THE STATE OF THE LAKE ONTARIO FISH COMMUNITY IN 1989

Great Lakes Fishery Commission

SPECIAL PUBLICATION 91-3

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THE STATE OF THE LAKE ONTARIO FISH COMMUNITY IN 1989

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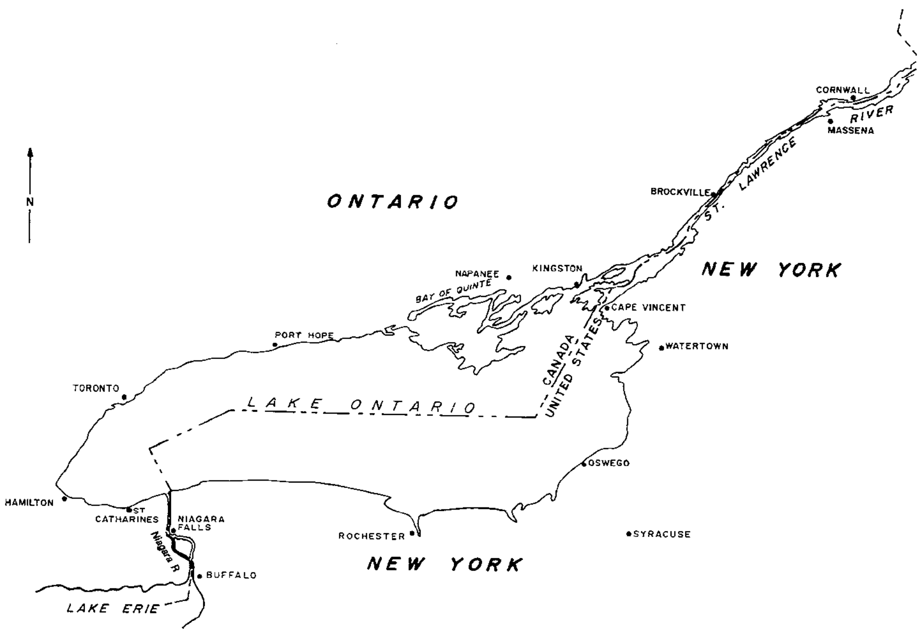

Lake Ontario

TABLE OF CONTENTS

EXECUTIVESUMMARY

The Lake Ontario fish community has undergone a number of profound changes from its original structure and composition. Lake sturgeon (Acipenser fulvescens), Atlantic salmon *(Salmo salar),* lake trout *(Salvelinus namaycush),* lake herring *(Coregonus artedii),* and deepwater ciscoes *(Coregonus* spp.) have become either depressed or extirpated. As a result of recent stocking programs and the introduction of several exotic species, the present Lake Ontario fish community includes top predators such as chinook salmon *(Oncorhynchus tshawytscha),* coho salmon (0. *kisutch),* lake trout, brown trout *(Salmo trutta),* rainbow trout (0. *mykiss),* and walleye *(Stizostedion vitreum vitreum).* This fish community is associated with a forage base comprised largely of alewife *Alosa pseudoharengus* an rainbow smelt *(Osmerus mordax).* While the lower Niagara River supports a fish community similar to Lake Ontario proper, the St. Lawrence River hosts a warmwater fish community characterized by smallmouth bass *(Micropterus dolomieui),* largemouth bass *(M. salmoides),* yellow perch *(Perca flavescens),* northern pike *(Esox lucius),* walleye, brown bullhead *(Ictalurus nebulosus),* and panfish-sized Centrarchidae. Habitat alteration (primarily from construction of the St. Lawrence Seaway) and overfishing were believed to have virtually eliminated lake sturgeon and greatly reduced resident walleye and muskellunge *(Esox masquinongy)* stocks in the St. Lawrence River.

Lake Ontario supports a commercial and recreational fishery. The commercial fishery is concentrated in the eastern portion of the lake and in the Ontario waters of the St. Lawrence River. In 1989, the landed catch from Lake Ontario and the St. Lawrence River was valued at almost $1.3 million, and the commercial fishing industry was estimated to employ over 300 people, mostly in Ontario. Lake Ontario also provides a world-class recreational fishery valued well over $200 million in 1989.

To identify a desirable fish community and its yield as well as to develop long-term management direction, draft Fish Community Objectives for Lake Ontario proper were jointly formulated in 1988 by the Province of Ontario and the state of New York. These draft objectives, reworded and condensed here, include:

1) maintaining viable populations of indigenous fish species and self-sustaining, non-indigenous salmonines (trout and salmon),

2) restoring populations of extirpated or depressed indigenous fish species,

3) maintaining a diverse complex of salmonine and coregonine (whitefish and ciscoes) fish species that produce an average annual yield of 2.5 kg/ha. This complex includes an adult lake trout population of 0.5-1.0 million fish with adult females averaging 7.5 years in age and producing an annual recruitment of 100,000 yearlings,

4) maintaining the current complex of warmwater fish species at a level producing an average annual yield of 1 kg/ha,

5) maintaining principal prey fish such as alewife, rainbow smelt, and slimy sculpin *(Cottus cognatus)* at an average annual biomass of 110 kg/ha for production of top predators, and

6) controlling the sea lamprey *(Petromyzon marinus)* population to restrict lake trout mortality to less than 90,000 fish annually.

Substantial progress has already been made in achieving these objectives. The preparation of several long-term Fishery Management Plans, continuation of a fish stocking program (approximately eight million fish stocked annually), enforcement of existing harvest control measures, and increased emphasis on habitat protection (including development of Remedial Action Plans for eight Areas of Concern) have all contributed to the general objective to maintain viable fish populations.

Comprehensive programs have been initiated to restore lake trout in Lake Ontario. Ontario and New York annually stock approximately two million lake trout at former spawning shoals. By 1989, these stocking programs produced an adult lake trout population of approximately 0.5 million fish averaging 6.3 years in age. Harvest control measures (including a protected size interval in New York waters) and sea lamprey control programs reduced lake trout annual mortality to 50% or below by 1989. Further improvements in lake trout survival will depend upon continued stocking programs and harvest control measures as well as maintenance of sea lamprey control efforts. Recent research activities have focused on evaluating spawning activity and the reproductive success of various lake trout strains. Small numbers of naturally produced fry and yearlings (first documented in 1983 and 1989, respectively) demonstrate that some reproduction is occurring. Finally, the lake trout rehabilitation plan of 1983 has been revised to reflect progress made to date and to focus research and management efforts over the next several years.

Ontario and New York have recently initiated stocking programs to re-establish Atlantic salmon in Lake Ontario. In 1989, almost 140,000 Atlantic salmon were released in carefully selected tributaries. Assessment programs have been directed to evaluate returns to both the recreational fishery and spawning grounds in tributaries. Stocking success may be limited by interspecific competition in streams with other juvenile salmonines, particularly rainbow trout.

In addition to lake trout and Atlantic salmon, a variety of other species are managed as part of the cold-water fish community. Chinook salmon are the most highly sought species by anglers, and represent over 40% of the total fish stocked in Lake Ontario. Rainbow trout, brown trout, and coho salmon are also stocked to diversify angling opportunities. Although stocking rates may vary from year to year, these species will continue to be managed as part of the fish community. Lake whitefish *(Coregonus clupeaformis)* and lake herring remain relatively stable though at reduced levels of abundance. Both species will continue to be harvested on a limited basis by the commercial fishery in the northeastern portion of the lake. In 1989, the harvest of salmonines by the Lake Ontario recreational fishery was estimated at 0.5 million fish. In conjunction with coregonines harvested in the commercial fishery, the overall yield from the cold-water fish community probably exceeded the objective of 2.5 kg/ha.

Although assessment information is inadequate and lakewide estimates of the recreational catch are unavailable, catches of warmwater fish have probably not reached the objective of 1 kg/ha average yield. Yellow perch populations are currently low and, with the exception of the Bay of Quinte, walleye are generally at a low but stable level. There is currently little detailed assessment information for other warmwater fish. The warmwater fishery will continue to be managed through harvest control measures, including quota management for the commercial fishery. An expanded assessment program will be required to fully evaluate existing yields from the warmwater fishery.

Forage fish abundance is presently thought to exceed the 110 kg/ha objective. The bulk of forage fish are alewife. Alewife abundance is a function of salmonine predation and winter severity. Colder than normal winters can result in severe die-offs. Efforts to monitor the status of principal prey species such as alewife, smelt, and slimy sculpin will be improved. To maintain community stability, fisheries managers will closely monitor prey and predator relationships.

Sea lamprey control efforts have been successful in reducing both the abundance of this parasite as well as lamprey-induced mortality on prey species such as lake trout. Based on bottom trawl surveys of fish carcasses, the number of lake trout killed by sea lamprey was estimated at 40,000 in 1989. This quantity is the lowest value recorded since the survey began in 1982. Similarly, the sea lamprey marking rate was the lowest recorded. Other parameters (such as the drop in marking rate on large lake trout) also indicate a reduction in sea lamprey abundance. Sea lamprey control should continue to be successful if the existing level of treatment can be maintained.

Problems that could delay or prevent the attainment of Fish Community Objectives are:

1) funding uncertainties for sea lamprey control,

2) insufficient numbers or inappropriate strains of lake trout for stocking,

3) introduction of and colonization by exotic species such as the zebra mussel *(Dreissena polymorpha)*,

4) degradation or loss of fisheries habitat,

5) instability of forage fish,

6) reductions in nutrient loading,

7) long-term declines of yellow perch, and

8) inadequate assessment information.

