Ecosystem Watch: Status of the Lake Ontario Ecosystem

Although, Lake Ontario is the smallest of the Great Lakes, its drainage basin is the most densely populated of any of the Great Lakes basins. Lake Ontario represents a very valuable natural resource providing economic, social, recreational, and aesthetic value to a broad spectrum of societal interests. This was not always the case. By the late 1960's, fish populations were decimated, beaches were fouled, and chemical toxins, such as DDT, were impairing reproduction of waterfowl. The recovery process began when Canada and United States adopted the 1972 Great Lakes Water Quality Agreement, which committed both countries to restoring and enhancing the water quality of the Great Lakes. At about the same time, aggressive programs were begun to control sea lamprey, rehabilitate lake trout and develop major hatchery supported fisheries for Pacific salmon, brown trout and rainbow trout. By the end of the 1980's, nearly everyone recognized that Lake Ontario was on the road to recovery: water quality improved, levels of toxic contaminants in fish decreased, and sport fisheries were more productive than ever.

Further Signs of Change

Looking back through the 1980's , scientists documented signs of change in the Lake Ontario ecosystem. The lake began to adjust to pollution controls and the build up of hatchery supported salmon and trout populations. Changes were occurring at all levels of the Lake Ontario food chain and included a reduction in available nutrients, zooplankton, alewife and smelt. Alewife and smelt are the principal food of the salmon, trout and other top predators. By the 1990's concerns were raised that the level of fish stocking was higher than could be supported by the available prey. After careful consideration, and extensive public consultation, stocking was reduced in 1993 and 1994, with a target to eventually decrease the demand on prey fish by 45 to 50 percent. It is expected that these changes will better balance predator demand with prey supply over the longer term.

Watching the Ecosystem

History tells us that Lake Ontario will continue to change, and that changes will not always be predictable. This emphasizes the need to carefully watch the Lake Ontario ecosystem at all levels - from nutrients to fish to man. Scientists and biologists from federal, state, and provincial agencies in both New York and Ontario have collaborated to provide the interested public with an update on the status of the Lake Ontario ecosystem. We have selected several key categories of information that, collectively, provide an overview of the state of the Lake

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Ontario ecosystem, and address emerging issues and concerns.

The following information is organized much like the Lake Ontario ecosystem. We first consider ***phosphorus levels and zooplankton production.*** Phosphorus is an important nutrient used by microscopic plants, called phytoplankton (also known as algae), to grow. Zooplankton, which are microscopic animals, feed on the phytoplankton, and in turn are fed upon by small fish. We also look at ***water transparency*** which is seen by the public as an easily observed measure of improving lake conditions. Information from these indicators can detect changes in the overall capacity of Lake Ontario to support other living plants and animals.

An important link from nutrients and zooplankton to large fish are the ***prey species***, such as alewife and smelt. As the primary source of food for most large fish species in Lake Ontario, changes in the status of these fish can greatly affect the ecosystem. Of the large ***predator species***, in the open waters of Lake Ontario, salmon and trout are the most economically important. Changes in their abundance through stocking, natural reproduction, and fishing can directly influence alewife and smelt populations.

Our look at the Lake Ontario ecosystem would not be complete if we did not consider two other important categories of information. These are ***exotic species***, such as zebra mussel and ***recovering species*** such as the lake whitefish.

Phosphorous Levels and Zooplankton Production

Scientist speculate that the pre-colonization level for phosphorus in Lake Ontario was 5 micrograms per litre ($\mu g.L^{-1}$). More recent measurements show summer phosphorus levels declined only slightly from 16.7 in 1969 to 14.4 $\mu g.L^{-1}$ in 1982. However, in response to more rigorous nutrient controls, summer phosphorus levels declined further through the early 1980's. As of 1987, concentration mid-lake has fluctuated around 9.7 $\mu g.L^{-1}$, excluding 1991 when a transitory peak in total phosphorus occurred. However, in the eastern outlet basin of Lake Ontario, the decline continued. In 1993 the summer total phosphorus level was 6.5 $\mu g.L^{-1}$, which is the lowest recorded value in this decade.

