LAKE ONTARIO FISHERIES UNIT

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Lake Ontario Fisheries Unit 1992 Program Summary

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Introduction

Since 1984, Lake Ontario Fisheries Unit (LOFU) staff have prepared an annual report summarizing work undertaken by Assessment and Research groups during the fiscal year (12 month period between April 1 and March 31).

On June 26, 1992 the Ontario Ministry of Natural Resources (OMNR) implemented a reorganized structure that changed administrative boundaries, working relationships, and functions. LOFU's original identity was derived from the fact that both Assessment (Glenora and Aurora) and Research groups received technical support (vessels, equipment, field technicians, systems) from an Operations group at Glenora. Little of that structure has changed with reorganization.

Reorganization established the Great Lakes Branch with Management Units for each the lakes. The Assessment and Operations groups are now part of the newly formed Lake Ontario Management Unit, which also includes Management and Compliance groups. The Lake Manager, Management biologists, and Compliance Supervisor have their office in Napanee. The Assessment office, formerly in Aurora, has moved to Maple along with the addition of a special project technician. The St. Lawrence River Management Unit, located in Brockville, in now included with the Lake Ontario Management Unit. The Research group continues to be part of Fisheries Policy Branch and both the Lake Ontario Research group and the Great Lakes Salmonid Research group are at Glenora.

Although, reporting relationships have changed, LOFU remains a diverse group of people, programs, support structures, and services that collectively have a common interest in providing high quality fisheries information to facilitate effective management of Lake Ontario's (including the St. Lawrence River) fisheries resources.

The annual report is intended to inform Lake Ontario fisheries managers and scientists of LOFU activities in a timely manner, and to promote cooperation and interaction among these groups. Sections in the annual report are written to highlight information of interest to Lake Ontario fisheries managers; they are not intended to be substitutes for refereed, journal publications. Some projects do not produce immediate results, and it is not possible to report on all our work. St. Lawrence River Management Unit activities are briefly summarized, but project results are reported under a separate cover.

The following provides an overview of LOFU activities in the last year and "ties up loose ends" by summarizing tasks and information not presented elsewhere in the report, including:

1. A summary of Assessment (including the St. Lawrence River Management Unit) and Research projects, project leaders, and other ongoing activities;
2. A summary of LOFU staff publications during 1992;
3. A report on 1992 commercial fish harvest in eastern Lake Ontario; and
4. A list of LOFU staff.

Summary of Assessment Activities During 1992/93

Seven programs involving 23 projects or special studies were conducted during 1992/93. A list of project names and associated project leaders is included in Appendix 1. All programs and special studies are summarized below, and where applicable, reference is made to sections in the 1992 Annual Report.

Fish Community indexing

The highest priority for LOFU Assessment is to develop and maintain indices of fish population abundance to detect long-term fish community changes. The newly designed eastern Lake Ontario fish community index program was implemented in 1992. This program represents the amalgamation of Assessment and former Research gillnetting and trawling projects in Lake Ontario and the Bay of Quinte. Results of this program were used to update the population status of yellow perch (Section 8), lake whitefish (Section 14) and walleye (Section 15). Smelt bottom trawling, in the western basin of Lake Ontario was again completed in cooperation with the U.S. Fish and Wildlife Service (USFWS), but the results were not reported.

We continued to work towards the development of a lakewide pelagic community indexing program in cooperation with the New York State Department of Environmental Conservation (NYSDEC). This year we completed a lakewide hydroacoustic and trawling survey in each of three seasons; spring, summer and fall (Section 16). Analyses of these data continue as we work to make whole-lake pelagic fish community indexing a routine part of our work. We also hosted a workshop, led by Andrew Goyke of the University of Maryland, to develop standard analytical protocols for hydroacoustic surveys. Progress was made on developing a meaningful geographic stratification of Lake Ontario for the purpose of sampling fish communities and understanding lakewide fish community dynamics, but the results were not reported.

Angler surveys (Section 9), lake trout index gillnetting program (Section 6), and salmonid spawning run monitoring programs (Section 13) remain our principal means of indexing salmonine communities in Lake Ontario.

Lake Trout Rehabilitation

Lake trout assessment continued to be guided by the "Joint Plan for the Rehabilitation of Lake Trout in Lake Ontario". An updated version of the plan, prepared by OMNR, NYSDEC and the USFWS, is currently under review. These agencies participate in a cooperative annual sampling program, collecting data on abundance, survival, and population structure of lake trout and determining sea lamprey impacts (Section 6). This sampling program converted from multifilament to monofilament nets gillnets in 1990. Experiments to compare the two gear types were completed but were not reported.

Lake trout sport harvests were monitored during angler surveys in the western, central (Section 9) and outlet basins of Lake Ontario (Section 7).

With support from LOFU, OMNR Aviation Services built a retractable, six element Yagi antennae for use with Twin Otter aircraft. The antennae is a valuable tool that will soon be available to fisheries investigators interested in conducting radio biotelemetry studies in the 150 mHz range. Future plans include the use of this technology to study lake trout spawning behaviour in eastern Lake Ontario.

Salmonid Assessment

Lake Ontario fish stocking statistics for 1992 were compiled and reported (Section 11). The salmonid angling surveys were continued in 1992 (Section 9), including a survey of the outlet basin fishery (Section 7). We also report angler activity patterns (Section 5) and charter boat fishing effort trends (Section 10). A spring lakewide shore fishery survey was also completed in 1992 but was not reported. We continued to monitor biological attributes of coho, chinook, and rainbow trout returning to spawn in the Credit and Ganaraska Rivers, including trends in body condition (Section 13). Support was provided for University of Guelph graduate student, Janice Clarkson, under the supervision of Dr. Mike Jones, to examine growth of rainbow trout in the Ganaraska River. Calcified tissue samples collected during angling surveys and monitoring programs will be used to develop techniques to distinguish between native and hatchery fish (see Research summary below).

Lake Whitefish Assessment

The status of lake whitefish populations in eastern Lake Ontario was updated using information from a variety of projects (Section 14). Other studies of lake whitefish were completed as part of the zebra mussel monitoring program (see below). A mark-recapture population assessment program for whitefish was completed in 1992 but was not analyzed. Our ability to manage lake whitefish will be greatly enhanced with the completion of studies to discriminate Lake Ontario and Bay of Quinte stocks (see Research summary below).

Walleye Assessment

Walleye commercial harvest in Lake Ontario (Section 12) and angling catch and harvest in the Bay of Quinte (Section 2) were summarized. A mark-recapture program to estimate the size of the eastern Lake Ontario and Bay of Quinte walleye population was completed in 1992 and provided an updated forecast of walleye population status under varying harvest scenarios (Section 15). A synthesis of past walleye harvest and index netting programs was initiated but was not reported.

Zebra Mussel Monitoring

The zebra mussel invasion monitoring program was discontinued in 1992. Growth and feeding studies of larval lake whitefish, and monitoring of zebra mussel colonization of lake whitefish spawning shoals in both the Bay of Quinte and Lake Ontario was continued (Section 4).

St. Lawrence River

Monitoring of the St. Lawrence River is a joint effort between OMNR and NYSDEC and program results are reported under a separate cover.[1] OMNR conducted warmwater fish community indexing programs in the Middle Corridor and Lake St. Francis sections of the St. Lawrence River in 1992. This complemented similar programs completed by NYSDEC for Lake St. Lawrence and Thousand Island areas. Muskellunge nursery and spawning habitat assessments were continued in 1992 as was further investigations of the Brandy Brook walleye spawning populations. Support was provided to Mr. Frank Phelan (Queens University Biological Station), Dr. David Philip, and Mark Kubacki (Illinois Natural History Survey) for a study of effects of pre-season catch and release angling on the reproductive success of largemouth and smallmouth bass. Zebra mussel colonization was monitored by placement of artificial substrates, examination of navigation buoys, and diving surveys. Support was provided to Cornwall Area Office to maintain the operation of the eel ladder and counter at the Moses-Saunders dam.

Other Work Involving LOFU Staff

Periodically, the results from LOFU programs are published in scientific journals. A list of recent publications is presented in Appendix 2.

On occasion, LOFU staff are called upon to serve on committees or conduct work outside our normal programs such as

1. The 1992 Annual Report of the St. Lawrence River Sub-Committee to the Lake Ontario Committee and the Great Lakes Fishery Commission. Ontario Ministry of Natural Resources.

fish stocking, collection of fish for contaminant analysis, attending workshops, technical exchanges, or presenting conference papers. Some prominent initiatives in 1992 included: 1) poster and paper presentations at three major scientific conferences: International Zebra Mussel Conference, International Association of Great Lakes Research Conference, and the Midwest Fish and Wildlife Conference, (2) assisted with the development and testing of FISHNET-II, a corporate data base management and analysis software, (3) participation in a review of aquaculture regulations, (4) development of provincial standards for assessing hatchery fin clipping quality, and (5) involvement in a review of the status of the Lake Ontario offshore pelagic ecosystem (Anonymous 1993)[2] and associated public meetings.

A list of 1992 LOFU staff, and colleagues working at the Glenora station, is presented in Appendix 3.

Commercial Fishing Landings in Lake Ontario

Commercial fish harvest statistics are included in this report for reference. During the 1992 calendar year, commercial fishermen reported harvesting a total of 1,113,877 lbs of fish with a landed value of $1,039,891.35. A more detailed summary is provided in Appendix 4.

Summary of Research Activities During 1992/93

Research Activities and Projects

During 1992-93, three different types of research activities were associated with the Glenora Fisheries Station. Under the auspices of the Lake Ontario Fisheries Unit and supervised by Dr. John Casselman, the Lake Ontario Research Unit of the Research Section of Fisheries Branch, Policy Division, conducted five projects through the integrated assistance of the Operations group of the Lake Ontario Fisheries Unit, Lake Ontario Management Unit, Great Lakes Branch, Operations Division. The Great Lakes Salmonid Research Unit of the Research Section of Fisheries Branch, Policy Division, operating out of the Glenora Fisheries Station and supervised by Dr. Michael Jones, conducted five research projects with the technical assistance of Les Stanfield and Mike Stoneman and with the administrative support of Fisheries Research Section, Maple. John Casselman also conducted three projects on age and growth research, some of which have a provincial scope. This research is conducted out of the Glenora Fisheries Station with its own casual technical support and with some assistance from the Operations group.

Specific details concerning these research projects are not presented in this 1992-93 Annual Report of the Lake Ontario Fisheries Unit. This introductory summary provides only a very general review and the salient points of the projects. Specifics on these projects can be found in the Annual Report of Fisheries Research Activities, 1991 to 1992, Research Section, Fisheries Policy Branch. Not all projects are reported because in some cases projects have just been initiated and adequate analyses have not yet been performed and a final manuscript or report is not yet available. More detailed preliminary reports are also not available at this time because of reorganization, staff changes and retirement, and commitments associated with producing publications for symposia.

Lake Ontario Fisheries Research Unit

During the 1992-93 field season, the long-term fish-sampling program that had been conducted and maintained for the past three decades by Research, and provided indices of relative abundance for the fish communities of Lake Ontario and the Bay of Quinte was conducted by Assessment. The continuity of this series is generally maintained, and Research is currently examining correlations and conversions so that data from the former series can be quantitatively compared with the catch and biological statistics obtained through the Assessment program. Specifics concerning this change in program are detailed in the 1991-92 annual report of the Lake Ontario Fisheries Unit.

Although Research continues to have interest in the indexing program and is conducting analyses on the long-term series, future research studies are planned which are shorter term, more specific, and focused on specific problems and processes. The OMNR Research review which was conducted during the late-1980s, provided direction for future research.

The OMNR RESEARCH PRIORITIES FOR LAKE ONTARIO FOR THE 1990s are listed below in order of decreasing priority, with a numerical rank weighting the relative importance (%) indicated in parentheses.

1. Determine what factors are limiting lake trout rehabilitation (14.4).
2. Quantify the factors affecting year-class strength (12.4).
3. Determine the migrations and movements of predators and prey (10.6).
4. Research sampling problems and determine the ability to detect change using relative catch statistics for conventional gear (10.4).
5. Quantify interspecific and intraspecific interaction and predict community dynamics for important predator and prey species (10.1).
6. Develop quantitative techniques for measuring fish biomass (10.0).
7. Study and refine the estimation of growth, production, and yield (9.1).

2. Anonymous. 1993. Status of the Lake Ontario offshore pelagic fish community and related ecosystem in 1992. Report from meeting of a task for technical evaluation to the Lake Ontario Committee of the Great Lakes Fishery Commission.