New management initiatives are proposed for the future. Pending allocation of funds, alternative methods of sea lamprey control will be examined. Assessment programs will be expanded to evaluate the success of the lake trout size limit in New York. Improved techniques to monitor forage fish abundance and document angling pressure and harvest of major sport fish species will be sought. Research will concentrate on evaluating the progress of lake trout and Atlantic salmon rehabilitation programs. Law enforcement efforts will be more coordinated and focus on charter fishing, professional fishing tournaments, and fish habitat protection. Cooperative fisheries management programs will be expanded on the St. Lawrence River to include regular monitoring of major sport fisheries, development of a ten-year muskellunge management plan, and a comprehensive inventory of existing fish habitat.

FISH COMMUNITY GOALS AND OBJECTIVES

Based on the Joint Strategic Plan for Management of Great Lakes Fisheries (Great Lakes Fishery Commission 1980), a common goal statement was developed for all Great Lakes fishery agencies:

> To secure fish communities, based on foundations of stable self-sustaining stocks, supplemented by judicious plantings of hatchery-reared fish, and provide from these communities an optimum contribution of fish, fishing opportunities and associated benefits to meet needs identified by society for:
>
> wholesome food,
> recreation,
> employment and income, and
> a healthy human environment.

In recognition of this broad goal and in keeping with procedures outlined in the Joint Plan, Fish Community Objectives were formulated for

Lake Ontario by the Lake Ontario Committee of the Great Lakes Fishery Commission (GLFC) in 1988. The Lake Ontario Committee is composed of a single fishery manager from the Province of Ontario and from the state of New York. These objectives were intended to define the desired structure of the Lake Ontario fish community as well as to provide a means to measure progress. The Fish Community Objectives for Lake Ontario are considered to be a draft statement to which both agencies are committed to refining and modifying as needed to ensure relevance. These draft objectives have been reworded as follows:

1) Maintain viable populations of indigenous fish species and of non-indigenous salmonine (trout and salmon) species that are self-sustaining and that contribute significantly to fisheries.

2) Encourage population restoration of extirpated or depressed indigenous fish species.

3) Maintain a diverse complex of salmonine and coregonine (whitefish and ciscoes) fish species that produce an average annual yield of 2.5 kg/ha.

   a) This complex includes a lake trout *(Salvelinus namaycush)* population consisting of 0.5-1.0 million adult fish. Adult females should average 7.5 years in age and produce an annual recruitment of 100,000 yearlings.

   b) Populations of Atlantic salmon *(Salmo salar),* rainbow trout *(Oncorhynchus mykiss),* brown trout *(Salmo trutta),* coho salmon *(0. kisutch),* chinook salmon *(0. tshawytscha),* lake whitefish (Coregonus *clupeaformis),* and lake herring *(C. artedii)* shall be managed as part of the cold-water species complex.

4) Maintain the current complex of warmwater fish species at a level producing an average annual yield of 1 kg/ha.

5) Maintain principal prey species such as alewife *(Alosa pseudoharengus),* rainbow smelt *(Osmerus mordax),* and slimy sculpin (Cottus *cognatus)* at an average annual biomass of 110 kg/ha for production of piscivorous fish species.

6) Limit the size of the sea lamprey *(Petromyzon marinus)* population to a level that will not cause mortality in excess of 90,000 lake trout annually.

This report summarizes the status of the fishery through 1989, indicates what progress is being made with regard to achieving Fish Community Objectives, and outlines future management direction for the Lake Ontario fishery.

BACKGROUND

Lake Definition and Management Jurisdiction

As described in the Convention on Great Lakes Fisheries between the United States and Canada (Great Lakes Fishery Commission 1956), Lake Ontario includes the waters of Lake Ontario proper (including the Bay of Quinte), the Niagara River below Niagara Falls, and the St. Lawrence River from Lake Ontario to the 45th parallel of latitude. Also included are tributary streams utilized by fish stocks of common concern as well as those required to be managed to minimize or eradicate sea lamprey populations.

Fisheries management responsibility is shared by the Ontario Ministry of Natural Resources (OMNR) for the Province of Ontario and the New York State Department of Environmental Conservation (NYDEC) for the state of New York. Sea lamprey control efforts are conducted by the Canadian Department of Fisheries and Oceans (DFO) and the United States Fish and Wildlife Service (USFWS) (agents for the GLFC). Fishery programs and management direction are coordinated by the Lake Ontario Committee of the GLFC.

Basin Characteristics

Although the smallest of the Laurentian Great Lakes, Lake Ontario based on volume is the twelfth largest lake in the world. Approximately 53% of the: lake’s surface area is within the Province of Ontario and the remainder is in the state of New York. The upper St. Lawrence River also falls within the jurisdictions of Ontario and New York. Lake Ontario water quality is generally characteristic of an oligotrophic system (Table 1). Lake Ontario (the lowermost of the Great Lakes) receives inputs of water and toxic substances from upstream sources. Water quality is also affected by industry, urban development, agriculture, and landfill leachate. Although the bottom topography of the lake is relatively smooth (Fig. l), there are four distinct basins. From west to east these offshore basins are the Niagara, Mississauga, Rochester, and Kingston Basins. They are separated by the Whitby-Olcott, Scotch Bonnet, and Duck-Galoo Sills, respectively (Fig. 2). The differentiation among the three most westerly basins (Niagara, Mississauga, and Rochester) is relatively subtle. The Duck-Galoo Sill (extending from Long Point to Stoney Point) produces a much more pronounced distinction between the Rochester and Kingston Basins. This distinction results in unique water quality characteristics in the Kingston Basin of Lake Ontario (Flint and Stevens 1989). Lake Ontario is also unique because it has the largest drainage basin relative to its size of all the Great Lakes. It is second only to Lake Superior in terms of depth relative to size (Flint and Stevens 1989).

Table 1. Selected physical, chemical, and morphometric parameters of Lake Ontario (Ryder 1972) and the Niagara and St. Lawrence Rivers (Edwards et al. 1989).

	LAKE ONTARIO	ST. LAWRENCE RIVER	NIAGARA RIVER'
MORPHOMETRIC			
No. tributaries			
New York	409	129[2,4]	7[1]
Ontario	371		6'
Surface area (km*)	19,477	655[2]	
Shoreline (km)	1,380		
Shore development factor	3		
Mean depth (m)	PO	10[2]	
Maximum depth (m)	237		
Drainage area (km^2)	70,655	766,000[1] 18.716'	683,000[1]
Altitude (m)	75		
River length (km)		869 182[2]	58'
Drop in elevation (m)		74	99'
Mean discharge (m^3/sec)			
annual		6.739	5,692
maximum		9.911	7,505
minimum	-	4,361	3,285
Flushing rate	8[3] (years)	11[2] (days)	
CLIMATIC			
Forest region		Great Lakes-St. Lawrence deciduous	
Climate region		Cool summer but no dry season	
Mean July temperature (°C)	21-24	21-24	21-24
Precipitation (cm)	60-100	60-100	60-100
Growing season (days)	200-220	200-220	200-220
CHEMICAL			
PH	8.0	8.2-8.7	7.3-8.5
Secchi disk (m)	5.5		
Turbidity (JTU)	1.2		
Total dissolved solids (mg/l)	134		
Total alkalinity (mg/l)	93	91.4	97.5

[1] Values for entire river system.
[2] Values for Ontario-New York (international) portion of river.
[3] Source: Flint and Stevens (1989).
[4] P. MacMahon, Ontario Ministry of Natural Resources, Brockville, Ontario.
[5] Values for river below Niagara Falls.

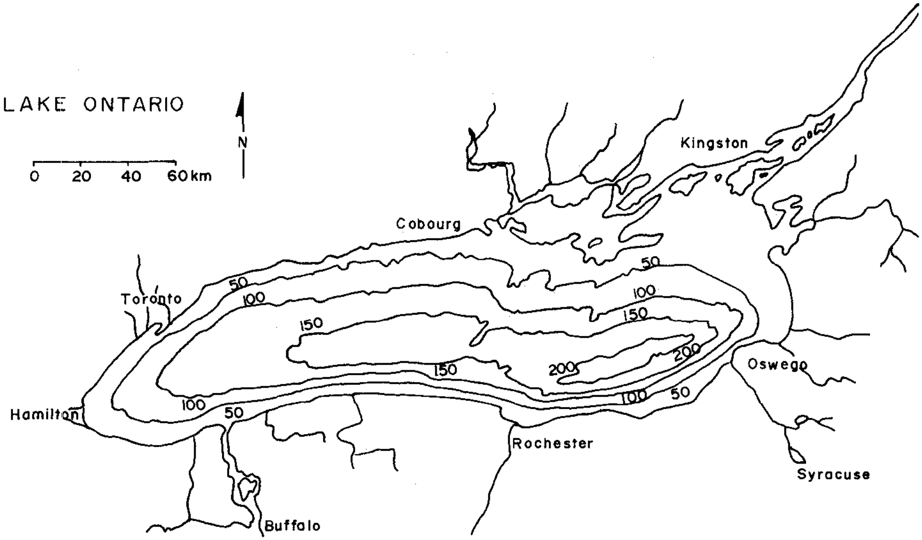

Fig. 1. Depth contours (m) for Lake Ontario.