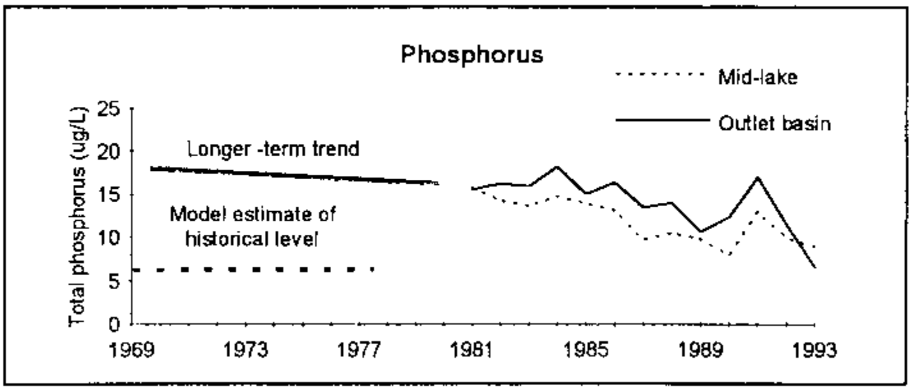

FIG. 1. Changes in mean summer total phosphorous levels.

Zooplankton production was higher during the period from 1981-85 mid-lake, and from 1981-86 in the eastern outlet basin than during the following years. In response to declines in phosphorous, zooplankton production decreased in subsequent years, averaging 9.63 grams of dry weight per square metre in the mid-lake and 10.32 in the outlet basin. Results from 1993 are not yet available, however, for the years 1991-92, zooplankton production remained low. In addition, changes in prey species abundance may have also affected zooplankton. Prey fish prefer to eat the largest zooplankton. As prey populations decline (see below), the abundance of larger zooplankton may increase. There are early indications that this is starting to occur in Lake Ontario but a clear picture has yet to emerge.

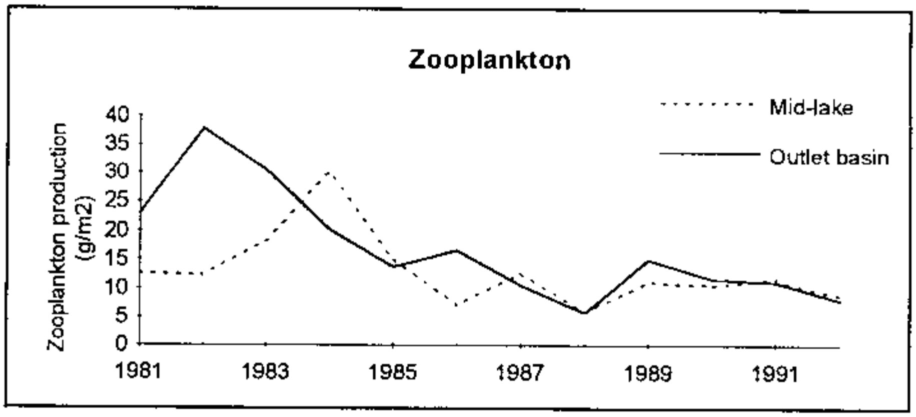

FIG. 2. Changes in mean summer zooplankton production .

Water Transparency

There are other indications that Lake Ontario continues to change. In the summer of 1993, many people reported an increase in water clarity and associated it with changes in the amount of nutrients and possibly the effect of filtering of the water by zebra mussel. As it turns out, changes in water transparency are related to a complexity of biological and chemical influences.

Transparency of the water is affected by a number of factors such as dissolved substances, phytoplankton, and other particles suspended in the water. Prior to the implementation of more rigorous pollution controls, nutrient levels in the 1970's supported phytoplankton abundances that were high enough to reduce water transparency. Today, changes in transparency may not always indicate changes in either water quality or phytoplankton abundance.