8. Study food, feeding, nutrition, and bioenergetics (6.6).

9. Determine the effects of environmental stress and climate change on distribution, growth, and production (4.1).

10. Refine and improve age, growth, mortality, and "stock origin" determination techniques (2.7).

11. Identify and discriminate among "stocks" of fish (2.0).

An important research project conducted by this unit involves a study of the long-term dynamics and interactions of the fish communities of the Outlet Basin of Lake Ontario and the Bay of Quinte. Analyses of species interactions are underway. The primary and direct effects of lake trout on smelt and smelt on lake whitefish have been substantiated for the fish community of the Outlet Basin. To extend the series, long-term commercial catch statistics have been correlated with the long-term Research series to provide an index of relative abundance that, for the commercial species, often commences in the 1900s. A joint analysis of the relative abundance of species common and moving between fish communities of the Outlet Basin and the Bay of Quinte is now underway. How the size of the white perch and walleye populations affect the migrations of alewife is being examined. The magnitude of the analysis is indicated by catch statistics over the 7-year period from 1984-91, which averaged 240,000 fish annually, 13.5% in gill nets and 86.5% in trawls. A general index of relative numerical abundance expressed as percent frequency of occurrence (+/- 95% confidence limits) follows for yearlings and older in the combined fish community of the Outlet Basin and the Bay of Quinte: alewife--38.1 (12.8), yellow perch--19.4 (10.6), rainbow smelt--11.7 (12.6), white perch--9.6 (9.0), gizzard shad--5.0 (7.0), trout-perch--3.1 (2.6), lake trout--2.0 (4.0), walleye--2.0 (1.2), spottail shiner--1.4 (2.4), white sucker--1.3 (1.3), bullhead--1.1 (1.1). Numerically, these 11 species account for more than 95% of the catch.

The sampling phase of another research project involving a comparison of monofilament and multifilament gill nets was completed in 1992. This rather technical project compares the hanging ratio and twine types of the standard multifilament gill net traditionally used in Lake Ontario with the new monofilament multimesh gang gill net that has now become the standard for Lake Ontario indexing and research programs. Extensive comparative fishing was conducted in 1991 and 1992. In 1992 a paired design was used to partition the effects of hanging ratio and twine type. Nets of each twine type and hanging ratio were fished repeatedly for three mesh sizes (38, 76, and 102 mm stretched mesh). The proximity of twine type influenced catchability in transparent water, so some additional netting will need to be conducted in early summer 1993 in the Outlet Basin. This will complete all sampling requirements for the final analysis. Conversion factors are being developed to compare catches in these two types of gill nets. Preliminary analyses of relative catchability and size difference substantiate results obtained in 1991 (see 1991 Annual Report, Lake Ontario Fisheries Unit, Casselman and Scott 1992; Hurley 1992). Multifactor ANOVAs are being used to examine the combined effects of twine type, mesh size, net placement, and replication. Preliminary analyses associated with the coolwater and warmwater species in the Bay of Quinte are now complete. For most species, difference in catchability appears to be related to twine type and not hanging ratio. The final analyses, including those involving the coldwater community of the Outlet Basin, will be completed in 1993. These will provide conversions for comparing catch by species. As these analyses progress, Research will consult with other groups in Lake Ontario who have comparable data that might be used either to test the conversions or to expand them.

Research on lake trout rehabilitation--the factors affecting early life history--continued in the spring of 1992 and in the fall of 1993. The study continues to examine the deposition, survival, and subsequent development of eggs and fry of hatchery lake trout in Lake Ontario, using *in situ* incubation on Yorkshire Bar and comparative experiments under laboratory conditions, both with controls from Lake Manitou. The study tests the hypothesis that early egg deposition, especially in a degraded spawning habitat, can detrimentally affect hatch and survival. Some hatchery stocks deposit eggs at relatively high temperatures; this causes accelerated development in heavily silted rubble that has not been adequately purged by fall winds, which can cause a high biological oxygen demand and conditions that detrimentally affect survival and development. It follows that in degraded eutrophied environments, deposition of eggs late in the fall at lower water temperatures would be more advantageous. Delayed and reciprocal transfers between Yorkshire Bar and controlled incubation conditions at the Glenora Fisheries Station were successfully completed by helicopter in late fall 1992. Depending upon results in the spring of 1993, the *in situ* incubation phase of this study, may be complete. We expect to be able to determine whether time and temperature of egg deposition and incubation effect premature hatch and subsequent survival. To plan future research, adults were sampled over the spawning season at Salmon Island, an inshore more sheltered spawning site.

As part of this lake trout rehabilitation research, each year we have examined all unmarked (external clips) lake trout that are taken in routine sampling programs conducted by the Lake Ontario Fisheries Unit. In 1992 samples and data were collected on 14 lake trout that appeared to be unclipped or marked. A detailed examination of the fins, scales, and otoliths of these fish for characteristics that have been shown to differentiate indigenous fish from those of hatchery origin (see 1990 Annual Report, Lake Ontario Fisheries Unit, Casselman 1991). Only one fish was classified as indigenous; the particulars concerning this fish and the other 7 indigenous lake trout taken in the past 4 years will be summarized elsewhere.

A new research study was initiated in late May and early June in the Outlet Basin and the Bay of Quinte, which used hydroacoustics and beam and bottom trawling to examine the relative abundance of various species. This study was conducted specifically to examine the spring spawning movement and migration of alewife from eastern Lake Ontario into the Bay of Quinte. This study deals specifically with items 2 and 3 in Research Needs (listed above) and was to initiate a study of the factors affecting the year-class strength of alewife in the spawning and nursery habitat of the Bay of Quinte. Eight stations were sampled from the Main Duck Sill in eastern Lake Ontario to Trenton. Day/night trawling and hydroacoustical surveys were conducted. The hydroacoustical survey was conducted by Drs. David Stanley and Charles Wilson of Louisiana State University. They have completed their analysis and are preparing their final report. The hydroacoustical and bottom-trawling data will then be compared and combined to jointly describe absolute and relative abundance. The spring of 1992 was abnormally cool, so the migration was probably delayed. However, ripe and running alewife were most abundant in the deep water in the eastern basin in the vicinity of the Upper Gap and in the lower reaches of the Bay of Quinte up to Conway. Catches and biological data, such as age and sex, are being studied in relation to depth, diel movement, and temperature. At this time in the migration, alewife densities were greatest at 8 to 11 °C.

Several other minor projects are being conducted. Research involving whitefish stock discrimination is underway. Stock separation is a prerequisite for a detailed analysis of lake whitefish abundance and dynamics in eastern Lake Ontario. Samples of mature whitefish were collected from several spawning locations during 1992. Data are being collected from the scales and otoliths of these fish to test scale methods developed last year (see 1991 Annual Report, Lake Ontario Fisheries Unit, Brown and Casselman 1992), and otolith shape data, age, and year-class strength estimates are being obtained. Analyses are not yet complete. However, three different stocks of whitefish exist in eastern Lake Ontario--one stock spawns in the open lake, another in the Bay of Quinte, and a much smaller stock frequents the west side of Prince Edward County and associated north shore. Another study was funded through the Canada-Ontario Agreement (COA), is examining the effects of changes in water quality on fish populations and ecosystem health. It specifically involves analysis of age, year-class strength, and growth chronology of white perch from the Bay of Quinte determined from 2,800 scale samples collected over the past 32 years. Data were extracted and stored electronically, using CSAGES. Changes in growth over this period are dramatic; growth rate in 1978 was an order of magnitude greater than in 1977. The study was initiated by Dr. Don Hurley; the data are collected and await analysis.

Great Lakes Salmonid Research Unit

The Great Lakes Salmonid Research Unit is studying the re-introduction of Atlantic salmon in Lake Ontario. Wilmot Creek is being specifically used as a study site to evaluate this re-introduction. A two-way weir is maintained to intercept migrating salmon and monitor the movement of other salmonids.

Stream ecology of salmonids is also being studied. The focus for this research is Wilmot Creek. The weir is being used in a mark-recapture program, along with creel surveys, to estimate rainbow trout abundance and harvest, and to investigate the relative success of different rainbow trout life history strategies (e.g. age-at-downstream migration). Quantitative sampling is being conducted at five benchmark stations throughout Wilmot Creek to monitor trends overtime, and in 1992 a more extensive sampling program was mounted to obtain statistically valid "whole-system" biomass estimates.

The Salmonid Unit is also collecting habitat data to evaluate models of habitat suitability for brook, brown, and rainbow trout. This is being done to determine the suitability of existing models such as HSI for evaluating the productive capacity of coldwater stream habitats for salmonids. The data base is extensive; salmonid biomass data exist for 900 site-years throughout southern Ontario. Additional data were collected during 1992 at over 60 sites distributed throughout southern Ontario. The study will result in the development of valid models to predict salmonid stream productivity capacity from various habitat variables for southern Ontario streams.

A research study was also initiated to examine an historical data set of adult rainbow trout migrating up the fishway in the Ganaraska River to determine changes in age and growth in this spawning stock with time. Scales were interpreted and data stored with CSAGES to conduct an objective study that will also apply techniques for discriminating between indigenous and hatchery fish. This technique, which has recently been developed and refined (see below), will help assess and study indigeny.

Dr. Michael Jones, unit leader, is also actively involved in modeling predator-prey interactions in the Great Lakes. This research is extremely timely for Lake Ontario, given the marked decrease in the relative abundance of the prey populations, especially apparent for larger individuals. This research specifically addresses the practical problem of maintaining an adequate balance between the numbers of stocked piscivores and the natural productivity of important prey species such as alewife and smelt. Updates on this research activity are published in a newsletter on the Sustainability of Intensively Managed Populations in Lake Ecosystems (SIMPLE)--a Task Area of the Board of Technical Experts of the Great Lakes Fishery Commission. Dr. Jones co-publishes this newsletter with Dr. Joe Koonce of Case Western Reserve University in Ohio. A computer model was developed for this exercise and has been used in a technical review of the status of the Lake Ontario offshore pelagic ecosystem.

Age-Growth and Environmental Studies Research Program

A research study was conducted by Lucian Marcogliese, a graduate student at Trent University, and John Casselman that developed scale methods that accurately discriminate between indigenous and hatchery rainbow trout. Circulus spacing about the first annulus has previously been shown to separate indigenous and hatchery rainbow trout; however, criteria for locating the first annulus are lacking, making this procedure subjective and imprecise. Therefore, the method was refined to use the first check on the scale regardless of designation. A dichotomous key was developed that locates the first check by classifying scale characteristics into categories, which can also be used to separate indigenous and hatchery rainbow trout. The key provides a classification error rate almost half (7.4%) that of the spacing method. The quantification of thick and thin circuli provided a quantitative method of classifying scales according to origin. Indigenous rainbow trout were abundant in the unclipped samples from Lake Ontario (44% +/- 6%). They composed the majority of the spawning population (65% +/- 10%), while hatchery fish were much more abundant in angled samples (70% +/- 6%).

Another study was initiated and completed by David Brown, seasonal contract research biologist, and John Casselman on the age, year-class strength, and otolith growth of freshwater drum from the Bay of Quinte. During the past 34 years, otolith samples have been removed from drum collected during routine community index netting of eastern Lake Ontario and the Bay of Quinte. An analysis of a subsample of these otoliths, using CSAGES, indicated that since 1946 there have been three strong year-classes--1955, 1983, 1977--comprising approximately 52% of all the drum collected. The 1955 year-class, which made up 67% of the sample prior to 1977, persists in current sampling, and is now over 35 years old. The relative abundance of these year-classes was correlated with the highest mean summer water temperatures, could easily be tracked in sequential sampling, and hence was used to validate age interpretation techniques. Growth was strongly correlated with water temperature, slowest in 1958, and fastest in 1959. Two stocks were differentiated by otolith growth characteristics created by a catastrophic and selective winterkill in the Bay of Quinte in 1977/78. Otoliths of the "bay" stock, which has a significantly lower growth potential, grew significantly more in 1979, showed greater overall annual variability, and were optically different than those of the "lake" stock. For the past 6 to 8 years, there has been a steady decrease in the growth of drum when compared to their thermal growth potential. The opposite was true for young-of-the-year.

Research is also being conducted jointly with Dr. Ed Crossman of the Royal Ontario Museum on esocid cleithra attained in the Cleithrum Project to determine what factors affect longevity, year-class strength, and growth of large esocids across the North American range. Mark Ruthven, through an EYC contract, is assisting. Data have been collected on 3,000 cleithra from trophy muskellunge and northern pike hybrids. The data are ready for preliminary analyses.

Research Personnel, Associations, and Activities

Dr. Donal Hurley retired at the end of 1992 from Fisheries Research at the Glenora Fisheries Station. For the past 25 years, Don has conducted research for the Department of Lands and Forests and the Ontario Ministry of Natural Resources at Glenora. Much of his research specifically involved the fish community of the Bay of Quinte. Two publications, one on white perch and the other on alewife, came out in 1992, both dealing with food and feeding, and trophic interactions. A number of projects that Don was recently involved in are summarized here. His experience and expertise involving the fish community of the Bay of Quinte were well known and extensively sought. Don was active in the development of all phases of the Quinte Remedial Action Plan. His contribution was significant and is widely acknowledged. It was enjoyable working with Don; we will miss him. We hope that Don keeps in contact with the Glenora Fisheries Station. His white perch research study, which has yet to be completed, needs his touch. Don hates winter driving; we now know why he picked the winter of 1992/93 to start staying home.

Dr. Michael Jones, along with Dr. Don Stewart of State University of New York at Syracuse, co-chaired a group that provided a technical evaluation of the status of the Lake Ontario Offshore Pelagic Fish Community and Related Ecosystem in 1992. This report was presented to the Lake Ontario Committee of the Great Lakes Fishery Commission in Kingston in July.

Mike Jones conducted model simulations and analyses to assist the Lake Ontario Management Unit with its review of predator-prey balance and changes in stocking levels and associated predator demand. These simulations, involving various stocking rate-predator demand scenarios, provided practical information that was important in explaining affects and alternatives during the public consultation process. Dr. Jones was also jointly responsible with Dr. Koonce for convening three major workshops (April'92, October '92, January '93) on the present and future state of the hatchery-dependent fisheries of Lakes Ontario and Michigan.