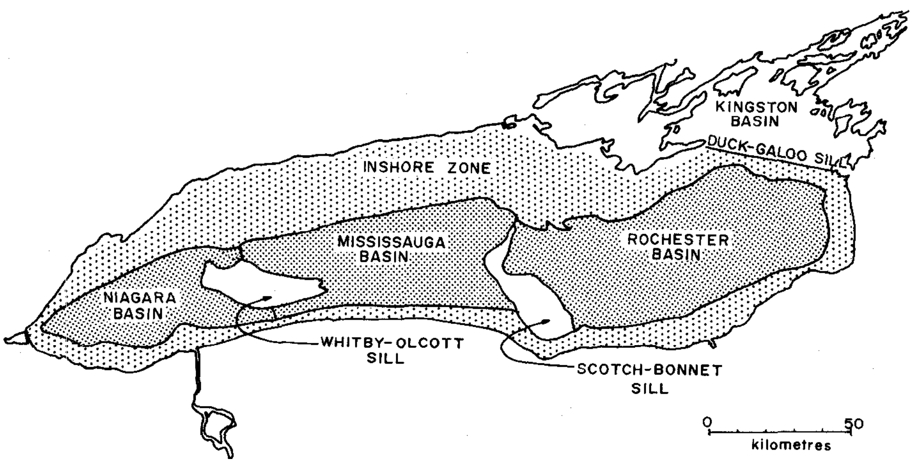

Fig. 2. Major sedimentation basins of Lake Ontario (Flint and Stevens 1989).

The Niagara River, draining Lake Erie and the upper Great Lakes, is the major inlet providing 86% of the total tributary inflow to Lake Ontario. The river drops almost 100 m in elevation during its 58 km course. The major feature of the Niagara River is Niagara Falls (56 m drop) which separates the upper and lower portions of the river. The Welland Canal was constructed to accommodate shipping around the falls. Water quality in the Niagara River is generally good, although some contamination of both water and sediments with toxic substances (PCBs, DDT, mirex, and mercury) has resulted mostly from industrial sources along the New York shoreline and tributaries (Edwards et al. 1989; Environment Canada et al. 1989).

The St. Lawrence River is the sole outlet for Lake Ontario and flows northeast to the Gulf of St. Lawrence. Ontario and New York share a 182 km (approximately) border in what is commonly known as the international section of the river. This portion of the river may be divided into four distinct reaches based on physical and limnological characteristics: the Thousand Islands (comprised of numerous bays, islands, and shoals), the middle corridor (a narrow, deep riverine channel), and Lakes St. Lawrence and St. Francis (relatively shallow, warmwater reservoirs). Construction of the St. Lawrence Seaway in the late 1950s resulted in a dramatic alteration of fish habitat, particularly in the lower portion of the river. However, water quality has remained similar to that of Lake Ontario.

History of the Fish Community

The early (circa 1800) Lake Ontario fish community was believed to be dominated by large individuals of locally adapted species including lake sturgeon (*Acipenser* fulvescens), lake trout, lake whitefish, burbot (*Lota lota*), and Atlantic salmon (Crossman and Van Meter 1979; Francis et al. 1979; Goodyear et al. 1982a; Emery 1985). The earliest records of the Lake Ontario fish community involve the commercial fishery (Baldwin et al. 1979). Historically, the Lake Ontario commercial fishery was based on a variety of species including lake herring, deepwater ciscoes (*Coregonus* spp.), lake trout, lake whitefish, American *eel (Anguilla rostrata),* walleye (*Stizostedion vitreum vitreum*), yellow perch (*Perca flavescens*), northern pike (*Esox lucius*), and bullheads (*Ictalurus* spp.). Commercial yields peaked at 3.4 million kg in the late 1800s and again at almost 2.7 million kg in 1924. The western basin Canadian and New York commercial fisheries were greatly reduced by the mid-1940s. Eastern basin fisheries persisted through the 1950s because of greater species diversity. Nearshore warmwater fish replaced dwindling offshore stocks of lake whitefish, lake herring, and lake trout. Presently, the commercial fishery is concentrated in the northeast portion of the lake and is based primarily on yellow perch, lake whitefish, American eel, and bullheads.

Largely as a result of human influence, the native fish community of Lake: Ontario and the St. Lawrence River has undergone dramatic changes over the past 100 years. The chronology of major events is shown below (Christie 1973):

1830-40	Collapse of Atlantic salmon stocks.
1860s	Reduction of deepwater ciscoes; alewife colonization.
1890-1910	Lake whitefish, lake trout, and burbot scarce; deepwater ciscoes abundant.
1920s	Lake whitefish, lake trout, burbot, and sea lamprey abundant; deepwater ciscoes scarce.
1930s	Lake trout, burbot, lake whitefish, and lake herring decline; deepwater ciscoes increase.
1940s	Lake trout, burbot, lake herring, and deepwater ciscoes collapse; smelt rise to dominance.
1950s	White bass *(Morone chrysops),* blue pike *(Stizostedion vitreum glaucum),* and deepwater sculpin *(Myoxocephalus quadricornis)* disappear; walleye dominant; lake whitefish abundant.
1960s	White perch *(Roccus americanus)* reach dominance; walleye decline; Bay of Quinte lake whitefish collapse; yellow perch abundant in open Lake Ontario.
1970s	Stocked salmonines increasing in abundance; major alewife die-off in 1976-77.
1980s	Walleye in Bay of Quinte abundant; modest recovery of lake whitefish; stocked salmonines (lake trout and chinook salmon) abundant; sea lamprey abundance reduced; the spiny water flea *(Bythotrephes cederstroemi)* and zebra mussel *(Dreissena polymorpha)* invade Lake Ontario.

Christie (1973) identified a number of factors that altered the Lake Ontario fish community:

1) Overfishing. Intensive commercial fishing was believed to be the major cause for the decline of lake herring, lake whitefish, and deepwater ciscoes.

2) Reduction/Loss of Predators. Between the time when burbot and lake trout were extirpated (1950s) and large-scale plantings of hatchery-reared salmonids were initiated (1970s), the offshore waters of Lake Ontario were virtually devoid of large piscivores. The absence of these top predators may have resulted in increased smelt abundance and a shift in sea lamprey predation to other species such as lake whitefish and deepwater ciscoes.

3) Alewife/Smelt Abundance. The increased abundance of alewife, smelt, and white perch affected native species such as yellow perch, lake whitefish, and lake herring.

4) Environmental Degradation. The degradation and loss of fish habitat, in addition to accelerated eutrophication (Hurley and Christie 1977) and increased levels of some toxic substances, have undoubtedly depreciated the Lake Ontario fish community.

In the mid- to late-1960s, New York and Ontario commenced plantings of three species of Pacific salmon: coho salmon, chinook salmon, and kokanee salmon ***(Oncorhynchus nerka).*** Large-scale plantings of lake trout, as part of a cooperative lake trout rehabilitation program between the OMNR and the USFWS, began in the mid-1970s. Since then, brown trout, rainbow trout, and Atlantic salmon have also been stocked on a regular basis. Current stocking programs are directed toward the rehabilitation of lake trout and Atlantic salmon as well as the provision of put-grow-and-take angling opportunities to sustain the recreational fishery. Ontario and New York have agreed to cap stocking programs at a maximum of eight million fish annually (Fig. 3).

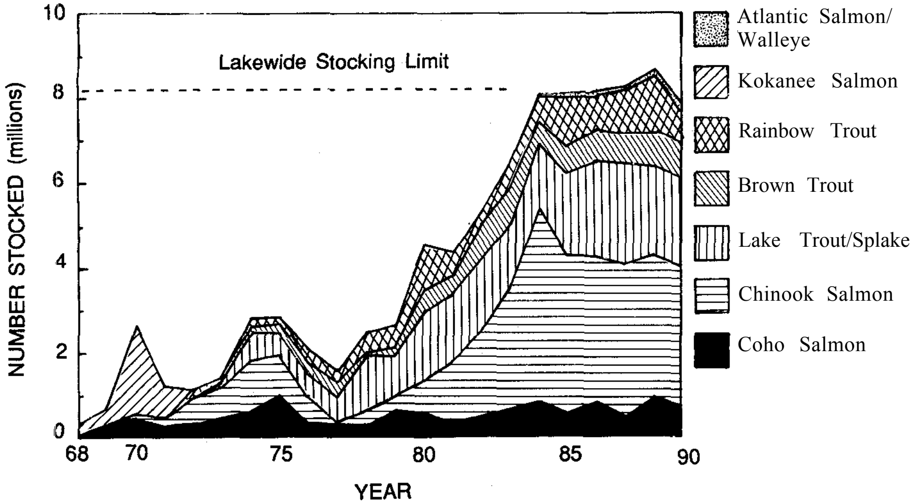

Fig. 3. Lake Ontario stocking trends including all yearlings and fingerlings and some fry and age-2 fish for combined Canadian and American plantings from 1968-89. Canadian splake (1968-76) are included with lake trout. The United States also stocked 326,000 and 106,000 brook trout *(Salvelinus fontinalis)* in 1980 and 1981, respectively.

The development of a world-class recreational fishery has been concurrent with the dramatic increase in the stocking of various salmonines. This fishery is largely hatchery dependent and also relies upon the maintenance of a productive base of forage fish comprised primarily of alewife and, to a lesser extent, smelt. Alewife abundance has fluctuated considerably since a dramatic increase following the 1976-77 die-off (O'Gorman 1988).

