, including the effects of aquatic invasive species, climate change and other factors, as well as improve measurements of phosphorus loading. These investigations must clarify whether observed environmental changes result from increased phosphorus loadings from outside the lake or as a result of changes in phosphorus cycling within the lake, which could be due to zebra and quagga mussels, environmental changes, or other factors.

Thus, the Governments should:

- Improve phosphorus monitoring from point and nonpoint sources to determine relative contributions of external loadings versus internal cycling;
- Improve research to resolve questions about cause-and-effect linkages between observed ecosystem changes and various stressors. The complexity of this issue requires a collaborative approach between water quality research and fisheries research, including linkages with watershed land use issues; and
- Ensure that these research and monitoring improvements employ an ecological modeling framework that enables the most cost-effective and ecologically meaningful programs to be developed and implemented. Doing so would provide the greatest value to resource management and policy.

Unraveling the complexity of the issues requires new research and monitoring studies under the umbrella of a modeling framework, as recommended by the Commission's Council of Great Lakes Research Managers.[15] The Parties should also develop a Great Lakes ecological observation and forecast network. Such a system of automated buoys and remote sensors would supplement traditional shipboard and shore-based sampling to provide simultaneous records at multiple locations, help us to observe large-scale patterns, test models and predictions, and to increase our understanding of ecosystem and species variability.[16]

Eutrophication was the predominant environmental issue in Lake Erie during the 1960's and 1970's, toxic contaminants in the 1980's, and invasive species in the 1990's. In the new millennium, scientists are recognizing that all of these issues and others, such as habitat loss and degradation, climate change and botulism, are occurring concurrently. The Commission commends the Parties for their rapid action to initiate a comprehensive study of the lake in 2002, with a large portion of the work coordinated and communicated through the Lake Erie Millennium Network. This network of scientists, managers and policymakers is playing a vital and increasingly important role to identify the issues and research priorities, obtaining the necessary data, and providing the binational forum for exchange of information and reporting. For the botulism issue, the Pennsylvania Sea Grant program and the New York Sea Grant program are providing a similar communication and coordination role.

Recommendation

The Commission recommends that Governments continue to fund binational research efforts begun in 2002 and 2003 to better understand changes in the Lake Erie ecosystem. The institutional model provided by the Lake Erie Millennium Network should be considered for adaptation and adoption on the other Great Lakes to foster enhanced binational cooperation and communication.