David Brown was hired as a seasonal biologist to work with Research. David is a recent graduate of Trent University and is enrolled as a part-time graduate student in the Watershed Ecosystems Graduate Program at Trent. His thesis research will study the effects of smallmouth bass introductions on native lake trout populations, using data collected by the AGES Unit.

In January 1993, the International Symposium on Fish Otolith Research and Applications was held in South Carolina. John Casselman was an invited member of the International Steering Committee, which had representatives from 6 countries. He was an invited convenor of a session on Growth and Morphology, was asked to participate on the Terminology Committee, and was invited, along with the other convenors, to provide an overview at the end of the symposium. Over 300 attended the symposium from 28 different countries, and there were 176 presentations. The proceedings will be published in book form. John's travel and attendance were paid for by the symposium. Yosef Tekle-Giorgis, David Brown, and Joe Dibbits travelled and attended with him. They presented three posters and two oral presentations: David's drum study (outlined earlier), Yosef's tropical otolith research (described later), and John presented a paper, "Quantitative electron microprobe X-ray analyses of the chemical composition of seasonal growth zones in calcified tissue of fish."

Ken Scott has greatly improved and refined the software package that he has helped develop to extract data from age and growth interpretation of fish--Calcified Structure Age and Growth data Extraction system (CSAGES). The software development for the data-collection version (3.21) of this package is complete. There has been restricted release of some copies to those who can test its application. Several units in Ontario routinely use CSAGES. It is widely sought, and one copy is currently used in Australia. Development is continuing on utilities that use these data. A workshop on the system and the software will be presented in August 1993 and, at that time, the 3.21 version will be formally released.

Yosef Tekle-Giorgis, senior lecturer in the Agricultural Faculty at the Agricultural Campus at Awassa of Addis Ababa University, returned to Canada under the auspices of the University of Waterloo to present some of the research that he conducted for his M.S. degree at the University of Waterloo at the International Otolith Symposium in South Carolina. His Master's research was supervised by Dr. John Casselman. Yosef will spend two months at the Glenora Fisheries Station completing this paper and two others on age determination of tropical fish. He developed a system using otoliths that increases precision and accuracy in age determination in tropical fish by not only assigning age and year-class but also more precisely discriminating between two recruitment cohorts of tilapia--one from March and another from September. The procedures were developed on a tropical fish but can be applied to any species that shows biannual or even multiannual reproduction (temperate-region cyprinids) and otolith growth cycles.

In 1992-93 John Casselman and Don Hurley reviewed and refereed 16 manuscripts for primary journals. Twelve of these pertained to age-growth research. Additional research proposals were reviewed for major granting agencies. One came from the National Science Foundation of the United States and involved relative growth of calcified tissue as a tool in fish systematics and taxonomy. Requested reviews of a number of technical reports were conducted--one concerning a synopsis of research and management prepared by the Esocid Technical Committee of the North Central Division of the American Fisheries Society. One textbook on age determination of aquatic animals was reviewed prior to publication. Several invited seminars were given--one at Louisiana State University in Baton Rouge on chemical composition of calcified tissue and relative growth in fishes.

In 1992 Dr. Steven Campana of the Bedford Institute of Fisheries and Oceans Canada and John Casselman completed a manuscript that will be published in the Canadian Journal of Fisheries and Aquatic Sciences on stock discrimination using otolith shape analysis. The research examines stock discreteness of northern cod in the North Atlantic. A technical report was published by Fisheries and Oceans Canada which describes the practical application of the method. Also in 1992, John Casselman and Dr. John Gunn of OMNR Cooperative Fisheries Unit, Laurentian University, published a paper on "Dynamics in year-class strength, growth and calcified-structure size of native lake trout (*Salvelinus namaycush*) exposed to moderate acidification and whole-lake neutralization." This study examined the changes in growth and relative size of the calcified structure of the lake trout population of Nelson Lake over a 16-year period and relative strength of the year-classes over a 21-year period.

Graduate student and university involvement is an important part of Fisheries Research at Glenora. John Casselman continues in his capacity as a Research Associate of the Royal Ontario Museum and a Conjunct Professor at Trent University, where he presides on two graduate student committees and supervises two graduate students. Lucian Marcogliese's research project involves fish communities in oligotrophic lakes in the Haliburton Highlands. Lucian is currently conducting some of his research and analyses at the Glenora Fisheries Station. David Brown's graduate research was described earlier John is also on Mike Mallette's graduate committee. Mike's Master's program is supervised by Dr. John Gunn at Laurentian University, Sudbury. Mike spent several months at the Glenora Fisheries Station preparing samples and interpreting otoliths as part of his study of the movements of brook trout in the Sutton River to determine whether certain fish migrate and spend part of their life in James Bay.

Mike Jones was recently appointed a Conjunct Professor at Trent University and will be supervising Christine Vander Dussen for her Masters project on habitat suitability models for stream salmonid fishes. As well, he is an associate member of the Faculty of Graduate Studies, University of Guelph, and serves on two graduate advisory committees there.

Research assisted studies of cormorants in eastern Lake Ontario in 1992. John Casselman helped personnel the Canadian Wildlife Service and the U.S. Fish and Wildlife Service in the identification of fish from hard parts in the regurgitates and boluses of cormorants. Data were also supplied that were used to examine cause and effect and changes in the relative abundance of cormorants in eastern Lake Ontario in a paper presented to the Colonial Waterbird Society by Dr. D. V. Weseloh in October 1992. At the same conference, he also presented a poster entitled "Calculated fish consumption by double-Crested cormorants in eastern Lake Ontario". John Casselman was a co-author in this study, which indicated that the double-breasted cormorant population in eastern Lake Ontario has a predatory effect equivalent to approximately ten times their numbers in lake trout. As aquatic predators, they would account for an estimated 4.6% (ranging from 3.7 to 5.7%) of the overall predation on prey fish. Overall, the cormorants at the present time are not considered significant predators of the coldwater or warmwater fish community.

Acknowledgments

Thanks to Linda Balsillie, Linda Blake, and Carol Ward for copy editing, processing and organizing the production of this report. Your extra efforts required to deal with staff shortages is greatly appreciated. Final formatting and publishing was completed by Peace Tree Printing. County Computer Services assisted with word processing. Thanks to all the contributors and reviewers who worked extremely hard this year to make it happen.

APPENDIX 1. Programs conducted by the Lake Ontario Fisheries Unit between April 1, 1992 and April 1, 1993

ASSESSMENT PROGRAMS

Fish Community Indexing

Western basin smelt bottom trawling (USFWS/OMNR)
Project Leader: Paul Savoie

Hydroacoustics and trawling survey (NYSDEC/OMNR)
Project Leader: Ted Schaner

Eastern Lake Ontario fish community index netting
Project Leader: Jim Hoyle

Lake Trout Rehabilitation

Cooperative lake trout gillnetting (NYSDEC/OMNR/USFWS)
Project Leader: Ted Schaner

Salmonid Assessment

Salmonid boat angler survey
Project Leader: Paul Savoie

Outlet basin angler survey
Project Leader: Jim Bowlby

Spring shore angler survey
Project Leader: Paul Savoie

Charter boat survey
Project Leader: Paul Savoie

Credit River coho/chinook monitoring
Project Leader: Jim Bowlby

Ganaraska River rainbow trout monitoring
Project Leader: Jim Bowlby

Lake Whitefish Assessment

Lake whitefish early life history studies
Project Leader: Jim Hoyle

Lake whitefish mark-recapture
Project Leader: Alastair Mathers

Walleye Assessment

Bay of Quinte creel surveys
Project Leader: Alastair Mathers

Walleye mark-recapture
Project Leader: Alastair Mathers

Commercial Fishery Monitoring

Walleye commercial harvest sampling
Project Leader: Alastair Mathers

Whitefish commercial harvest sampling
Project Leader: Jim Hoyle

St. Lawrence River Projects

St. Lawrence River fish community indexing
Project Leader: Anne Hendrick

St. Lawrence River zebra mussel monitoring
Project Leader: Anne Hendrick

St. Lawrence River muskellunge nursery and spawning habitat assessment
Project Leader: Anne Hendrick

Cornwall eel ladder monitoring
Project Leader: Anne Hendrick

Special Projects

Yellow perch population dynamics
Project Leader: Jim Hoyle

Walleye catch-at-age analysis
Project Leader: Mike Rawson

Lake Ontario stratification
Project Leader: Tom Stewart

RESEARCH PROGRAMS

Fish community dynamics of the outlet basin of Lake Ontario
Project Leader: Dr. John Casselman

Fish community studies of the Bay of Quinte
Project leader: Dr. Donal Hurley

Age, year-class strength and 45-year growth chronology of freshwater drum of the Bay of Quinte and Lake Ontario
Project Leader: David Brown

Lake trout rehabilitation studies
Project Leader: Dr. John Casselman

Comparison of monofilament and multifilament gillnets-conversions for long-term data sets
Project Leader: Dr. John Casselman

Lake whitefish stock discrimination studies
Project Leader: Dr. John Casselman

Discrimination between hatchery and native rainbow trout
Project Leader: Dr. John Casselman

Development of a calcified structure age and growth data extraction system (CSAGES)
Project Leader: Dr. John Casselman

Modeling predator-prey interactions among Lake Ontario offshore pelagic fish species
Project Leader: Dr. Michael L. Jones

Evaluating constraints to the restoration of Atlantic salmon populations in Lake Ontario
Project Leader: Dr. Michael Jones

Development and testing of reliable methods for the determination of stream salmonid biomass and abundance
Project Leader: Dr. Michael L. Jones

Investigations of life history variations in naturalized steelhead populations in the Great Lakes
Project Leader: Dr. Michael L. Jones

APPENDIX 2. Research papers published by LOFU staff during 1992.

CASSELMAN, J.M. AND J.M. GUNN. 1992. Dynamics in year-class strength, growth, and calcified-structure size of native lake trout (*Salvelinus namaycush*) exposed to moderate acidification and whole-lake neutralization. Can. J. Fish. Aquat. Sci. 49:102-113.

JONES, M.L., J. F. KOONCE AND R. O'GORMAN. 1993. Sustainability of hatchery-dependent salmonine fisheries in Lake Ontario: the conflict between predator demand and prey supply. Accepted for publication in Trans. Amer. Fish. Soc.

HURLEY, D.A. 1992. Feeding and trophic interactions of white perch (*Morone americana*) in the Bay of Quinte, Lake Ontario. Can. J. Fish. Aquat. Sci. 49:2249-2259.

STRUSS, R.H. AND D.A. HURLEY. 1992. Interactions between alewife (*Alosa pseudoharengus*) their food, and phytoplankton biomass in the Bay of Quinte, Lake Ontario. J. Great Lakes Res.

APPENDIX 3. LOFU staff in 1992.

Operations Staff at Glenora

David Jeffrey, Operations Supervisor
John Kinney, Administrative Clerk
Carol Ward, Secretary/Administrative Support/Library
Linda Balsillie, Secretary/Reception/Administrative Support
Linda Blake, Secretary/Reception/Administrative Support
Ken Scott, Computer Systems and Database Manager
Kelly Sarley, Data Technician
Dawn Walsh, Senior Technician-Field Operations
Chuck Wood, Senior Technician-Marine Service
Wayne Miller, Senior Technician-Base Operations
Jeff Church, Age Interpretation Technician
Dale Dewey, Resource Technician III
Steve Lawrence, Resource Technician III
Tim Shannon, Resource Technician III
Joe Dibbits, Technician
Steve Welham, Technician
Terry Cronin, Technician
Randy Gumsey, Technician
Ambrose McCambridge, Technician
Tom Lawrence, Technician
Alan McIntosh, Boat Captain
Elaine Sheriff, Technician
Lisa McWilliams, Technician
Sean Corrigan, Technician
Matthew Brailley, Technician
John Cooke, Technician
Shane Lockwood, Technician
Vaughan Jamieson, Technician, Commercial Fish, Fish Culture

Research Staff at Glenora

Dr. John Casselman, Senior Research Scientist
Dr. Donal Hurley, Research Scientist
David Brown, Research Project Biologist
Dr. Michael Jones, Research Scientist (Salmonid Unit)
Les Stanfield, Senior Research Technician (Salmonid Unit)
Mike Stoneman, Research Technician (Salmonid Unit)
Christine Vander Dussen, Research Assistant (Salmonid Unit)

Fisheries Policy Branch Staff at Glenora

Cheryl Lewis, Warmwater Fisheries Specialist

Assessment Staff at Glenora

Tom Stewart, Assessment Supervisor
Jim Hoyle, Assessment Biologist
Alastair Mathers, Assessment Biologist
Ted Schaner, Assessment Biologist
Mike Rawson, Assessment Biologist

Assessment and Operations Staff at Maple

Jim Bowlby, Assessment Biologist
Paul Savoie, Assessment Biologist
Sandra Michaelsen, Assessment Biologist
Rob Dalziel, Special Projects Technician

Assessment and Operations Staff at Brockville (St. Lawrence River Management Unit)

Anne Hendrick, Assessment Biologist
Sean Bond, Technician

APPENDIX 4. Commercial fish harvest in Lake Ontario in 1992. To be consistent with reports in other years these statistics exclude St. Lawrence River and western Lake Ontario landings. Harvest from Lake Ontario embayments (West Lake, East Lake, and Consecon Lake) are included. The St. Lawrence River statistics are reported by Hendrick (1993).[3] There are five commercial fishing licenses in western Lake Ontario which account for only a very small proportion of the total harvest. Prepared by Joanne Kerr, Napanee Area Office.