The lower Niagara River supports a cold-water fishery similar to that in Lake Ontario. The fishery is based on species such as rainbow trout, coho salmon, lake trout, white bass, and to a lesser extent, yellow perch, freshwater drum *(Aplodinotus grunniens),* and rock bass *(Ambloplites rupestris).* The fish community in the lower Niagara River has undergone a number of changes as a result of habitat loss, impaired water quality, overharvest, and the introduction of exotic species. Grass pickerel *(Esox americanus vermiculatus)* and lake sturgeon, once considered abundant, are now rare. Other species such as rainbow trout, smelt, alewife, goldfish *(Carassius auratus),* carp *(Cyprinus carpio),* white perch, coho salmon, and chinook salmon have all developed reproducing populations as a result of introductions.

Historically, the international portion of the St. Lawrence River has supported both commercial and recreational fisheries comprised of warmwater species such as walleye, northern pike, largemouth bass *(Micropterus salmoides),* smallmouth bass *(M. dolomieui),* yellow perch, and various bullheads (Evermann and Kendall 1902, Hamre 1973; Goodyear et al. 1982b). The river was also renowned for its muskellunge *(Esox masquinongy)* fishery yielding the world angling record (31.7 kg) in 1957. Major changes in the St. Lawrence River fishery have resulted from habitat alteration attributed to the construction of the St. Lawrence Seaway as well as hydroelectric development (Eckersley and McCullough 1990). Walleye appear to be most affected by these developments. Sturgeon and muskellunge stocks have also deteriorated largely because of overfishing and habitat alteration. Today the walleye fishery is showing signs of recovery and smallmouth bass and yellow perch remain relatively stable. Compared to the past, the present St. Lawrence River fish community is characterized by an increased abundance of new species such as alewife, white perch, and carp.

PROBLEMS AND ISSUES

Eleven issues that could prevent attainment of the desired fish community structure in Lake Ontario are identified in the Fish Community Objectives for Lake Ontario. Eight of these issues are:

1) Sea Lamprey Control. The success of the lake trout rehabilitation program and maintenance of the high-quality salmonid fishery in Lake Ontario depend upon effective sea lamprey control. Recent funding problems have made the long-term effectiveness of the program unclear. Funding of the sea lamprey control program must be adequate to meet fishery objectives and to develop and diversify control methods.

2) Lake Trout Production. Shortages of preferred strains of lake trout from provincial and federal hatcheries may delay rehabilitation of lake trout. Because of shortages caused by disease, neither Ontario nor the USFWS achieved target levels of lake trout planting in 1989. Initial results indicate that Seneca Lake and Lake Superior strains may be the most appropriate varieties to achieve rehabilitation. Efforts by Ontario to change strains in hatcheries have been delayed because of disease management procedures, including quarantine and planning requirements.

3) Exotic Species. The recent introduction of the zebra mussel to Lake Ontario is cause for great concern. The zebra mussel has demonstrated potential to rapidly colonize, foul spawning reefs, increase water clarity, and disrupt the food chain. Coordinated efforts will be required to monitor colonization, assess impacts on fisheries, and develop mitigative measures.

4) Alteration/Loss of Habitat. Harmful alteration, destruction, and loss of fish habitat in Lake Ontario continues. Also, the presence of a variety of toxins has resulted in consumption advisories for many fish from Lake Ontario. A Lake Ontario Toxics Management Plan (Enviroment Canada et al. 1989) is in effect and Remedial Action Plans are being developed (Great Lakes Water Quality Board 1987). However, remediation based on these plans is yet to be implemented.

5) Forage Base Instability. Lake Ontario presently has the highest salmonid stocking rate and the lowest diversity of cold-water prey among the Great Lakes (S. Brandt, Solomons, MD, pers. commun.). In recent years, concerns have heightened over the potential for an alewife collapse, a subsequent shift in forage fish composition, and resulting consequences to the fishery. Fishery managers must determine the likelihood of such an event, the social and economic ramifications, and what actions, if any, can be taken to prevent or mitigate these problems. Present efforts are focusing on improving programs to monitor forage fish stocks, especially alewife, and on developing a predator-prey simulation model to explore the implications of different management strategies.

6) Reduced Nutrient Levels. The trend toward reduced nutrients in Lake Ontario raises concerns about future levels of fish production, especially terminal predators that are sport fish (International Joint Commission 1988; Flint 1989; Boyce et al. 1990). This trend has been identified in other Great Lakes, and should be considered by the GLFC as a future issue. Several agencies are presently studying nutrient levels in Lake Ontario.

7) Decline of Yellow Perch. The long-term decline of yellow perch in many areas is being monitored, but no solution appears evident without a decline of alewives. The type of catastrophic alewife mortality that would benefit yellow perch stocks would be devastating to trout and salmon stocks and to the fishery. Development of a contingency program to evaluate possible management options after a catastrophic alewife die-off is underway.

8) Inadequate Knowledge. Sound management of the Lake Ontario fishery is hampered by inadequate knowledge caused by funding shortfalls. Of primary importance is the implementation of a lakewide program to monitor the status of the Lake Ontario fish community, including the relative abundance of major prey species. Hydroacoustics or some other precise lakewide assessment effort should be developed immediately. Without a thorough understanding of long-term fish community dynamics, uncertainty will continue to surround the maintenance of a high-quality salmonid fishery. Even though cooperative efforts are underway, more technical and financial emphasis is required to adequately address this issue.

STATE OF THE FISH COMMUNITY

Recreational and Commercial Fisheries

In 1989, the open-water sport fishery in New York waters of Lake Ontario harvested 288,527 fish with an effort of 205,251 boat trips (Schneider et al. 1990). This effort resulted in direct angler expenditures valued at approximately $131 million. In Ontario waters, the estimated fishing effort and harvest by open-water anglers in 1989 was 142,508 boat trips and 173,588 fish (Stewart et al. 1990). In addition, the Bay of Quinte was estimated to have sustained 69,100 boat trips in 1989. The direct economic value of the Ontario fishery was estimated at over $54 million.

The St. Lawrence River provides a heavily utilized sport fishery. Based on a 1988 survey of the Ontario side of the river, angling pressure was estimated at over 175,000 angler days with an associated harvest of 528,023 fish. The quality of smallmouth bass angling in the St. Lawrence River was among the best in the Province of Ontario.

Current estimates of angling effort on the Ontario side of the lower Niagara River are lacking. Based on a 1983-84 survey, angling effort amounted to 97,547 hours annually on the Ontario side of the lower river (B. Lewies, Ontario Ministry of Natural Resources, Fonthill, Ontario, pers. commun.). The most recent information of angling activity on the New York side of the lower Niagara River is from a 1988 statewide survey (Connelly et al. 1990). This survey estimated that 22,000 anglers spent 240,570 angler days of effort on the lower Niagara River. While these figures are believed to overestimate actual angling effort, they do indicate wide participation in the lower Niagara River fishery.

Although much reduced from former years, a commercial fishery continues in the Ontario and New York waters of Lake Ontario. In New

York, 45 commercial fishing licenses are issued to 19 licensees. The 1989 landed catch of 59,503 kg was valued at approximately $88,000 (New York Department of Environmental Conservation 1990). The Ontario waters of Lake Ontario support a larger commercial fishery concentrated almost exclusively in the central and eastern portions of the lake. In 1989, 141 commercial fishing licenses were issued, and the landed catch was valued at almost $1 million. The Ontario commercial fishery provides direct employment and income for 200-300 people.

In 1989, 31 commercial fishing licenses were issued by the Province of Ontario for fishing on the St. Lawrence River. The reported harvest exceeded 240,000 kg. The landed catch, comprised largely of coarse fish, was valued at over $200,000 (New York Department of Environmental Conservation and Ontario Ministry of Natural Resources 1990). There is no commercial fishery in the lower Niagara River.

Progress in Meeting Objectives

To identify progress of the fishery management agencies, the status of the Lake Ontario fish community is reviewed in relation to objectives for its structure and function. In general, Lake Ontario fish stocks are improving in the late 1980s. Predatory fish, whether stocked or wild, are at encouraging levels of abundance, sea lamprey numbers are low, and forage fish are abundant.

Objective 1

Maintain Viable Populations of Indigenous Fish Species and of Non-indigenous Salmonine Species that are Self-sustaining and that Contribute Significantly to Fisheries

This objective was developed to provide a general statement on the desired fish community structure for Lake Ontario. Other fish community objectives provide details for certain species and components of the fish community. Priorities in order of importance are:

1) indigenous species,

2) self-sustaining, non-indigenous salmonine species, and

3) non-indigenous salmonine species that are not self-sustaining.

Important indigenous species include smallmouth bass, walleye, yellow perch, brown bullhead (Ictalurus *nebulosus),* lake whitefish, muskellunge, and lake herring. The main self-sustaining, non-indigenous salmonine is rainbow trout (also called steelhead). Non-indigenous salmonines that are not self-sustaining are chinook salmon, coho salmon, and brown trout.