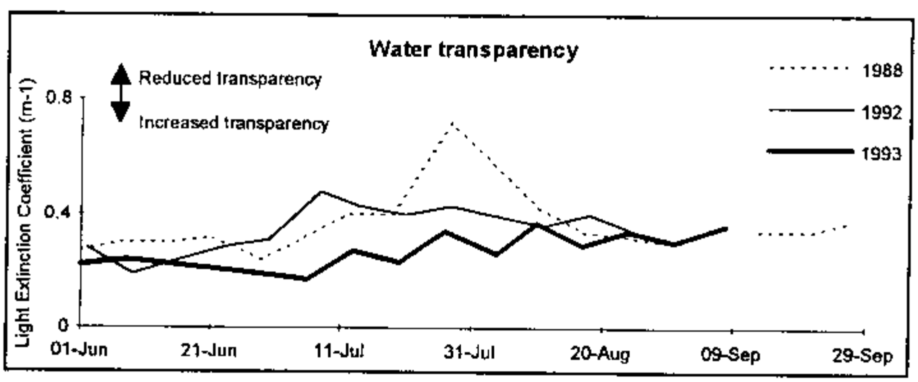

FIG. 3. Changes in water transparency for selected years in the eastern outlet basin of Lake Ontario.

In Lake Ontario, transparency will often decrease in August when calcium carbonate precipitates in the water due to a process called "whiting". Whiting is caused by warm temperatures and phytoplankton photosynthesis (the process through which sunlight and nutrients are converted to plant material). When this effect is most strong the water can take on a "milky" appearance. The dominant effect of phytoplankton on transparency is primarily related to the chemical changes brought about by photosynthesis and not necessarily by an increase in the abundance of these small plants.

Zebra mussels are capable of filtering large quantities of particles from the water and thus increasing water transparency. In Lake Ontario, zebra mussels are less likely to influence offshore water transparency because of the large volume of Lake Ontario. However, Lake Ontario derives over 80% of its water from Lake Erie and the changes brought about by the zebra mussels in Lake Erie will influence Lake Ontario.

Water transparency is measured by using a light sensitive instrument that measures the rate at which light dissipates with depth. In 1993, measurements confirmed an overall increase in water transparency and the absence of a summer reduction in water transparency. This effect was most evident in eastern Lake Ontario. Since water temperatures were not exceptionally low in 1993, changes may be due either to zebra mussel, or chemical changes associated with photosynthesis. A more definitive answer will have to await further data analysis.

Prey Species

Management agencies have been closely monitoring the status of prey fish populations in Lake Ontario. The longest time series is from index bottom trawls in U.S. waters, which indicate a reduction in biomass since the early 1980's. More recently, hydroacoustic surveys have measured the total biomass of prey in Lake Ontario. Since the first hydroacoustic survey in 1991, total prey biomass has declined, and was at an extremely low level in 1993.

These observations are consistent with the changes in the size structure of the alewife population which dominate the biomass. In the fall 1993, there were few fish in the size range of 70 to 100 mm (3-4 inches), and the abundance of large alewife greater than 125 mm (5 inches) was very low compared to 1991 and 1992. Young-of-the-year alewife, resulting from the 1993 hatch, were evident in

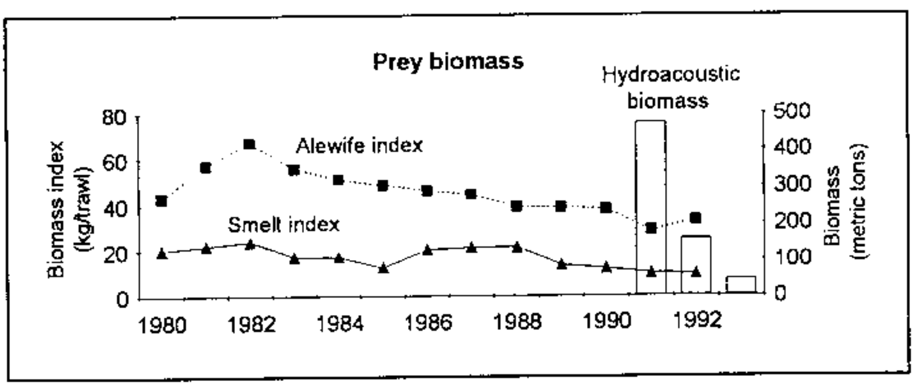

FIG. 4. Changes in the prey biomass in Lake Ontario. The lines represent 3 year running averages of standard bottom trawl catches from United States waters. The smelt index is scaled by a factor of three. The bars represent whole lake hydroacoustic estimates of total prey fish biomass.