Species	Harvest (lbs)	Price/lb (dollars)	Value (dollars)
Bowfin	2445	0.08	209.61
Bullhead	216490	0.36	78138.50
Carp	11256	0.40	4527.05
Catfish	9391	0.26	2527.26
Crappie	18381	1.55	28585.20
Drum	19269	0.13	2568.76
Eels	212773	1.85	394717.53
Lake herring	10440	0.48	5026.10
Lake whitefish	305210	0.66	202035.30
Rock bass	14431	0.26	3768.38
Sunfish	40989	0.35	14460.98
Suckers	2990	0.13	410.15
White bass	3146	0.79	2488.40
White perch	29783	0.51	15479.15
Walleye	25393	1.31	33449.85
Yellow perch	191489	1.31	251499.61
Total	1,113,877		$1,039,891.83

3. Hendrick, A. The 1992 commercial food fish industry on the St. Lawrence River. *In*. The 1992 Annual Report of the St. Lawrence River Sub-Committee to the Lake Ontario Committee and the Great Lakes Fishery Commission. Ontario Ministry of Natural Resources.

Bay of Quinte Angling Surveys, 1992

A. Mathers

Ontario Ministry of Natural Resources
Lake Ontario Fisheries Unit
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Lake Ontario Fisheries Unit, 1992 Annual Report, Section 2

The walleye angling fishery in the Bay of Quinte remains large and productive. Combined ice and open-water angling effort (965,850 rod-hours) and walleye harvest (279,381 fish) are both at all time highs. The open-water fishery is still much larger than the ice fishery; representing 60% of the angling effort and 75% of the walleye harvest. However the ice fishery has grown relative to the open-water fishery. Walleye harvest rates (HUE) for both the ice and the open-water fisheries suggest a productive fishery.

Recommendations

1. Maintain current index survey design provided the complete open-water and ice fishing surveys can be conducted during 1993.

Introduction

Angling surveys have been conducted on the Bay of Quinte periodically since 1957 (Mathers 1992). Traditionally, walleye make up the bulk of the angling harvest. Fishing pressure on the Bay of Quinte was minimal when walleye populations were very low in the late 1960's and 1970's and no angling surveys were conducted at that time. With the resurgence of walleye since 1978 (Bowlby et al. 1989), a large sport fishery has once again developed on the Bay of Quinte. This report summarizes the results of the 1992 ice and open-water angling surveys on the Bay of Quinte and provides comparative data from previous years.

The Lake Ontario Fisheries Unit has monitored the Bay of Quinte ice fishery biennially from 1982 to 1988 and annually since 1988, and has monitored the open-water fishery annually since 1979. Survey designs are framed around the walleye open-season. Bay of Quinte angling surveys are designed to estimate angling effort, catch, harvest, and to collect biological data on sport fish populations. Sampling, like the fishery itself, focuses on walleye.

During 1992, the walleye season in the Bay of Quinte was closed from March 1 until May 1, inclusive. There was a four fish daily bag limit with no restrictions on the size of fish harvested. Anglers were allowed to fish with two lines during the ice fishery and one line during the open-water fishery.

Methods

The basic design and analysis of 1992 ice and open-water angling surveys on the Bay of Quinte were based on using CREESYS (Lester and Trippel 1985). The angling surveys were stratified by day-type (weekdays and weekend days), and season (open-water survey only, see below). Also, the surveys covered the Bay of Quinte from Trenton to Glenora and included 12 geographic areas (Fig. 1).

Ice Fishery Angling Effort

Angling effort was measured using aerial counts. During each flight, 'on-ice' anglers and fish huts were counted separately for each of the 12 geographic areas. Two flights were scheduled for each week, one weekend day and one weekday. Twenty-four flights were scheduled between December 7, 1991 and February 26, 1992. Very little ice fishing occurred prior to December 27, 1991 because of the poor ice conditions; therefore the four flights scheduled for this time period were canceled. Four other flights were canceled due to inclement weather. All angling was assumed to occur between 0700 and 1700 h.

Ice Fishery Angling Catch and Harvest

As in previous surveys, angler interviews and hut occupancy counts were conducted on areas 32, and 33 (Fig.1). In 1992, area 93 was added in anticipation of a shift in angling effort. The 'on-ice' surveys were conducted twice each

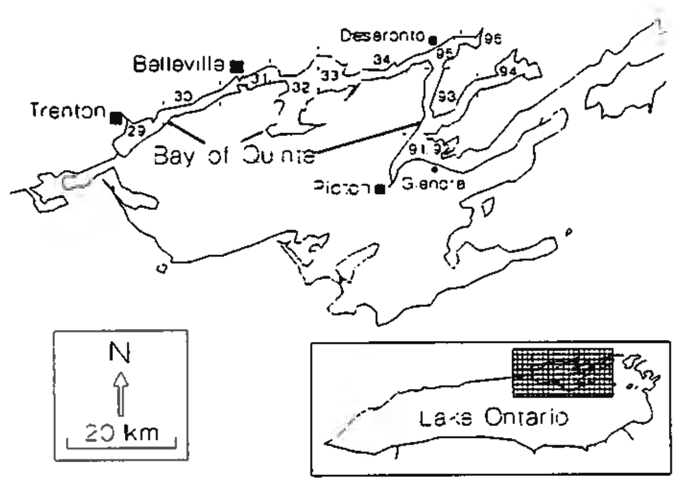

FIG. 1. Twelve geographic areas used in the 1992 Bay of Quinte angling surveys (29-Trenton, 30-Maketewis Island, 31-Belleville, 32-Point Anne, 33-Trident Point, 34-Telegraph Narrows, 95-Deseronto, 96-Napanee River, 93-Long Reach, 94-Hay Bay, 92-Baggot's Bay, 91-Picton Bay.

week, one weekend day and one weekday, between December 29, 1991 and February 26, 1992. The estimated catch and harvest of walleye in the survey areas were expanded to determine the walleye catch and harvest for the entire Bay of Quinte based on the geographic pattern of fishing success observed during the 1989 ice fishing survey. Weather permitting, fork length measurements were collected for all fish observed.

Open-water Fishery Angling Effort

In recent years, an index survey has been used to assess the open-water fishery. Index surveys involve monitoring some seasons of the open-water fishery and expanding the results, based on patterns of fishing observed in years of complete survey coverage.

The 1992 open-water angling survey was conducted from May 2, the opening-day of the walleye season, to May 31 and again from July 2 to July 26. These time periods correspond to three of the six open-water survey seasons defined by Mathers and Bowlby (1990) (Table 1). All angling was assumed to occur between 0700 and 2000 h on the opening weekend and between 0700 and 2100 h for the remainder of the survey.

Angling effort was determined by a combination of aerial and 'on-water' boat counts. Generally, 4 counts (aerial and on-water combined) were made per week with the exception of the opening weekend. Eight aerial counts were made during the opening weekend. During the May season two flights were made on each weekend and two on-water counts were made during weekdays. For the July season on-water boat counts were made during both weekdays and weekend days - except for the July 1st long weekend.

Open-water Angling Catch and Harvest

Angler interviews were conducted on all areas to estimate species-specific catch and harvest rates and to collect biological data on major sport fish populations. During the opening weekend, fork length-tally information was collected for all walleye observed. Thereafter, biological sampling included a fork length and scale sample for age interpretation from a random sample of walleye. Walleye greater than 9-yr-old were grouped into one category because of the difficulty of age interpretation using scales from these older fish. Length-tally information was collected for all other species observed in the anglers harvest. The number and approximate size of all walleye released by anglers was also recorded.

Results and Discussion

Ice Fishery Angling Effort

Angling effort during the 1992 ice fishery (December 27, 1991 to February 29, 1992) was estimated at 388,469 rod-hours (Table 2). Ice fishing pressure has increased at a relatively consistent rate since the early 1980's, until this year (Fig. 2). The 1992 effort was 69% higher than 1991 ice fishing effort - a dramatic increase. 'On-ice' anglers and ice hut anglers accounted for 54 and 46% of the total angling effort, respectively.

Estimates from previous years were based on fishing during January and February only. As in previous years the ice fishing effort in December 1991 can be considered negligible due to poor ice conditions.

TABLE 1. Description of seasons used in the open-water angling survey. Only the opening weekend, May and July seasons were sampled. The other seasons were extrapolated using expansion factors (shown) based on the seasonal pattern of angling effort (rod-hours), walleye catch and walleye harvest observed in 1988.

Season	Effort	Catch	Harvest
Opening weekend (May 2 to 3)	0.176	0.073	0.100
May = May 4 to 31 (next four weeks)	0.330	0.452	0.409
June = June 1 to June 28 (remainder of June)	0.073	0.047	0.041
July = June 29 to July 26 (week including July long weekend + next three weeks)	0.150	0.262	0.263
August = July 27 to Sept. 7 (remainder of July to Labour Day)	0.196	0.129	0.156
Fall = Sept. 8 to Nov. 30 (remainder of Sept. to end of Nov.)	0.076	0.038	0.031

TABLE 2. The estimated angling effort (rod-hours), walleye catch and walleye harvest for the 1992 angling surveys on the Bay of Quinte.

Season[a]	Angling effort	Walleye catch	Walleye harvest
Ice Fishery	388,469	56,494	43,343
Open-water Fishery			
Opening weekend	76,520	16,759	13,949
May	32,757	140,636	74,352
June[b]	44,678	10,471	5,236
July	58,583	13,045	11,165
August[b]	118,913	23,625	9,840
Fall[b]	45,930	3,353	3,907
Open-water total	77,381	222,887	128,449
Annual Total	965,850	279,381	71,792

[a]See Table 1 for definition of seasons.
[b]Estimate based on the seasonal pattern observed in 1988.

In the past Long Reach (area 93), Point Anne (area 32), and Trident Point (area 33) (Fig. 1) have been the areas with the highest angling effort in the Bay of Quinte. During the 1991 fishery, angling effort in the Long Reach area represented 20% of the total for the whole Bay of Quinte while the Point Anne and Trident Point areas combined represented 28%. This pattern changed dramatically during the 1992 fishery. Angling effort at Point Anne and Trident Point declined markedly and represented only 8% of the total fishing effort. In contrast, angling effort in the Long Reach area represented 48% of the total fishing effort in all areas.

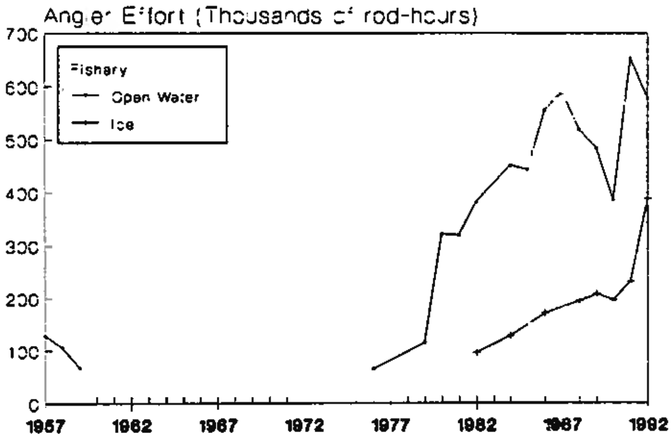

FIG. 2. Angling effort (rod-hours) during the Bay of Quinte ice and open-water fisheries from 1957 to 1992.

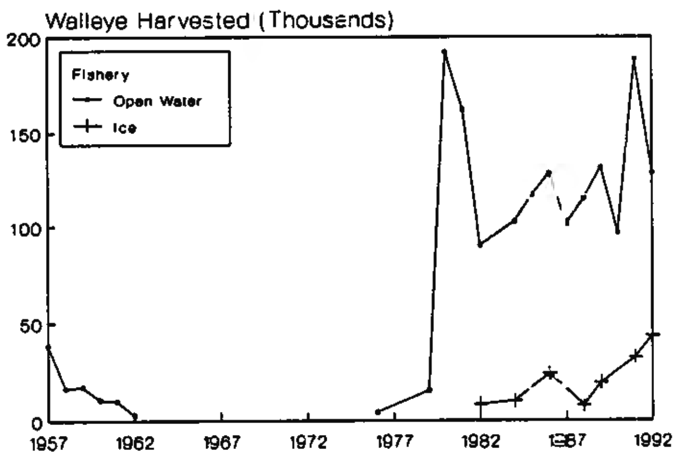

FIG. 3. Walleye harvest during the Bay of Quinte ice and open-water sport fisheries from 1957 to 1992.