The current fisheries management program in Lake Ontario began in the mid-1960s. Major efforts in this program include:

1) Preparation of Fishery Management Plans (FMPs). The following long-term FMPs identify both strategic direction and local tactics designed to meet overall Fish Community Objectives for Lake Ontario:

   a) State of New York--Strategic Lake Ontario Fishery Management Plan (1989),

   b) Province of Ontario--Strategic Lake Ontario Fishery Management Plan (in preparation),

   c) Province of Ontario--District Fishery Management Plans (four of five district plans completed), and

   d) Ontario Ministry of Natural Resources/New York Department of Environmental Conservation--St. Lawrence River Muskellunge Management Plan (LaPan and Penney 1991).

2) Fish Habitat Protection and Rehabilitation. Protection of fish habitat has been given greater emphasis in recent years because of increased attention brought about by the FMP process and increased enforcement of habitat protection provisions of the Canada Fisheries Act and the New York Environmental Conservation Law. In addition, Remedial Action Plans have been initiated for the eleven Areas of Concern identified for Lake Ontario and the St. Lawrence River (International Joint Commission 1988) as follows:

Oswego River
Rochester embayment
Niagara River
Bay of Quinte
Port Hope
Toronto waterfront
Hamilton Harbour
Buffalo River
Eighteen Mile Creek
Massena (St. Lawrence River)
Cornwall (St. Lawrence River)

The Remedial Action Plan process defines local environmental problems, indicates specific measures necessary to control pollution sources and restore water quality, and identifies jurisdictions and agencies responsible for implementing remedial programs.

3) Fish Stocking. The numbers of fish stocked by Ontario and New York have increased from approximately 300,000 fish in 1968 to almost eight million fish in 1989. Currently, stocking efforts involve the release of six fish species that provide the basis for the recreational fishery.

4) Harvest Control. Regulations are in place to control fish harvest. These regulations include:

    a) daily catch and possession limits,

    b) commercial quotas,

    c) open and closed seasons,

    d) fish sanctuaries, and

    e) size limits.

The major obstacle to restoring and maintaining indigenous, self-sustaining fish populations is the reduced abundance of many indigenous species such as yellow perch and lake herring. The future of such populations depends upon the protection and maintenance of adequate habitats and spawning stocks. Also, a joint strategic FMP and Fish Community Objectives are needed for the Niagara and St. Lawrence Rivers.

Objective 2

Encourage the Restoration of Extirpated or Depressed Indigenous Fish Species

With efforts focused on lake trout and Atlantic salmon, the restoration of extirpated fish species in Lake Ontario has received a high priority in both Ontario and New York. The development of the lake trout rehabilitation plan (Schneider et al. 1983) by the OMNR, NYDEC, and USFWS was the first joint Fishery Management Plan for Lake Ontario. This plan went into effect in 1982 and is being revised in 1991. Ontario and New York are also developing rehabilitation plans for Atlantic salmon in Lake Ontario.

The goal of the Atlantic salmon rehabilitation program is to rehabilitate populations to partial self-sustainability in a number of Lake Ontario tributaries. The potential for Atlantic salmon rehabilitation is limited by the presence of dams and habitat alterations in many spawning streams historically used by Atlantic salmon. Within the relatively few streams with suitable spawning habitat and still accessible to anadromous fish, naturally reproduced juveniles of other species (primarily rainbow trout) severely limit recruitment of Atlantic salmon because of interspecific competition. Limited stocking programs (64,000 smolts in New York and 75,000 in Ontario during 1989) were aimed at creating a presence of Atlantic salmon in Lake Ontario and stimulating natural reproduction. The Atlantic salmon program is evaluated by angler surveys on New York and Ontario shores. Only 1,248 and 503 fish were harvested during 1989 in New York and Ontario waters, respectively. No effort was made in 1989 to evaluate spawning runs of Atlantic salmon from Lake Ontario.

The goal of the lake trout rehabilitation program in Lake Ontario is to rehabilitate the lake trout population of Lake Ontario so that adult spawning stock(s) encompasses several year-classes, sustains itself at a relatively stable level by natural reproduction, and produces a useable annual surplus (Schneider et al. 1983). Significant progress is being made toward rehabilitation. The survival of adult (six years of age and older) lake trout was 50% in 1989 and is approaching the plan objective of 60%. Improving survival has resulted in increased numbers of spawning adults. Naturally reproduced fry were first observed in 1983 and are now routinely collected from several spawning reefs. Recovery of naturally reproduced yearlings provided the first indication of natural recruitment in 1989 (Ontario Ministry of Natural Resources 1990).

By limiting commercial and angler harvest and mortality caused by sea lamprey predation, a sizeable adult population of stocked lake trout is being developed. During 1989, over two million lake trout reared in OMNR and USFWS hatcheries were stocked into Lake Ontario. The stocked fish comprised five genetic strains and all were marked to facilitate future recognition of naturally reproduced lake trout (those without marks are likely wild).

The improved survival of lake trout is the result of a lower harvest by the sport fishery, reduced incidental catch in the commercial fishery, and lower sea lamprey-induced mortality. With 42,000 and 4,000 fish recorded from the New York and Ontario waters of Lake Ontario, respectively, the 1989 recreational harvest of lake trout was lower than the target of 60,000 fish. New York implemented a size limit in 1987 to control harvest. Indices of lake trout mortality caused by sea lamprey predation have declined by approximately 75% since the late 1970s (New York Department of Environmental Conservation 1990). This decline is because of an intensive sea lamprey control program administered by the GLFC. The program has been expanded into the Oneida Lake system, a previously untreated area of sea lamprey recruitment.

Lake trout are being intensively studied by NYDEC, OMNR, USFWS, and Cornell University biologists (New York Department of Environmental Conservation 1990). A total of 757 lake trout eggs were collected in the fall of 1989 (which was the best year). Egg survival on spawning shoals has not been found to differ from a control situation. Although Ontario researchers identified two naturally produced yearlings in 1989, recruitment to adult stocks by natural reproduction is insignificant. Success in the lake trout and Atlantic salmon rehabilitation efforts will depend upon stocking adequate numbers of hatchery-reared fish, controlling harvest, suppressing sea lamprey, and monitoring populations. Restoration of stream spawning and nursery habitat and improving passage around dams are especially critical for Atlantic salmon.

Formal programs have not been initiated to rehabilitate other extirpated or depressed indigenous fish, including deepwater ciscoes, lake sturgeon, burbot, and deepwater sculpin. Efforts are required to examine the need for these species in the fish community and to evaluate potential options for their rehabilitation.

Objective 3

Maintain a Diverse Complex of Salmonine and Coregonine Fish Species that Produce an Average Annual Yield of 2.5 kg/ha

a) This complex shall include a lake trout population consisting of OS-1.0 million adult fish. Adult females should average 7.5 years of age and produce an annual recruitment of 100,000 yearlings.

b) Populations of Atlantic salmon, rainbow trout, brown trout, coho salmon, chinook salmon, lake whitefish, and lake herring shall be managed as part of the cold-water species complex.

The salmonine/coregonine yield objective of 2.5 kg/ha was formulated on the most recent information available. This information includes reports of commercial landings and estimates of recreational harvest derived from creel census. Salmonine yields are maintained through stocking programs conducted by Ontario and New York. In 1989, these jurisdictions released into Lake Ontario a total of 7,770,746 trout and salmon comprised of six species (Table 2). Salmonine harvests for 1985-89 are summarized in Table 3. An estimated 461,104 trout and salmon were harvested from Lake Ontario in 1989. With the possible exception of lake trout, the contribution of the six salmonines to the total harvest is roughly proportional to the numbers stocked.

Table 2. Numbers of salmonines stocked into Lake Ontario in 1989 (Ontario Ministry of Natural Resources).

Species	Age size	Ontario	New York	Lakewide (% of total)
Lake trout	Fingerlings	0	232,000	232,000
	Yearlings	1,124,039	778,300	1,902,339
	Subtotal	1,124,039	1,010,300	2,134,339
				(27.5%)
Atlantic salmon	Fingerlings	15,000	14,700	29,700
	Yearlings	60,782	49,500	110,282
	Subtotal	75,782	64,200	139,982
				(1.8%)
Rainbow trout/ steelhead	Fingerlings	0	100,000	100,000
	Yearlings	118,493	478,200	596,693
	Subtotal	118,493	578,200	696,693
				(9.0%)
Brown trout	Fingerlings	0	38,000	38,000
	Yearlings	360,092	407,300	767,392
	Subtotal	360,092	445,300	805,392
				(10.4%)
Chinook salmon	Fingerlings	541,187	2,752,000	3,293,187
				(42.4%)
Coho salmon	Fingerlings	87,024	213,400	300,424
	Yearlings	203,629	197,100	400,729
	Subtotal	290,653	410,500	701,153
				(9.0%)
	Fingerlings	643,211	3,350,100	3,993,311
	Yearlings	1,867,035	1,910,400	3,777,435
	Total	2,510,246	5,260,500	7,770,746
				(100.1%)

Table 3. Estimated numbers of salmonines harvested from Lake Ontario in 1985-89 (New York data from Schneider et al. 1990a).