the fall survey, but their average length was unusually small. By the end of 1993, the alewife population was comprised of primarily two age classes: undersized young-of-the-year, and two year olds. The apparent loss of the largest alewife occurred sometime between the summer and fall surveys of 1993, and could have been directly related to intensive predation.

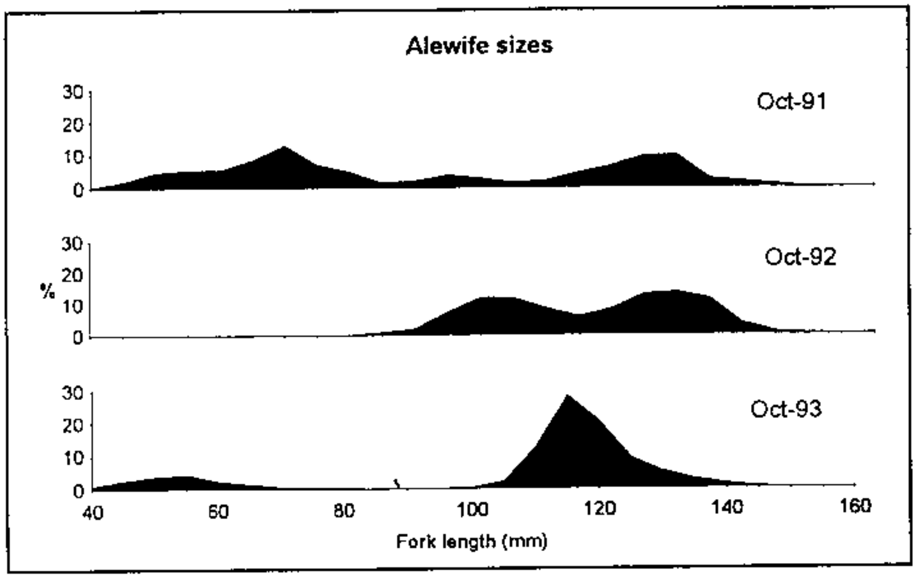

FIG. 5. Length frequency distributions of alewife caught in mid-water trawls in the fall of 1991-93.

Predator Species

In response to the concern of high predator demand and diminishing prey biomass, fish stocking was reduced substantially in 1993 and 1994. However, due to the effect of fish stocked in earlier years, the reduction in predator demand lags behind the reductions in stocking. The full effect of stocking changes on predator demand will not occur until 1996. As the system responds to the reduced stocking and other ecosystem perturbations, predator and prey population status will be closely monitored to determine if further actions are warranted.

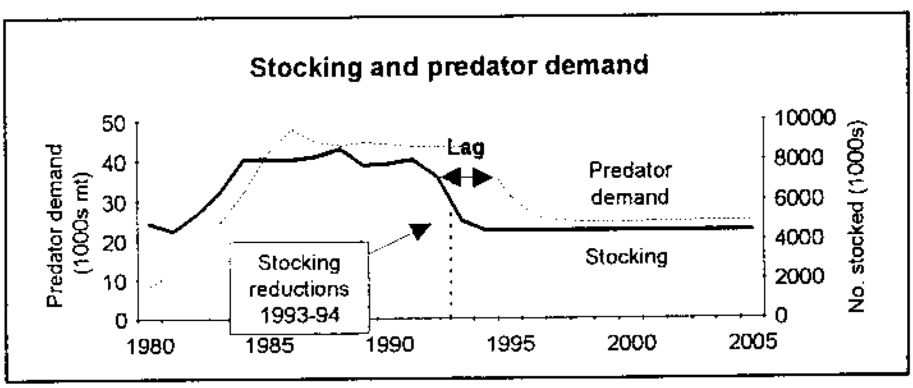

FIG. 6. Number of salmon and trout stocked by Canadian and United States agencies combined and the estimated total predator demand of all salmon and trout in Lake Ontario by year.