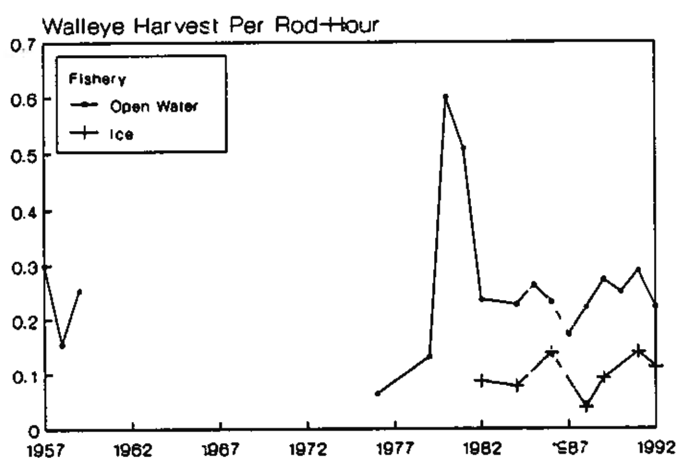

FIG. 4. Walleye harvest per rod-hour of angling effort during the Bay of Quinte ice and open-water fisheries from 1957 to 1992.

Ice Fishery Angling Catch and Harvest

The estimated catch and harvest of walleye for the entire Bay of Quinte were 56,494 and 43,343, respectively, for the December 27, 1991 to February 29, 1992, time period (Table 2). The level of harvest is higher than that observed in any previous years (Fig. 3). The estimated catch-per-unit-effort (CUE - number/rod-hour) and harvest-per-unit-effort (HUE - number/rod-hour) by walleye fishermen were 0.145 and 0.112, respectively. The harvest rate is similar to those observed in previous surveys (Fig. 4).

Open-water Fishery Angling Effort

Angling effort for the open-water fishing season was 577,381 rod-hours (Table 2). This level of effort is similar to the high levels observed in 1991, 1987 and 1986 (Fig. 2). The low angling effort in 1990 was attributed, in part, to poor weather conditions (Hoyle and Mathers 1991).

Open-water Fishery Angling Catch and Harvest

Consistent with the high angling effort, the catch (222,887 fish) and harvest (128,449 fish) of walleye during the 1992 open-water season were similar to recent years though lower than 1991 (Table 2, Fig. 3). Fishing success rates were similar (number caught and harvested/hour were 0.386 and 0.222, respectively) to other surveys since the early 1980's (Fig. 4).

Biological Attributes of the Walleye Harvest

The mean fork length and weight of walleye harvested during the 1992 open-water fishery were 410 mm (17 in total length) and 940 g (2.1 lb), slightly larger than the previous open-water fishery. The mean age of walleye harvested during the open-water fishery was 3.7 yr (Fig. 5).

The mean fork length of the walleye harvested during the ice fishery was 456 mm (19 in total length) and the mean weight 1.4 kg (3.1 lb). Larger fish are much more commonly caught in the ice fishery than in the open-water fishery (Fig. 6), as observed in previous years (Mathers 1992). The mean age of walleye harvested during the ice fishery was 5.2 yr (Fig. 5).

Survey Design Considerations

This years estimates (and most other recent estimates) of angler harvest and angler effort during the open-water and the ice fisheries rely on extrapolation of index surveys. For example, the 1992 open-water fishing survey was conducted during May and July only. The results were extrapolated based on the seasonal pattern of angler activity and harvest observed during the 1988 survey, which was conducted May to November. For the 1992 ice fishing survey, fish hut and angler counts were completed for the entire Bay of Quinte. However, angler interviews were only conducted in Long Reach, Point Anne, and Trident Point and extrapolated based on the geographic pattern of angler harvest observed in 1989 (conducted on all parts of the Bay).

The use of index areas for some components of the survey allows us to directly survey a portion of the fishery, save money, and still provide an estimate of the whole fishery. However, the patterns of angling activity change with time and the more extensive surveys must be conducted periodically to increase our confidence in expanded estimates of

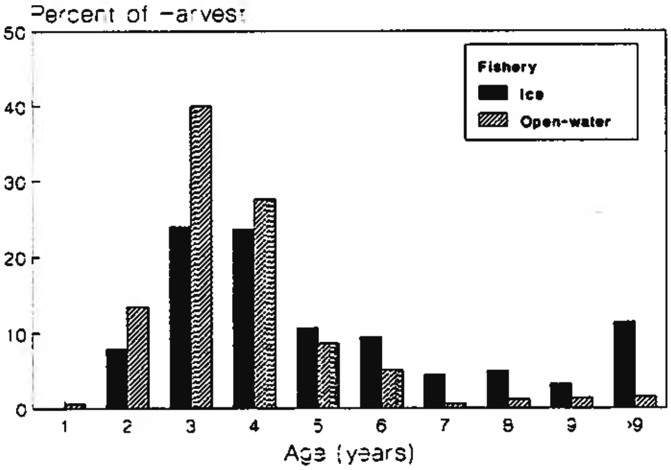

FIG. 5. Percent of walleye harvest by age-class during the Bay of Quinte ice and open-water fisheries in 1992.

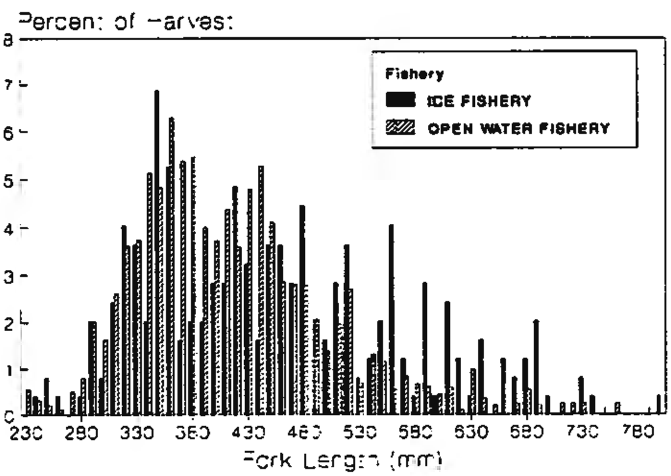

FIG. 6. Percent of walleye harvest contributed by 10 mm fork length-classes during the Bay of Quinte ice and open-water fisheries in 1992.

the whole fishery. The next survey which will include all seasons and all locations is scheduled for 1993.

There are other walleye angling fisheries in Lake Ontario which need further study. Fall shoreline fisheries in the Bay of Quinte area, which includes the walleye fisheries at Picton Harbour, Belleville Bridge, and Meyer's Pier, were surveyed in 1992 (Savoie and Bowlby 1992). It was estimated that 750 walleye were harvested in these fisheries, although the authors considered this a minimum estimate since angling effort continued after their survey ended. Bowlby and Mathers (1993) estimated that anglers who fish for walleye from boats in the outlet basin of Lake Ontario harvested 273 walleye during the summer of 1992. The fishery in the Bay of Quinte during December is largely unquantified because of the difficulty in conducting a survey at this time of year. Periodic surveys of these peripheral fisheries confirms their magnitude and allows us to maintain the accuracy of our population models.

Acknowledgments

Dawn Walsh, Terry Cronin, Ambrose McCambridge, Dale Dewey, Tim Shannon, and Steve Lawrence, of L.O.F.U. Operations staff, conducted the field work for this project.

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Assessment of Stocked Brown Trout, Rainbow Trout, Coho Salmon and Chinook Salmon in Lake Ontario

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Lake Ontario Fisheries Unit, 1992 Annual Report, Section 3

New data from spring and fall shore fisheries, the Outlet Basin boat fishery, and three more years of the western boat fishery have been used in this report to update stocking assessment of brown trout, rainbow trout, and coho salmon stocked by OMNR into Lake Ontario. In the western boat fishery, brown trout stocked by OMNR have steadily increased as a percent of the total salmonine harvest to 2.7% in 1992, and the percentage of brown trout with OMNR fin clips reached 74.4% in 1992. Brown trout stocked by OMNR were more important to the fall shore fishery, where they made up 12.3% of the total salmonine harvest. OMNR brown trout made up 66.0% of the brown trout harvest in the fall shore fishery and 81.3% in the spring shore fishery. An estimated 133 brown trout stocked by OMNR were harvested in the Outlet Basin boat fishery during 1992. The average return rate was 0.11% or about one brown trout harvested for 1000 stocked in the Outlet basin. No OMNR brown trout were observed in spring or fall shore fisheries in the Outlet Basin. Combining catch of OMNR brown trout in the western boat fishery, the winter boat fishery, and the spring and fall shore fisheries, return rates to the harvest will probably be about 6%. In the western boat fishery, rainbow trout stocked by OMNR increased as a percent of the total salmonine harvest to 2.8% in 1990, but declined to 2.0% in 1992. The percentage of rainbow trout with OMNR fin clips steadily increased in the harvest and reached 8.0% in 1991 and 7.7% in 1992. Rainbow trout stocked by OMNR were 1.0% of the total salmonine harvest in the fall shore fishery. OMNR rainbow trout made up 3.3% of the rainbow trout harvest in the fall shore fishery and 1.2% in the spring shore fishery. There were no recent surveys of the stream fisheries. However, the stream harvest of OMNR rainbow trout may be more than double the harvest in the boat fishery. Accordingly, returns of OMNR rainbow trout may be in the same order of magnitude as OMNR brown trout. Rainbow trout were examined for fin clips at the fishway in Streetsville on the Credit River during spawning migrations in April of 1989, 1990, and 1991. The percent of OMNR clips observed at the fishway increased from 47.4% in 1989 to 70.2% in 1991. Nevertheless, natural reproduction may account for significant numbers of rainbow trout in the Credit River particularly from the tributaries of Black Creek and Silver Creek. Moreover, the planned destruction of a dam in Georgetown should increase habitat available for natural reproduction. During April 1992, 66 spawning rainbow trout were captured by electrofishing in Bronte Creek and examined for fin clips. Twenty-four percent of these rainbow trout had OMNR clips. All of the remaining fish were unclipped suggesting that natural reproduction of rainbow trout in Bronte Creek might be significant. In an 810 m section of Bronte Creek on May 30, 1992 the yearling rainbow trout population was estimated at 1048. In the western boat fishery, OMNR coho salmon declined as a percent of the total salmonine harvest from 14.5% in 1983 to 1.0% in 1992, likely due to increasing availablility of and angler favour for chinook salmon, and to changes in the Toronto Star Great Salmon Hunt rules. The Skagit strain tended to have a higher proportion of OMNR clips and higher return rates than the other two strains of OMNR coho salmon. The Skagit strain of coho salmon may have staged earlier than the other two OMNR strains, making them more vulnerable to the boat fishery. OMNR coho salmon made up 98.4% of the coho salmon harvest in the fall shore fishery and 0% in the spring shore fishery. Fin clipped chinook salmon stocked in the Credit River during 1989 were examined for fin clips during egg collections when they returned to spawn in 1992. It was estimated that 3.2-6.9% of the run of age 3+ chinooks were wild.

Recommendations

1. Reduce significantly or discontinue stocking brown trout in the Outlet Basin.
2. Survey angling fisheries in Lake Ontario tributary streams.
3. Reduce rainbow trout stocking in the Credit River and Bronte Creek.
4. If coho salmon are reconsidered for stocking in Lake Ontario, then use strains that stage earlier for spawning.

Introduction

Most salmonines in Lake Ontario have been stocked by New York State Department of Environmental Conservation (NYSDEC), Ontario Ministry of Natural Resources (OMNR), and the United States Fish and Wildlife Service. In 1991 Ontario stocked 2,851,962 salmonines into Lake Ontario (OMNR, unpublished data). Most fish stocked by OMNR have been marked with fin clips to assess stocking success and to evaluate natural reproduction. Chinook salmon have not generally been fin clipped with the exception of about 100,000 chinook which were clipped in 1989. Lake trout stocking in Lake Ontario has been evaluated on a yearly basis as part of the lake trout rehabilitation program (Schneider *et al.* 1992). Bowlby (1991) evaluated the stocking success of brown trout, rainbow trout, and coho salmon stocked by OMNR into Lake Ontario for 1983 to 1989. Stocking success of these species was measured in terms of harvest returns. That report was restricted in scope since it used data from only the the western boat fishery (*e.g.* Stewart *et al.* 1990). New data from spring and fall shore fisheries (Savoie and Bowlby 1992), an Outlet Basin boat fishery (Bowlby and Mathers 1993), and three more years of the western boat fishery (Bowlby and Savoie 1992, Savoie and Bowlby 1993) have been used in this report to update stocking assessment of brown trout, rainbow trout, and coho salmon stocked by OMNR into Lake Ontario. The purpose here was to provide information for making stocking decisions for Lake Ontario.

Methods

Fin clip and harvest data from the western boat fishery (Niagara River to Wellington) for 1990, 1991, and 1992 (Bowlby and Savoie 1992, Savoie and Bowlby 1993) were used to update previous estimates as outlined by Bowlby (1991). Other fisheries were surveyed once. The winter boat fishery at Pickering Nuclear Generating Station was surveyed during 1989 (Schaap *et al.* 1989). Shore fisheries along the entire Ontario shoreline of Lake Ontario were surveyed during fall 1991 (Savoie and Bowlby 1992) and spring 1992 (OMNR, unpublished data). Harvest data from the spring shore fishery is not yet available. The boat fishery in the Outlet Basin was surveyed during spring and summer 1992 (Bowlby and Mathers 1993).

Natural reproduction of rainbow trout was assessed in the Credit River and Bronte Creek. These streams have been the two most important stocking locations for rainbow trout on the Ontario side of Lake Ontario. Rainbow trout were examined for fin clips at the fishway in Streetsville on the Credit River during spawning migrations in April of 1989, 1990, and 1991. During April 1992, rainbow trout were captured by electrofishing in Bronte Creek and examined for fin clips. On May 30 1992, Peterson population estimates of rainbow trout and brown trout were made at an 810 m section of Bronte Creek between Lowville and Cedar Springs. Fish were captured by electrofishing, marked, released, and recaptured four days later.