SPECIES	JURISDICTION	1985	1986	1987	1988	1989
Chinook salmon	Ontario	*34,949*[1]	56,131[1]	48,341[2]	*30,385*[1]	*96,370*[3]
	New York	*47,388*	66,171	152,808	81,737	134,896
	Subtotal	*82,331*	*122,302*	151,149	112,122	231,266
Coho salmon	Ontario	6,881[1]	11,169[1]	4,978[2]	*6,516*[1]	15,567[3]
	New York	14,981	16,465	14,927	*21,993*	*20,555*
	Subtotal	*21,868*	*21,634*	19,905	*28,569*	*36,122*
Lake trout	Ontario	2,221[1]	1,719[1]	15,077[2]	1,421[1]	*3,854*[3]
	New York	83,145	85,064	*88,142*	36,037	42,118
	Subtotal	85,372	*86.783*	103,819	37,458	45,972
Rainbow trout	Ontario	11,047[1]	15,339[1]	14,028[2]	19,197[1]	54,133[3]
	New York	*24,262*	19,081	19,958	41,814	41,981
	Subtotal	35,309	34,420	33,986	61,011	*96,114*
Brown trout	Ontario	2,144[1]	989[1]	1,067[2]	1,856	2,145[3]
	New York	57,219	77,753	*58,676*	42,064	47,729
	Subtotal	59,363	78.742	*59,743*	43,920	49,874
Atlantic salmon	Ontario	85[1]	134[1]	152[2]	139[1]	508[3]
	New York	*605*	*856*	*803*	1,242	1,248
	Subtotal	*690*	*990*	*955*	1,381	1,756
Summary	Ontario	57,339	85,481	83,643	59,574	172,577
	New York	227,600	265,390	285,914	224,887	288,527
	Total	284,939	350,871	369,557	284,461	461,104

[1] Values for western portion of Ontario waters.
[2] Lakewide estimate (Ontario waters).
[3] Ontario data for western and central basins from Stewart et al. 1990.

Since 1984, the yield of salmonines has been estimated at 3.0-3.5 kg/ha. This yield is above yields predicted from empirical models using historical data. The difference in current versus predicted yields may be attributed to differences in the modern and historic fish communities. It is not known if recent yields can be sustained over the long term, particularly because of reductions in nutrient loading to the lake and of concerns about stability of forage fish. Progress towards achieving the salmonine/coregonine objectives are discussed for each species as follows:

Lake Trout. Lake trout stocking is utilized primarily to develop a large stock of adult fish and to eventually produce a naturally reproducing population. Since 1985, annual lake trout plantings have averaged over two million fish.

The estimated number of adult lake trout in Lake Ontario is approximately 0.5 million adult fish. The average age of adult females is 6.3 years. A small number of wild yearlings are being recruited.

Stocking is also undertaken to provide limited amounts of fish for the recreational fishery, and a variety of regulations are employed to control harvest. The estimated lakewide harvest of lake trout in 1989 was 45,972 fish. This figure is undoubtedly an underestimate since values for the Kingston Basin (which supports the largest lake trout fishery in Canadian waters) are not included.

Increasing average age of spawning females and egg production (Figs. 4a, b), lowered sea lamprey-induced mortality (Figs. 5a, b, c), improved survival (Fig. 6), and stockings approaching target levels indicate that the rehabilitation effort is on schedule (Ontario Ministry of Natural Resources 1990). Therefore, the prospects are good that all lake trout objectives will be met by the year 2000.

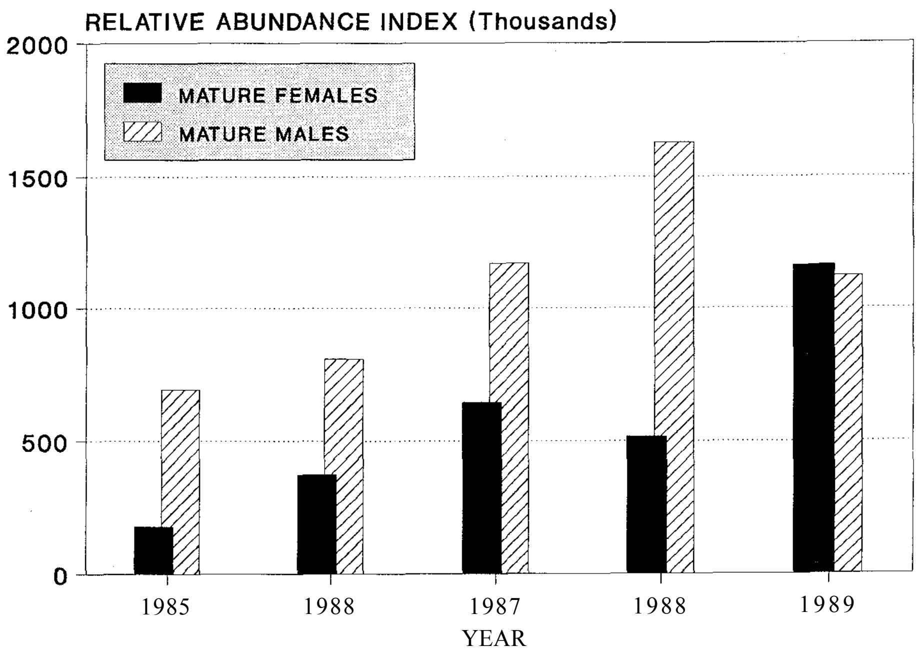

Fig 4a. Relative abundance of mature lake trout in the Canadian waters of Lake Ontario.

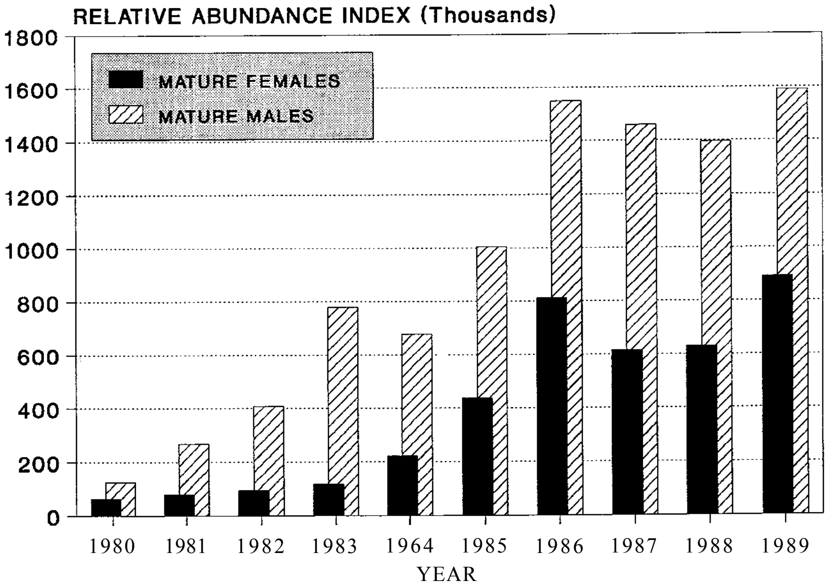

Fig. 4b. Relative abundance of mature lake trout in the United States waters of Lake Ontario.

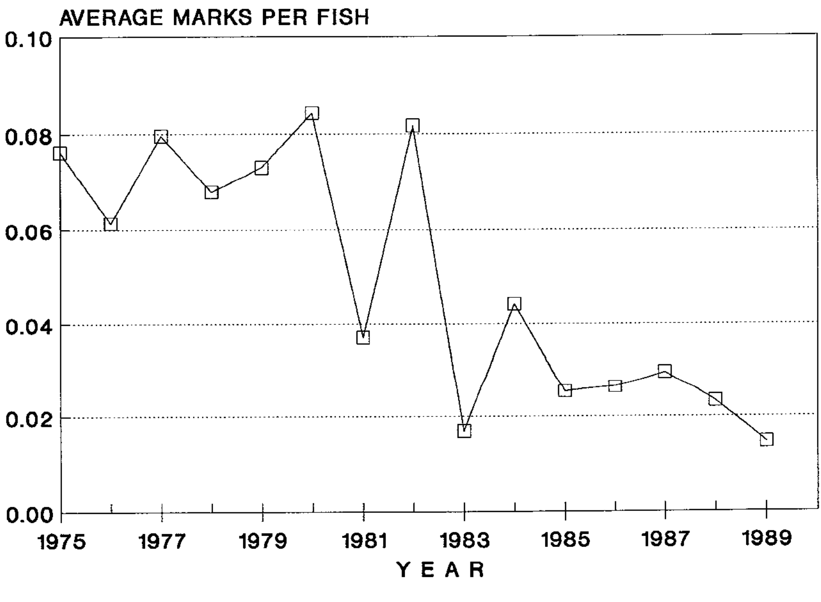

Fig. 5a. Sea lamprey marking rates (A1 wounds only) on lake trout sampled from Lake Ontario, 1975-89.

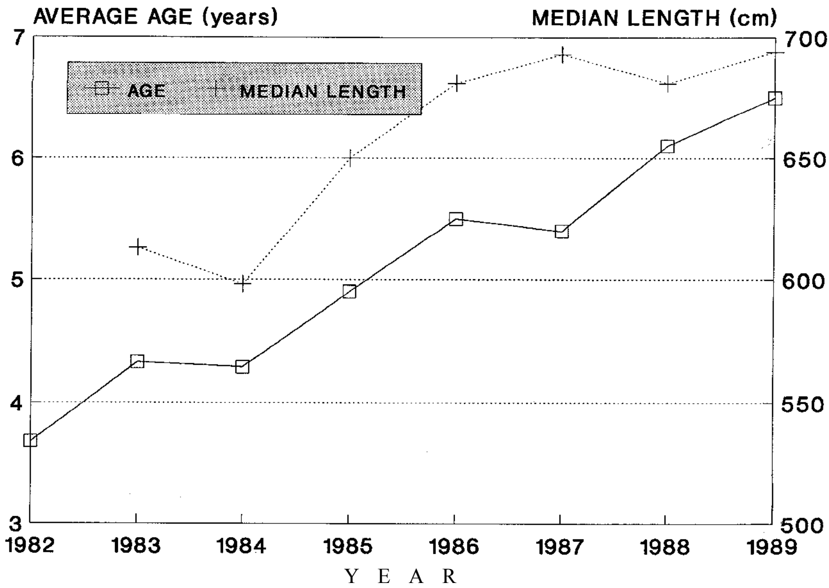

Fig. 5b. Average age and median length of lake trout carcasses recovered from the bottom of Lake Ontario during carcass surveys, 1982-89.