To date the response of salmon and trout populations to the apparent reduction in prey is unclear. Being at the top of the food chain, the response in the top predators will lag behind changes in prey populations. Recent observations show that condition factor (weight at a given length) of salmon and trout declined through the early 1980's, but since 1986, has levelled off or improved. Sport fishing effort declined slightly in both New York and Ontario in 1993, but catch rates were better than average and the result was an overall increase in total catch compared to 1992. Continued surveillance should enable us to detect longer term responses in the predator populations and associated sport fishery.

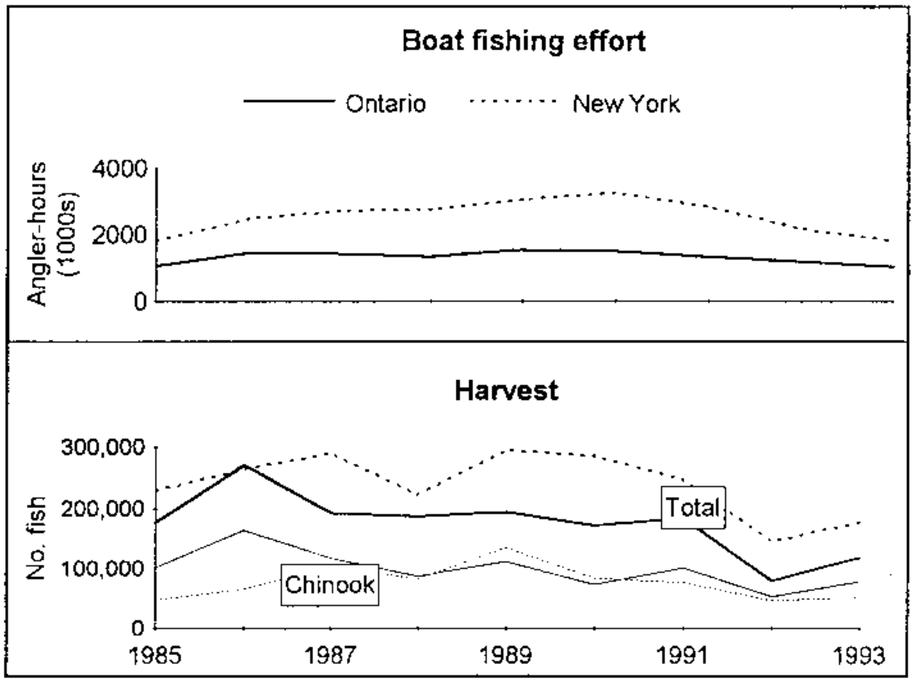

FIG. 7. Changes in the total boat fishing effort, total harvest of trout and salmon, and total harvest of chinook, for both Canadian and United States waters.

Exotic Species

Scientists recently concluded that there has been a total of 136 exotic aquatic organisms introduced to the Great Lakes. A large majority of these were unintentional introductions and their impact on the ecosystem cannot be reliably predicted. The list includes species we have become accustomed to such as smelt and alewife. An example of a newly colonizing exotic is the zebra mussel and its close cousin the quagga mussel. These organism are disrupting water supply systems and could potentially impact water quality and fisheries. Surveys to index the abundance of zebra mussels in Lake Ontario occurred in 1991 and 1993. Results indicate that zebra mussel densities have increased in some regions by ten-fold from 1991 to 1993, but remained low in other areas. The highest concentrations are in the Niagara area, and likely the south shore of Lake Ontario. Densities are moderate in eastern Lake Ontario, and it appears that the mussels have yet to firmly establish themselves in north central Lake Ontario. As the population continues to develop and expand its range, ecosystem impacts will become more evident.