To assess natural reproduction of chinook salmon resulting from the spawning run in 1988, 100,136 fin clipped chinook fingerlings were stocked along with another 74,670 unclipped fingerlings in the Credit River during 1989. These fish returned to the Credit River to spawn in 1992 at age 3+. They were examined for fin clips during egg collections for Ringwood Fish Culture Station. A sample of 201 chinook salmon fingerlings were retained at Ringwood to assess fin regeneration (OMNR, unpublished data).

Bowlby (1991) used the proportion of clipped and unclipped fish in the samples from the western boat fishery as a method of estimating natural reproduction on a lakewide basis. That method has not been used here because more recent data suggests that the assumption of complete mixing of NYSDEC fish, OMNR fish, and wild fish was not valid, and so estimates of natural reproduction for brown trout and coho salmon presented by Bowlby (1991) may not be valid.

Results and Discussion

Brown Trout Returns to Anglers

In the western boat fishery, brown trout stocked by OMNR have steadily increased as a percent of the total salmonine harvest from 0.2% in 1983 to 2.7% in 1992 (Fig. 1). In 1992 this harvest exceeded that of OMNR rainbow trout and of OMNR coho salmon. This corresponds to an increase in the percentage of brown trout with OMNR fin clips in the harvest, which reached 74.4% in 1992 (Fig. 2). Apparently, increases in overall brown trout harvest in the western boat fishery in 1991 and 1992 (Bowlby and Savoie 1992, Savoie and Bowlby 1993) were partially related to OMNR brown trout. Declines in harvest of OMNR brown trout and percent OMNR clips in 1989 and 1990 (Figs. 1, 2) were related to poor year classes of fish stocked in 1988 and 1989 (Fig. 3). A year class has been labeled for the year the fish were stocked as yearlings. These poor year classes were also evident in the fall shore fishery (Fig. 4). The reasons for these poor year classes were unclear since there were no apparent differences in fish size, hatchery, stocking location, or stocking time.

The low return rates for brown trout in the harvest of the western boat fishery have improved for the 1990 and 1991 year classes, considering that they will continue to return to the fishery for several years (Fig. 3). A brown trout year class remains in the fishery for six or seven years (Table 1), but already after one or two years in the fishery the 1990 and 1991 year classes show signs of more than doubling past harvest return rates. The higher return rates appear to be the result of higher recruitment and increased targeting of brown trout by boat anglers.

Brown trout stocked by OMNR were more important to the fall shore fishery, where they made up 12.3% of the total salmonine harvest. This was greater than the combined harvest of rainbow trout and coho salmon stocked by OMNR (Fig. 5). OMNR brown trout made up 66.0% of the brown trout harvest in the fall shore fishery and 81.3% in the spring shore fishery (Fig. 6).

An estimated 133 brown trout stocked by OMNR were harvested in the Outlet Basin boat fishery during 1992. During the period from 1987 to 1991, OMNR stocked an average of 116,502 brown trout per year (29.4% of the OMNR brown trout stocked into Lake Ontario) into the Outlet Basin. The average return rate was 0.11% or about one fish harvested for 1000 stocked. No OMNR brown trout were observed in spring or fall shore fisheries in the Outlet Basin.

We cannot make as accurate estimates of return rates for the fisheries which are not sampled as often. However, we can compare harvest and use it as a relative indicator of return. In comparing harvest of OMNR brown trout in the winter boat fishery at Pickering during 1989 to the western boat fishery during 1988 and 1989 (Fig. 7), it is fair to assume the return rates from the winter boat fishery are similar to the western boat fishery. Likewise, in comparing harvest of OMNR brown trout in the fall shore fishery to the western boat fishery during 1991 (Fig. 7), it is fair to assume the return rates from the fall shore fishery are about one-half of the western boat fishery. Although the harvest estimates from the spring shore fishery in 1992 have not yet been calculated, early indications are that harvest rates and return rates of OMNR brown trout would be similar to the fall shore fishery. The harvest of OMNR brown trout in the Outlet Basin fishery is small compared with the western boat fishery (Fig. 7), and will not be considered further. Based on the above, return rates of OMNR brown trout in the western boat fishery are about one-third of the surveyed fishery in Western Lake Ontario. Moreover, the Lake Ontario tributary stream fishery has not yet been surveyed, but the OMNR brown trout catch in it may be significant in some streams. If we assume the return rate to harvest in the western boat fishery for more recent year classes will be at least 2%, then return rates to harvest for the total western fishery will be about 6%. Moreover, the release rate for OMNR brown trout in these fisheries is about 50%. Therefore, return rates of more recent year classes to the catch will probably be about 12%, without accounting for catch in streams or in New York waters. In conclusion the return rates of OMNR brown trout in western Lake Ontario are now excellent. However, in the Outlet Basin return rates of OMNR brown trout are at least fifty times less than return rates in western Lake Ontario. In the Outlet Basin index netting indicates abundant brown trout in their preferred habitat (OMNR, unpublished data). Apparently, anglers in the east do not target brown trout.

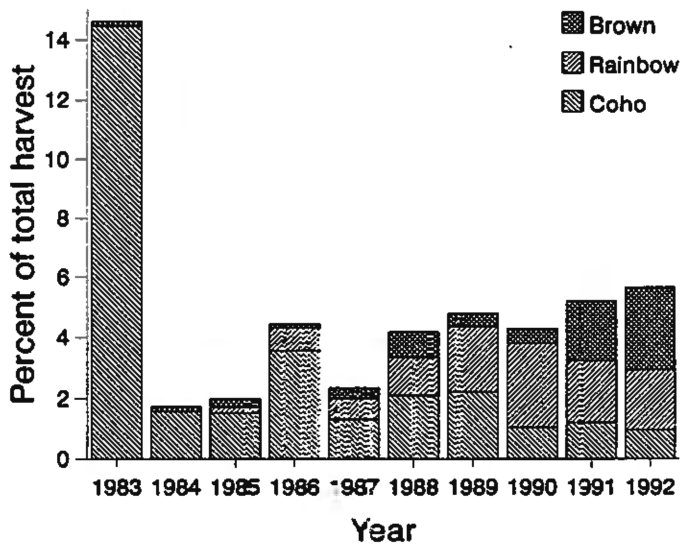

FIG. 1. The harvest of OMNR brown trout, rainbow trout, amd coho salmon as a percentage of the total salmonine harvest in the Lake Ontario western boat fishery during 1983 to 1992.

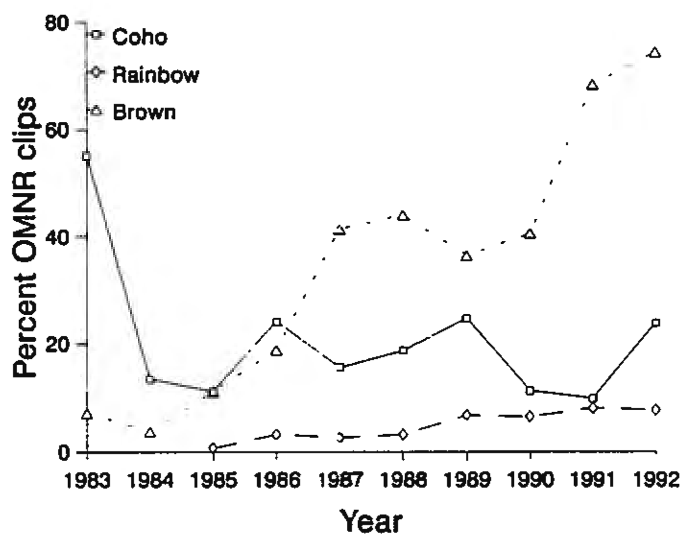

FIG. 2. The the percent of brown trout, rainbow trout, amd coho salmon with OMNR fin clips in the Lake Ontario western boat fishery during 1983 to 1992.

Rainbow Trout Returns to Anglers

Only the Ganaraska strain has been evaluated here. It was first stocked in 1984. Previously Normandale strains were stocked into Lake Ontario by OMNR. Sometimes they were not clipped before stocking. The Normandale strains were highly domesticated and survival was thought to be low. Their use has been discontinued, and so they have not been considered in this assessment.

In the western boat fishery, rainbow trout stocked by OMNR steadily increased as a percent of the total salmonine harvest from 0.2% in 1985 to 2.8% in 1990, but declined to 2.0% in 1992 (Fig.). In 1990 and 1991 this harvest exceeded harvest of OMNR brown trout and of OMNR coho salmon. The percentage of rainbow trout with OMNR fin clips steadily increased in the harvest and reached 8.0% in

TABLE 1. Number of OMNR brown trout, rainbow trout, and coho salmon observed by cohort (year stocked as yearling equivalent) in the western Lake Ontario boat fishery during 1983 to 1992.

Year class	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	Total
				Year Observed							
Brown trout											
1983	1	0	0	0	0	0	0	0	0	0	1
1984		1	0	1	2	1	0	0	0	0	5
1985			2	4	6	11	0	2	0	0	25
1986				1	25	37	6	0	1	1	71
1987					1	48	17	3	2	8	79
1988						2	6	6	1	2	27
1989							0	3	1	3	7
1990								1	8	13	22
1991									0	31	31
Total	1	1	2	6	34	99	39	15	13	58	268
Rainbow trout											
1984			3	20	5	1	1	0	0	0	30
1985				8	13	14	2	1	0	0	38
1986					6	22	13	7	1	1	50
1987						12	13	5	1	4	35
1988							26	9	7	0	42
1989								0	3	2	5
1990									2	3	5
1991										1	1
Total			3	28	24	49	55	22	14	11	206
Coho salmon											
1982	129	0	0	0	0	0	0	0	0	0	129
1983	4	11	0	0	0	0	0	0	0	0	15
1984		3	15	0	0	0	0	0	0	0	18
1985			3	94	0	0	0	0	0	0	97
1986				2	60	0	0	0	0	0	62
1987					1	99	0	0	0	0	100
1988						2	88	0	0	0	90
1989							3	14	0	0	17
1990								0	12	0	12
1991									0	10	10
Total	133	14	18	96	61	101	91	14	12	10	550

1991 and 7.7% in 1992 (Fig. 2). Since its peak in 1988 rainbow trout harvest in the western boat fishery has declined by 62% (Savoie and Bowlby 1993). Moreover, since its peak in 1990 the OMNR rainbow trout harvest has declined by 48%. The 1987 year class of OMNR rainbow trout was poor (Fig. 3). Otherwise, the 1989 and 1990 harvest of OMNR rainbow trout would have been greater. The poor 1987 year class may have been related to small fish size when stocking.

Return rates for OMNR rainbow trout in the harvest of the western boat fishery have been quite consistent with the exception of the 1987 year class (Fig. 3). Rainbow trout are generally seen in the fishery for five or six years (Table 1), and so substantial increases in return of the 1989, 1990 and 1991 year classes should be expected. Accordingly, a return to harvest of 2% appears to be the typical for OMNR rainbow trout in the western boat fishery.

Rainbow trout stocked by OMNR were less important to the fall shore fishery, where they made up 1.0% of the total salmonine harvest (Fig. 5). OMNR rainbow trout made up 3.3% of the rainbow trout harvest in the fall shore fishery and 1.2% in the spring shore fishery (Fig. 6).

No rainbow trout stocked by OMNR were harvested in the Outlet Basin boat fishery or in spring or fall shore fisheries in the Outlet Basin. This is not surprising since OMNR has not stocked rainbow trout in the Outlet Basin.

The western boat fishery during 1991 harvested about 20 times as many OMNR rainbow trout as the fall shore fishery during 1991. Although the analysis of the spring shore fishery is not yet complete, it would appear to harvest a similar number of OMNR rainbow trout as the fall shore fishery. The stream fisheries of the Credit River, Bronte Creek, Rouge River and Duffins Creek were likely responsible for the greatest harvest of OMNR rainbow trout. Unfortunately, there were no recent surveys of these fisheries. Based on estimates of Savoie and Bowlby (1991) the stream harvest of OMNR rainbow trout may be more than double the harvest in the boat fishery. Accordingly, with inclusion of the stream harvest, returns of OMNR rainbow trout may be in the same order of magnitude as OMNR brown trout.

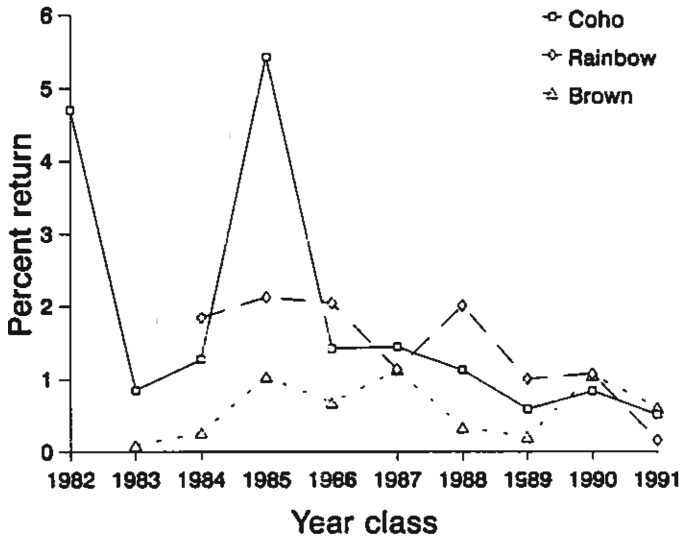

FIG. 3. The return of OMNR brown trout, rainbow trout, and coho salmon in the Lake Ontario western boat fishery as a percentage of the number stocked in each year class. Year classes are labeled for the year stocked as yearlings.