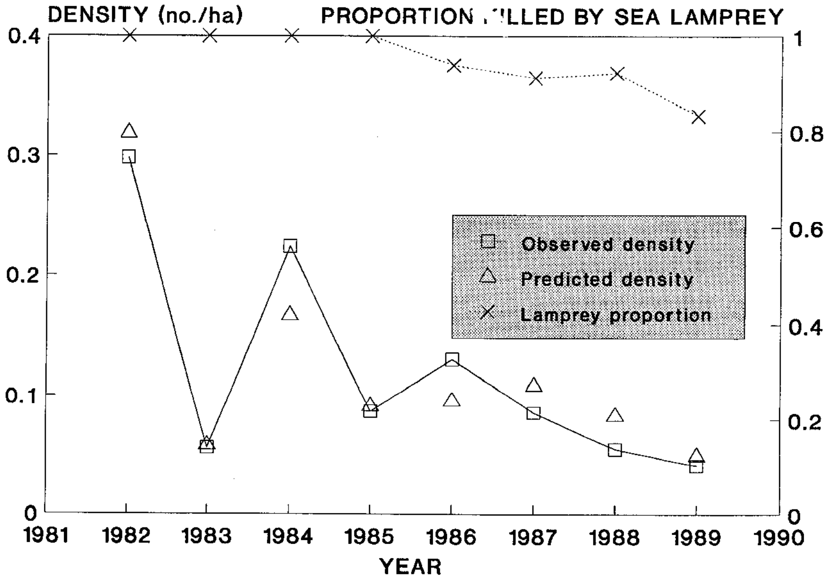

Fig. 5c. Carcass densities and proportion killed by sea lamprey in the 30-99 m depth strata of Lake Ontario. Predicted densities were calculated from the relationship between observed carcass density and Al marking rates. Density = 4.018 (marking rate) -0.0096, r = 0.964**

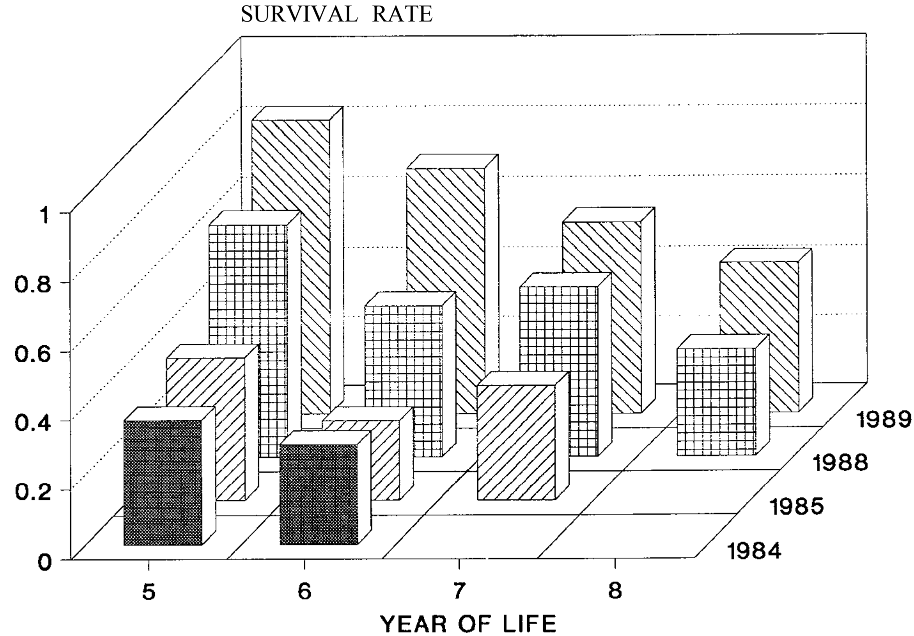

Fig. 6. Annual survival rate of lake trout for the 1984-89 year-classes in Lake Ontario.

Other Salmonines and Coregonines. Other salmonines and coregonines in addition to lake trout are intensively managed. After stocking, Atlantic salmon, rainbow trout, brown trout, coho salmon, and chinook salmon are evaluated in creel surveys and assessment gillnets. Lake whitefish and lake herring populations are monitored by Ontario and New York, but are more intensively studied by Ontario.

Atlantic Salmon (Landlocked). Atlantic salmon stocking rates have been moderate since initial plantings by New York in 1983 and Ontario in 1987. As stated earlier, the lakewide sport catch is less than 2,000 and is not expected to grow. Streams having the best Atlantic salmon habitat are Little Sandy Creek (New York), Wilmot Creek (Ontario), and the Credit River (Ontario). These streams also support other salmonines (such as rainbow trout) which are potential competitors. Future programs will include monitoring spawning runs, rearing fry in upwelling incubation boxes, and making experimental lake plantings.

Rainbow Trout (Steelhead). Rainbow trout are stocked on a put-grow-and-take basis and are providing good fisheries. Almost 700,000 rainbow trout were stocked in Lake Ontario in 1989 and the bulk of these plantings

(600,000 fish) occurred in New York waters. Natural reproduction in many Lake Ontario tributaries supplements stocking. As many as 22% of the rainbow trout caught by boat anglers fishing in Ontario waters result from natural reproduction (Ontario Ministry of Natural Resources 1990).

In 1989, Ontario anglers harvested 54,000 rainbow trout while New York anglers harvested 42,000. In addition to boat angling, rainbow trout also provide popular stream and river fisheries. The most heavily utilized stream and river fisheries are in the Niagara, Salmon, Oswego, Credit, and Ganaraska Rivers and the North Sandy, Irondequoit, Bronte, Duffins and Wilmot Creeks. In the future, New York will experiment with different strains of rainbow trout (such as Skamania steelhead) to provide alternate fishing experiences. Ontario plans to intensify efforts to determine the catch of rainbow trout in shoreline and stream fisheries.

Brown Trout. A total of 805,392 brown trout were stocked in Lake Ontario in 1989 to provide angling opportunities primarily for shoreline and nearshore small-boat anglers. The brown trout put-grow-and-take stocking program is considered successful particularly in New York waters. During the 1989 fishing season, the estimated harvest of brown trout was 2,150 fish in Ontario and 47,700 in New York. The Ontario harvest estimate is based solely on boat anglers and excludes stream and shoreline fishermen. As a result, the Ontario value is undoubtedly an underestimate. Creel programs should be implemented in the future to evaluate the Ontario fishery.

Brown trout are caught mostly during the spring, although recent angling success for chinook salmon during this period may be reducing effort formerly directed at brown trout. In New York waters, brown trout harvests are highest in the eastern and east-central portions of the lake. In Ontario, most brown trout angling activity is concentrated in the North Channel, the Ganaraska River, and near the Pickering Nuclear Generating Station. A record brown trout (weighing 14.1 kg) was angled from the Ontario waters of the western basin in 1989.

Coho Salmon. Coho salmon are planted in Lake Ontario to increase the diversity of angling opportunities for put-grow-and-take fishing. Approximately 700,000 coho salmon, comprised of fingerlings and yearlings, were stocked in 1989. In Ontario waters, coho salmon plantings are confined to the western basin of the lake.

Because of the short duration of the lake fishery, smaller average size of fish, and lack of interest among many anglers, coho salmon comprise only a small segment (5-10%) of the Lake Ontario salmonine fishery. During the 1989 open-water fishery, the estimated coho salmon harvest was 36,100 fish. The world record coho salmon (15.1 kg) was taken from Lake Ontario in 1989.

Chinook Salmon. Chinook salmon are the most heavily stocked fish species in Lake Ontario. In 1989, almost 3.3 million chinook salmon fingerlings were released. The majority of these fish (84%) were planted by New York. Hatchery-reared chinook salmon are planted broadly throughout coastal New York waters but, in Ontario, stocking efforts are concentrated in the western portion of the lake. Recently, small plantings have been initiated in the Wellington area in east-central waters.

In Lake Ontario, chinook salmon are the largest of all stocked fish. Large size (exceeding 18 kg) combined with sporting quality make them the most highly sought species among anglers. More and more fishing effort targeted at chinook salmon has resulted in increased 1985-89 harvests from Lake Ontario (Table 3). In 1989, an estimated 231,300 chinook salmon were harvested from Lake Ontario. Angler preferences for chinook salmon and the increased availability of this species appear to have reduced angling pressure on other species, especially lake trout.

Lake Whitefish. Historically, lake whitefish were the most important species in the commercial fishery. Most of the harvest came from the eastern outlet (Kingston) basin. Whitefish yields peaked in 1924 at 1,263,945 kg (Baldwin et al. 1979). Over 1.2 million kg of this harvest came from the Ontario side of the lake. In 1989, only 56,560 kg of whitefish were harvested by the Ontario commercial fishery from the eastern basin, indicating depressed stocks. Whitefish are not actively sought by recreational anglers on Lake Ontario and are not fished commercially in New York.