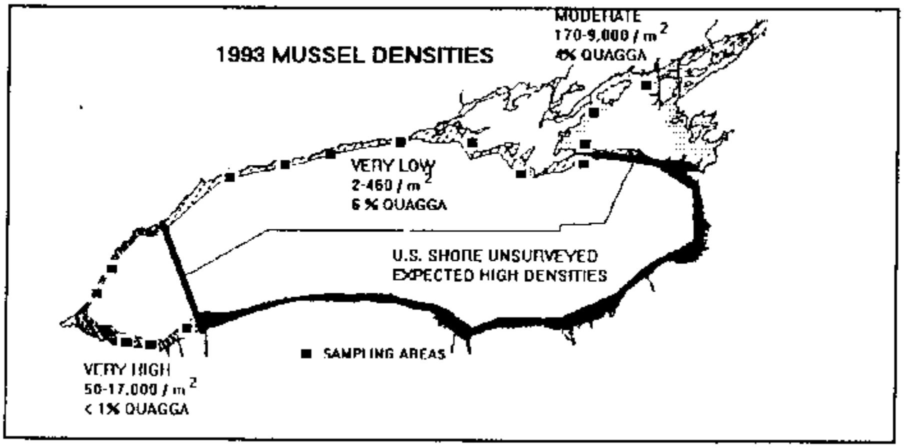

FIG. 8. Density and composition of mussel population in surveyed regions of Lake Ontario in 1993.

Recovering Species

Reduction in phosphorous levels and other ecosystem changes suggest that the Lake Ontario ecosystem continues to improve. Another sign that the system is recovering, is the resurgence of native species that were near dangerously low levels of abundance. For example, lake whitefish abundance has increased dramatically in recent years. We may also expect populations of lake herring, burbot, and lake trout to respond positively as the ecosystem continues to change.

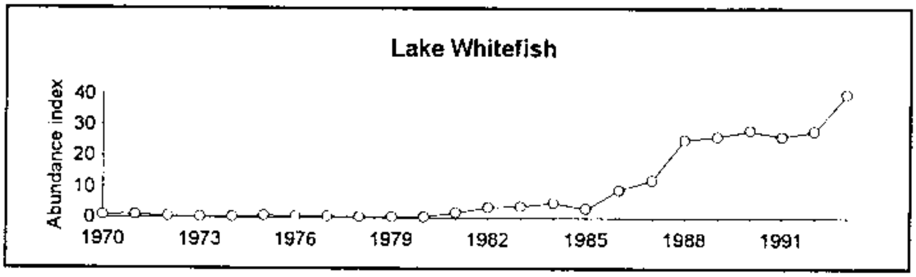

FIG. 9. Changes in the catch of lake whitefish in a standard index gillnet in the outlet basin of Lake Ontario.

In Summary

Through the 1980's the Lake Ontario ecosystem changed. In response to pollution controls, nutrient levels and zooplankton production declined. Although, stocking programs and sea lamprey control increased the populations of salmon and trout, biomass of their principal prey species, alewife and smelt, declined.

As we entered the 1990's, we became more aware of how the lake adjusted to these changes. Levels of phosphorus and zooplankton production may be stabilizing. However, as we better understand the impact of developing zebra mussel populations, it seems that further declines in phosphorus and zooplankton production are possible. Prey fish populations continue to decline, and only time will tell if efforts to reduce predator demand, through stocking reductions, will be sufficient to allow smelt and alewife populations to sustain themselves. Alewife are susceptible to severe winter temperatures, and the near record breaking cold experienced in the winter of 1994 will further stress the alewife. Response of other fish populations to these changes cannot be confidently predicted. Species such as the lake whitefish have increased dramatically over the last decade and the abundance of lake herring, burbot, lake trout or other species may also respond to changing conditions. These potential changes in the fish community will have a major role in determining the future of all Lake Ontario fisheries.

Lake Ontario remains in a state of flux, and there is a need for continued surveillance. Fisheries management agencies and their partners are committed to ensuring the continued health of the Lake Ontario ecosystem to provide sustained benefits to society including requirements for recreational activity, wholesome food, employment and income, and cultural heritage. We welcome your comments.

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