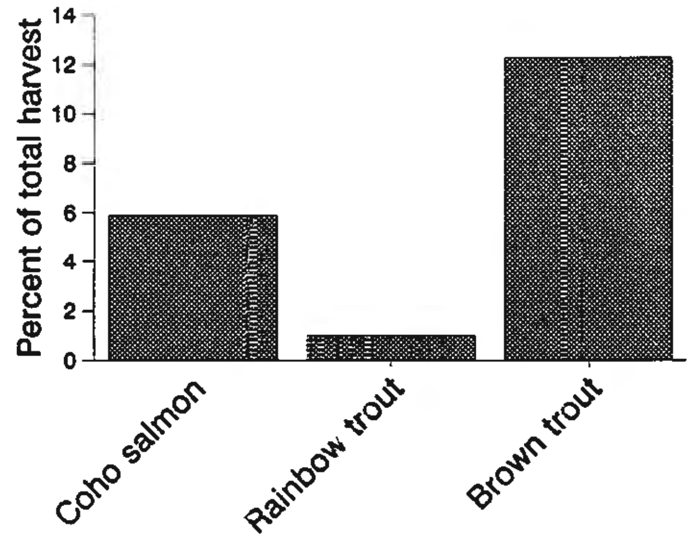

FIG. 5. The harvest of OMNR brown trout, rainbow trout, and coho salmon as a percentage of the total salmonine harvest in the Lake Ontario fall shore fishery during 1991.

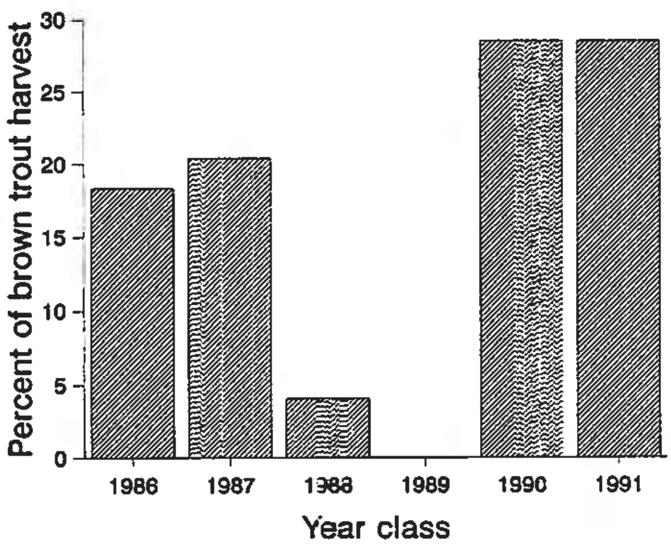

FIG. 4. The harvest distribution of OMNR brown trout by year class in the Lake Ontario fall shore fishery during 1991. Sample size was 49.

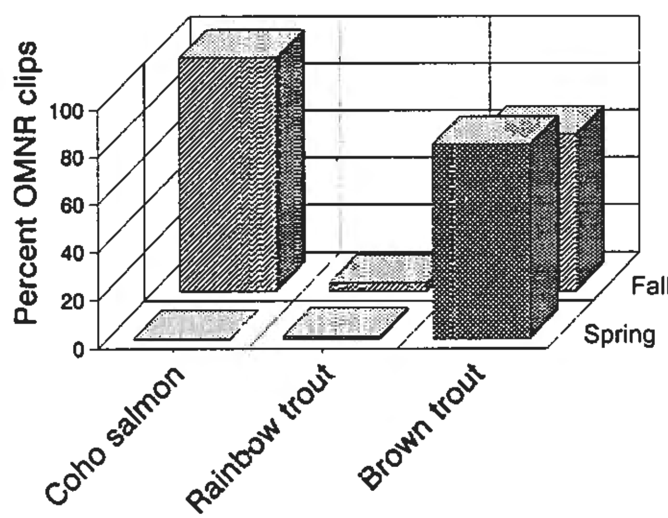

FIG. 6. The the percent of brown trout, rainbow trout, and coho salmon with OMNR fin clips in the Lake Ontario fall shore fishery during 1991 and in the spring shore fishery during 1992.

Rainbow Trout in the Credit River and Bronte Creek

The percent of OMNR clips observed at the fishway on the Credit River increased from 47.4% in 1989 to 70.2% in 1991 (Fig. 8). The coincidental decrease in unclipped rainbow trout is consistent with a more general decline in wild rainbow trout in the Ganaraska River (OMNR, unpublished. data) and some Georgian Bay streams (Dave Reid, Lake Huron Management Unit, pers. comm.). A series of dry summers in the late 1980s or a more general increase in fishing pressure directed towards rainbow trout might be the cause of these declines. Although unclipped rainbow trout were stocked in the Credit River before 1984, the size of the unclipped fish in these samples were too small for them to have been stocked prior to 1984. Electrofishing indicated that Black Creek and Silver Creek had significant numbers of juvenile rainbow trout and accounted for most of the natural reproduction of rainbow trout in the Credit River (OMNR, unpublished data). Moreover, the planned destruction of a dam in Georgetown should increase habitat available for natural reproduction. Considering rates of natural reproduction in the Credit River and the potential availability of higher quality spawning and nursery habitat, stocking of rainbow trout could be reduced in the Credit River.

In Bronte Creek 24% of 66 spawning rainbow trout observed in 1992 had OMNR clips. All of the remaining fish were unclipped indicating that natural reproduction of rainbow trout in Bronte Creek was significant. Moreover, in an 810 m section of Bronte Creek on May 30, 1992 the juvenile rainbow trout population was estimated at 1048. This section is representative of about 10 km of stream. Based on length distribution almost all of these fish were yearlings with about 1% 2-year-old fish. In Wilmot Creek in 1992 more than 75% of 2-year-old rainbow trout and more than 20% of the yearlings smolted before this date (M. Jones, pers. comm.). Thus significant production of 2-year-old and yearling rainbow trout was likely missed in Bronte Creek due to smolting. As well, a 1987 electofishing survey of Limestone Creek, a tributary of Bronte Creek, has indicated high density of juvenile rainbow trout (OMNR, unpublished data). Stocking of rainbow trout could be reduced in Bronte Creek since natural reproduction appears to be significant

Coho Salmon

Three strains of coho salmon were stocked by OMNR on a rotational basis (Dimond and Bowlby 1992). OMNR discontinued stocking of coho salmon because of lack of space resulting from three hatchery closures (LeTendre and Savoie 1992). However, their evaluation here may be useful for discussions if we wish to reconsider stocking coho salmon.

In the western boat fishery, coho salmon stocked by OMNR greatly declined as a percent of the total salmonine harvest from 14.5% in 1983 to 1.0% in 1992, (Fig. 1). This decline was despite a doubling in coho stocking by OMNR from the early 1980s to the late 1980s. During this period chinook salmon stocking was increased by OMNR and NYSDEC, and coho became less favoured by anglers than chinook. Moreover, changes in the Toronto Star Great Salmon Hunt (Star derby) rules appears to have greatly impacted coho harvest. OMNR coho are most vulnerable when they stage near the mouth of spawning rivers in the fall. The end date of the Star derby moved from September 25 in 1983 to September 14 in 1984 to September 7 in 1986. As well, the minimum size limit for the Star derby was increased from 5 lb in 1984 to 8 lb in 1985 and subsequently to 10 lb. Since 1985 the average size coho returning to the Credit River has typically been between 8 and 10 lb (Dimond and Bowlby 1992). The percentage of coho salmon with OMNR fin clips was 55.2% in 1983 but in subsequent years ranged between 9.8% and 24.1% (Fig. 2). The Skagit strain which returned in 1983, 1986, 1989 and 1992 tended to have a higher proportion of OMNR clips (Fig. 2). The Skagit strain originally spawned earlier than the other two OMNR strains (Dimond and Bowlby 1992), and therefore, may have staged earlier making them more vulnerable to the boat fishery. Harvest rate of coho salmon in Lake Ontario peaked before 1983 (Stewart *et al.* 1990). In 1982 coho salmon in the western boat fishery dominated other species and were 90.2% of the harvest, but in 1983 they were only 26.2% of the harvest (Bowlby and Savoie 1992)

Return rates of OMNR coho salmon showed strain effects and the effect of reduced angler interest in coho in later years or perhaps reduced stocking survival (Fig. 3). The Skagit strain had excellent return rates for the 1982 and 1985 year classes. The effect of changing angler preferences is confounded with stocking survival and so we cannot properly evaluate stocking survival. Coho salmon are in the fishery for only two years because of their three year life cycle (Table 1). Most of their contribution to the fishery occurs in their third year. Accordingly, return rates and catch rates for coho are more variable than brown trout or rainbow trout. Moreover, good and bad year classes tend to make a "boom or bust" fishery because each year class tends to dominate the fishery for one year.

Coho salmon stocked by OMNR were more important to the fall shore fishery, where they made up 5.9% of the total salmonine harvest (Fig. 5). OMNR coho salmon made up 98.4% of the coho salmon harvest in the fall shore fishery and 0% in the spring shore fishery (Fig. 6).

No coho salmon stocked by OMNR were harvested in the Outlet Basin boat fishery or in spring or fall shore fish-

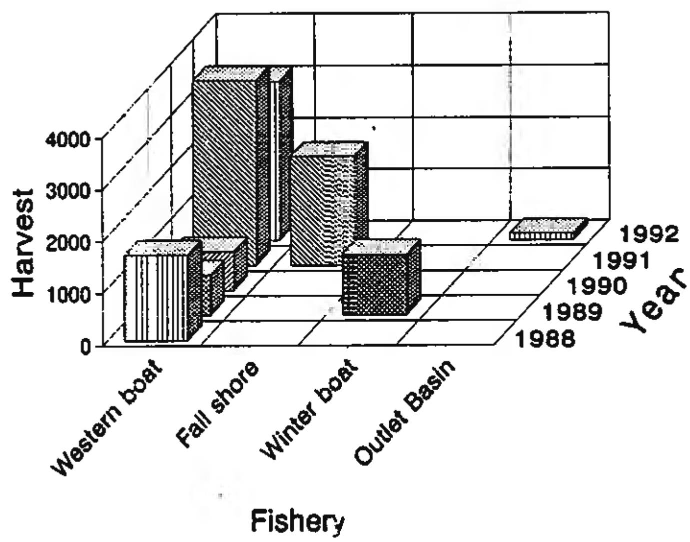

FIG. 7. Harvest of OMNR brown trout by Lake Ontario fishery and year.

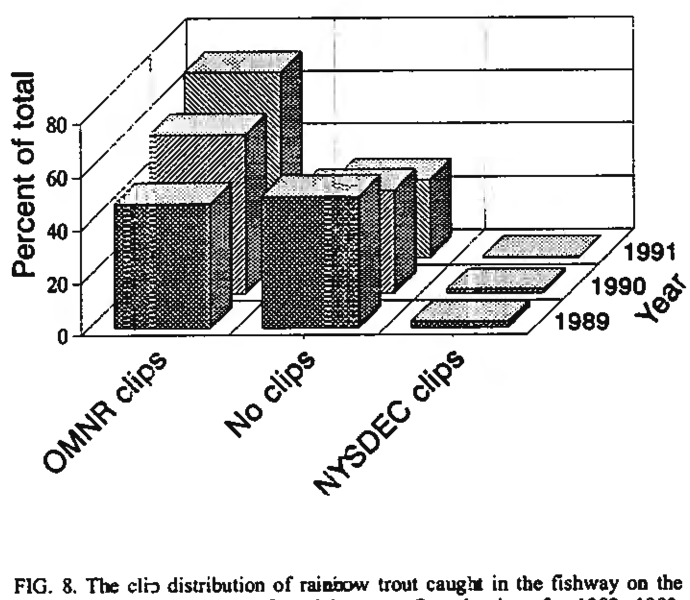

FIG. 8. The clip distribution of rainbow trout caught in the fishway on the Credit River as a percent of total by year. Sample sizes for 1989, 1990, and 1991, respectively were 76, 286, and 548.

eries in the Outlet Basin. This is not surprising since OMNR has not stocked coho salmon in the Outlet Basin.

The western boat fishery during 1991 harvested about twice as many OMNR coho salmon as the fall shore fishery during 1991. The spring shore fishery harvested very few OMNR coho salmon. The stream fisheries of the Credit River and Bronte Creek were likely responsible for significant harvest of OMNR coho salmon. Unfortunately, there were no recent surveys of these fisheries. Considering the low return rates of OMNR coho salmon from the boat and shore fisheries, returns from the stream fisheries would have to be very large to justify stocking coho salmon. However, if we return to stocking coho salmon then different strains that stage to spawn earlier should be considered.