Whitefish stocks may be making a modest recovery in Lake Ontario (Bowlby 1990a). However, the large alewife population in Lake Ontario may be limiting the abundance of whitefish. Also, the colonization by zebra mussels may have a detrimental impact on whitefish spawning grounds.

Lake Herring. In association with deepwater ciscoes, lake herring were also a very important component of the commercial fishery until their collapse in the 1940s (Christie 1973). In recent years, the only commercial harvest has been by Canadian fishermen in the eastern portion of the lake. In 1989, this fishery harvested 1,510 kg of lake herring with a landed value of $1,931 (Canadian).

Currently, lake herring stocks seem stable at relatively low levels of abundance (Bowlby 1990b). Lake herring, like whitefish, may be limited by abundant alewife and smelt populations in Lake Ontario. The impact of zebra mussels on lake herring is unknown.

Objective 4

Maintain the Current Complex of Warmwater Fish Species at a Level Producing an Average Annual Yield of 1 kg/ha

This objective was based on a collective review of historic yields from both the commercial and recreational fisheries and is believed to represent a target which can be sustained over the long term. Although lakewide yield estimates are not available, the harvest of warmwater fish stocks has probably not approached the 1 kg/ha figure in recent years.

Evaluation of the Lake Ontario warmwater fish community is inadequate. Present efforts consist of assessment netting in New York waters of the eastern basin, surveys in New York of a limited number of eastern basin anglers, assessment efforts in the Bay of Quinte, and compilation of commercial catch statistics by the OMNR and NYDEC.

In the Bay of Quinte, yellow perch and brown bullhead stocks appear stable, and white perch abundance remains low (Ontario Ministry of Natural Resources 1990). Walleye have increased to an estimated 733,600 fish (age two and older) in the population (Ontario Ministry of Natural Resources 1990). The harvest of walleye in 1989 was 3,900 fish (7,400 kg) by the commercial fishery and 153,460 fish by the sport fishery.

In the New York waters of eastern Lake Ontario, the harvest of 81,400 smallmouth bass in 1989 was nearly double the previous high in 1987 (New York Department of Environmental Conservation 1990). Currently, the yellow perch population is so depressed that sport fishermen are switching their effort to alternate species. The decline in perch is thought to have resulted from intense fishing pressure by both the commercial and recreational fisheries as well as by alewife predation on perch fry. Walleye stocks are reduced but stable and self-sustaining. Sport-fishing groups in New York are presently planting walleye in the bays of central and western Lake Ontario. Commercial fishermen harvested 59,100 yellow perch, and 66,500 brown bullheads in 1989 (New York Department of Environmental Conservation 1990). Anglers were estimated to have harvested 4,700 yellow perch and 81,500 smallmouth bass in 1989.

Objective 5

Maintain Principal Prey Species such as Alewife, Rainbow Smelt, and Slimy Sculpin at an Average Annual Biomass of 110 kg/ha for Production of Piscivorous Fish Species

The biomass of the principal prey species (alewife, smelt, and slimy sculpin) is believed to be considerably higher than the 110 kg/ha required to maintain Lake Ontario fish production. In 1989, alewife abundance was 80% of the all-time high (R. O'Gorman, U.S. Fish and Wildlife Service, Oswego, New York, pers. commun.). Predators appear to have cropped off larger smelt, resulting in a population of abundant smaller (younger) smelt. Although the total smelt biomass is low, the species does not appear to be in danger of further decline. The slimy sculpin population (recently depressed) is increasing, and appears to be at the level observed in the early 1980s. Intensive cropping of the three principal forage species has resulted in population structures where most biomass is in small fish.

Abundance of alewives appears to be greatly influenced by weather. Alewives remain very abundant unless a die-off is caused by a colder-than-average winter (Ontario Ministry of Natural Resources 1990). Smelt, the other principal forage species for salmonines, appear to be buffered from salmonine predation by alewife. Smelt have cyclical trends caused by cannibalism. Alewives were in relatively poor condition in the fall of 1989 and vulnerable to winter mortality. An exceptionally cold December in 1989 set the stage for a major die-off in 1989-90, but mild weather in January and February 1990 brought overall temperatures in line with long-term averages. Crashes of the alewife population have occurred in the past following severe winters, and the potential for catastrophic mortality continues to exist each winter.

Unfortunately, the available sampling method does not produce a reliable estimate of forage fish production (Ontario Ministry of Natural Resources 1990). Production estimates are derived from bottom trawling. However, trawlable bottom is limited mostly to the New York shore and to western waters. Hydroacoustic assessment of forage fish is presently being developed for the eastern end of Lake Ontario. This technique (used in conjunction with midwater trawling) will be used to generate production estimates of alewife and smelt for the entire lake. In the interim, existing information is being used to model predator-prey relationships in Lake Ontario.

Objective 6

Limit the Size of the Sea Lamprey Population to a Level that Will Not Cause Mortality in Excess of 90,000 Lake Trout Annually

Indices of sea lamprey activity (Fig. 5a) in 1988 and 1989 fell to the lowest levels yet observed. The success of sea lamprey control efforts in Lake Ontario is measured by the effects of sea lamprey on the salmonines. Many salmonines caught by anglers and all salmonines captured in assessment programs are examined to determine the number of sea lamprey attack marks on each fish. In addition, an extensive trawling effort is conducted each fall to collect the carcasses of dead lake trout which have dropped to the lake bottom. The number of dead lake trout killed by sea lamprey was extremely low in 1988 and 1989 (0.055/ha and 0.041/ha, respectively). These were the lowest values since the survey began in 1982. This level of sea lamprey control will meet the goal of less than 90,000 lamprey-induced lake trout deaths annually.

Similarly, the number of fresh lamprey marks (Al marks) per fish also dropped in 1989 to the lowest level ever recorded. Carcass size (length) has increased since 1982, indicating that more large lake trout are available as prey. Sea lamprey attack the largest fish available, and are thought to act more as a parasite than a predator on large specimens. Also encouraging, sea lamprey marking rates on lake trout (53.3-63.2 cm long) declined in both Canadian and U.S. waters. These indices were corroborated by substantial improvements in lake trout survival, abundance, and size of spawning stock.

The outlook for maintaining tolerable levels of sea lamprey-induced mortality is quite good. In the past, surges in sea lamprey abundance in Lake Ontario appear to have been caused by recruitment from major producers such as Fish Creek and the Black River. Timely treatments of these and other tributaries should maintain sea lamprey abundance at the existing low levels.

FUTURE MANAGEMENT DIRECTION

Successful management of the Lake Ontario fishery will continue to depend on the cooperative efforts of the OMNR, NYDEC, USFWS, Canadian DFO, and the GLFC. The sea lamprey control program is projected to be maintained at its current level. Cooperative efforts will be expanded to develop techniques and implement lakewide programs designed to provide better information on the Lake Ontario fish community. The status of forage fish will be used to determine the numbers and species mix of salmonine predators that can be sustained on a long-term basis. As part of the fish community assessment program, more attention will be directed at lower trophic levels of the food web. In Ontario, biologists will begin to collate information on fish habitat with the long-term goal of establishing a habitat inventory, assessment, and rehabilitation program.

Fisheries assessment programs will continue to determine fishing pressure and harvest on specific fisheries, monitor the status of major sport-fish species and their prey, and evaluate the lake trout rehabilitation program. Monitoring the harvest of both the commercial and sport fisheries will continue to be carried out by New York and Ontario. This monitoring will involve primarily creel census and angler diary programs for the sport fishery and onboard/dockside catch sampling for the commercial fishery. New York will continue to assess the use of a protected size interval (69-76 cm or 27-30 in.) on lake trout. Ontario will closely monitor the commercial fishery to evaluate the success of recent measures to reduce the incidental catch of sport-fish species in the commercial fishery.

A number of strategic Fishery Management Plans for Lake Ontario should be completed in 1991. New York has already prepared a FMP for Lake Ontario and Ontario anticipates completing a draft strategic Fishery Management Plan in 1991. In addition, the Joint Plan for the Rehabilitation of Lake Trout in Lake Ontario (Schneider et al. 1983) is under review, and a revised plan is nearly completed.

In the past, fisheries enforcement efforts have focused primarily on illegal harvest. New terms of reference are presently being drafted to prioritize enforcement activities on Lake Ontario. In the future, model regulations will be proposed. More enforcement efforts will be directed at professional fishing tournaments, charter boat fisheries, and fish habitat protection. There will also be increased emphasis on a more coordinated enforcement program between Ontario and New York on Lake Ontario. This same emphasis on a more coordinated enforcement program is also sought between Ontario, New York, and Quebec for the St. Lawrence River.

Ontario and New York have recognized the importance of the St. Lawrence River fishery and have formally established St. Lawrence River Fisheries Management Units. The thrust of these cooperative programs will continue to involve river-wide index fishing projects designed to monitor the relative abundance and biological characteristics of resident fish species, creel surveys to evaluate recreational fisheries, and improved assessments to provide more detailed information for management of muskellunge. In the future, more attention will be directed to monitor the downstream movements of Lake Ontario salmonines into the St. Lawrence River, inventory and assess fisheries habitat, and evaluate alternate forms of fish community assessment.

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