Chinook Salmon Natural Reproduction

During the 1992 egg collection at the Credit River 176 clipped chinook and 180 unclipped chinook aged 3+ were observed. Fin clip regeneration rates were judged to be between 1.9% and 9.3% depending on the criteria used for judging fin clip quality (OMNR, unpublished data). The conservative fin clip regeneration rate (1.9%) predicted that 6.9% of the run of age 3+ chinook was wild (Table 2); the liberal fin clip regeneration rate predicted that 3.2% of the run was wild. A detection limit (P=0.05) of 6.2% was calculated using a one-tailed Fisher's exact test, *i.e.* if less than 6.2% of the run of was wild then it was not significantly different than 0. In conclusion, if successful natural reproduction of chinook salmon ocurred during the run of 1988 in the Credit River, then it contributed no more to the population in Lake Ontario than the successful reproduction of one female chinook.

Acknowledgments

The Credit River Anglers Association and the Isaac Walton Fly Fishing Club assisted with stream collections of rainbow trout. Ringwood FCS staff assisted with clipping, holding, clip evaluation, and collection of chinook salmon in the Credit River. Phil Smith and Tom Stewart privided comments which made significant improvements to an earlier draft.

TABLE 2. Estimates of wild 3-year-old chinook salmon in the Credit River spawning run during 1992.

	Clip regeneration rate	
	0.0932	0.0186
Observed number of clipped fish	176	176
Observed number of unclipped fish	180	180
Adjusted number of clipped fish	192	179
Adjusted number of unclipped fish	164	177
Expected number of clipped fish	204	204
Expected number of unclipped fish	152	152
P (adjusted vs expected; Fisher's exact one-tailed test)	0.203	0.036
Percent natural	3.24	6.92

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Lake Whitefish Early Life History Studies in the Bay of Quinte and Eastern Lake Ontario, 1992

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Lake Ontario Fisheries Unit, 1992 Annual Report, Section 4

Eastern Lake Ontario lake whitefish (*Coregonus clupeaformis*) larval fish sampling and spawning shoal studies were conducted in the spring and fall of 1992. By counting otolith daily growth rings, it was determined that lake whitefish hatched and emerged over a protracted period of time, from April 1 to 26. Those fish hatching prior to mid-April, when water temperatures and zooplankton densities fluctuated at low levels, did not appear in samples collected after the third week of April, suggesting that larval lake whitefish survival was low prior to mid-April. Growth of larval fish hatching after mid-April was faster than that observed in 1991 but, due to delayed spring warming, the 1992 larval fish had not caught up in size to those of 1991 by the time fish had disappeared from surface waters in mid-May. Cyclopoid copepodids and two small-bodied cladocerans, *Chydorus sphaericus* and *Bosmina longirostris*, predominated in the larval lake whitefish diet with the larval fish selecting the largest prey individuals available. Larval lake whitefish appeared to affect zooplankton community structure in nearshore areas. Dive surveys documented lake whitefish egg deposition and zebra mussel presence (50 per m^2) for the first time at a Lake Ontario lake whitefish spawning site.

Recommendations

1. Continue to assess larval lake whitefish diet and growth relative to zooplankton community structure in order to document impacts on whitefish population dynamics resulting from zebra mussel (*Dreissena polymorpha*) invasion.
2. Monitor zebra mussel colonization of lake whitefish spawning shoals.

Introduction

Lake Ontario lake whitefish (*Coregonus clupeaformis*) are concentrated in the eastern end of the lake where habitat is most suitable. Ongoing assessment indicates that the eastern Lake Ontario lake whitefish population is supported by two major spawning populations, one which migrates into the Bay of Quinte to spawn; and the other which spawns in Lake Ontario, mostly along the south shore of Prince Edward County.

Dive surveys, conducted in November/December, 1990, confirmed the presence of lake whitefish eggs at the two Bay of Quinte sites studied, Makatewis Island and Trident Point (Hoyle and Melkic 1991). Areas of egg deposition have yet to be confirmed for the lake Ontario spawning population, but commercial fishing activity in November along the south shore of Prince Edward County centers on large congregations of lake whitefish, apparently spawning, near Gull Bar, Petticoat Cove, and areas east of Petticoat Point to Long Point.

This report describes the results of lake whitefish larval fish sampling and spawning shoal studies conducted in 1992 on the Bay of Quinte and Lake Ontario. The objectives of these studies were to examine hatch dates, larval fish diet and growth (including concurrent sampling of the zooplankton community), and to determine whitefish egg and zebra mussel densities on spawning shoals in the Bay of Quinte and Lake Ontario.

Methods

Study Sites

Larval fish sampling

Larval Lake whitefish sampling was conducted at three Bay of Quinte sites (Trident Point, Sherman's Point, and Indian Point) and one Lake Ontario site (Petticoat Cove), during April and May 1992 (Fig. 1). Sampling began immediately following 'ice-out' on the Bay of Quinte. Each site was sampled from two to four times at roughly 2 week intervals on a rotational basis until larval whitefish disappeared from surface waters about mid-May.

Dive surveys

Dive surveys were conducted on two Bay of Quinte sites (Makatewis Island and Trident Point) and one Lake Ontario site (Petticoat Cove), immediately following the lake whitefish spawning run in November 1992.

Water Temperature

Continuous water temperature recorders (TempMentors, Ryan Instruments, Redmond, Washington) were installed, on the bottom, at the Trident Point and Petticoat Cove study sites immediately following 'ice-out' on the Bay of Quinte. A third TempMentor was installed at Glenora (Fig. 1), where it could be easily monitored by Lake Ontario Fisheries Unit staff, on a permanent basis.

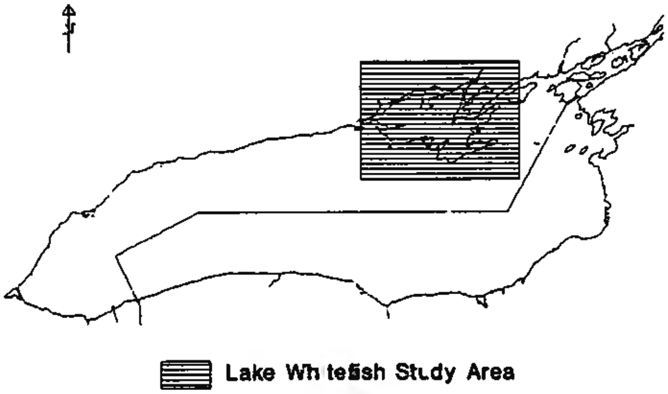

FIG. 1a. Map of Lake Ontario and the Bay of Quinte. The lake whitefish study area is highlighted.

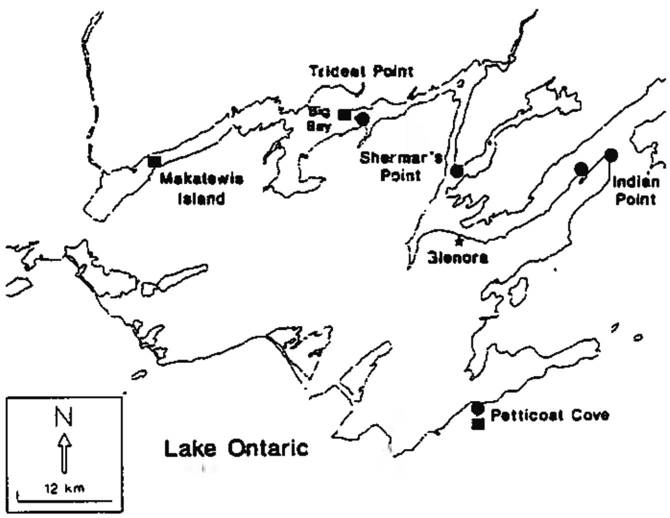

FIG. 1b. Map of lake whitefish study area (enlargement of highlighted area in Fig. 1a). Circles represent larval lake whitefish and zooplankton sampling locations. Squares indicate locations of dive surveys on lake whitefish spawning shoals.

Larval Fish Sampling

Larval fish sampling involved the use of a 0.5 m mouth dia tow net (see Loftus 1982; Cucin and Faber 1985 for gear specifications), and a small (12 cm by 20 cm) fine-mesh aquarium dipnet attached to a 1.5 m wooden handle.

The larval fish tow net was pulled through surface waters (0.5 to 2 m water depth) at a speed of 0.5 m/s for 5 to 15 min duration. The dipnet was used to 'scoop' through schools of larval fish observed by field crews, typically in shallow nearshore areas.

Larval fish were kept alive in a 250 ml jar of water in a cooler of ice until they could be processed.

Back at the lab, typically within one to two h from time of capture, a random sample of larval lake whitefish were measured for total length (to 0.1 mm; n = 41 to 81 per site per sampling occasion) and wet weight (to 0.0001 g; n = 10).

Thirty larval fish were then preserved in in 5% buffered formalin for subsequent stomach content removal and identification. Buffered formalin was used because it proved suitable for preserving both the larval fish and their stomach contents, which consisted of zooplankton. Stomach contents were removed under a dissecting microscope. The stomach contents of 10 larval whitefish were combined into a single sample, and analyzed in the same fashion as zooplankton samples (see below). Thus, three replicate samples, each consisting of the stomach contents of 10 fish were obtained for each sampling site on each sampling occasion.

Ten larval fish (same fish for which weights were taken) were preserved in 95% ethanol (preferred for otolith preservation, John Casselman, Ontario Ministry of Natural Resources, R. R. # 4, Picton, Ontario, personal communication) for later otolith extraction, preparation, and age interpretation. Otoliths were used to estimate the age and hatch date of the fish by counting daily growth rings (Powles and Warlen 1988). This method was validated for lake whitefish by Hoyle (1992).

Growth, calculated as instantaneous rate of increase in total length, was determined by back-calculation of fish lengths from measurement of otolith daily growth rings. Daily increments of larval fish total length were shown to be proportional to daily increments between rings or microzones on otoliths (geometric mean regression, total length in mm = 100.592 (otolith radius in mm) + 10.643, n = 29, r = 0.973).

Zooplankton Sampling

Zooplankton sampling was carried out concurrently with larval fish collections using a Wisconsin net (OMNR 1990). Three replicate zooplankton samples were taken and preserved in buffered formalin. Each sample represented a total water volume of 1870 l, assuming 100% flow efficiency for 6 min surface tows.

Zooplankton samples were identified, enumerated, and measured for size (maximum length measurement not including appendages).

Zooplankton samples were collected simultaneously, in the same locations, as larval fish samples. This methodology allowed direct comparison of larval whitefish stomach contents with available zooplankton.

In addition to zooplankton sampling in nearshore areas where larval whitefish were located, offshore samples were collected at the Sherman's Point site to contrast zooplankton community structure in nearshore and offshore habitats.

Spawning Shoal Dive Surveys

Dive surveys were conducted to determine lake whitefish egg and zebra mussel densities, and to obtain video footage of the substrate. Methods were somewhat different than those employed in 1990 (Hoyle and Melkic 1991).

At the two confirmed lake whitefish spawning sites previously surveyed on the Bay of Quinte, Makatewis Island and Trident Point (Hoyle and Melkic 1991), 300 m transects were established. Egg and zebra mussel densities were determined at 20 m intervals (15 samples) using a 0.5 m^2 quadrat. Zebra mussels were counted visually while eggs were suctioned from within the substrate using a SCUBA powered air lifter for later enumeration. The substrate along the entire length of each 300 m transect was video taped.

The Lake Ontario site, Petticoat Cove, had not previously been surveyed by divers but was a suspected lake whitefish spawning area (Hoyle and Melkic 1991). Here, divers determined egg and zebra mussel densities at several random locations on a rock-rubble bar, located previously from the water surface, in an area which otherwise consists mainly of flat limestone bedrock. Video footage was obtained for each sampling location.

Results and Discussion

Water Temperature

Studies began on April 13, 1992, the first day upon which field crews were able to reach the Trident Point sampling site. Much of the Bay of Quinte was ice-free on this date, especially narrow areas of the Bay where water currents are greatest. Immediately to the west of Trident Point (within a few hundred m), Big Bay was still ice-covered. The water temperature at Trident point on this date was 3°C, increasing to nearly 4°C the following day but then decreasing slightly over the next two days. After April 17 the water temperature increased quickly to over 9 °C by April 25 (Fig. 2).

Initially, water temperatures were greater, at 4 to 5 °C, on Lake Ontario at the Petticoat Cove sampling site but after April 16, declined rapidly to less than 3 °C (April 17). Like the situation at Trident Point, water temperatures at Petticoat Cove rose rapidly until April 25 but always remained lower than those at the Bay of Quinte site.

Water temperatures at Glenora were intermediate compared to Trident Point and Petticoat Cove, but having been recorded from an earlier date (while much of the Bay of Quinte was still under ice-cover), showed a sharp decline in temperature from April 10 to 11 following a winter storm event.

Larval Fish Sampling

Sampling dates, water temperatures, numbers of larval whitefish captured, mean lengths, weights and ages, estimated hatch dates, and zooplankton densities are shown in Table 1. Larval fish were captured during the first visit to each site, immediately following 'ice-out'. This observation was in sharp contrast to the situation in 1991. 'Ice-out' occurred 2 to 3 weeks earlier in 1991, and larval fish were not observed until about 2 weeks following 'ice-out'.

Hatch dates

Larval whitefish caught on the first visit (mid-April, 1992) to each Bay of Quinte site were determined to have mean hatch dates of April 8 to 14. By contrast, samples of larval lake whitefish taken on two subsequent visits to each site (late April or early May, and mid-May) were both found to have mean hatch dates around April 18 to 20. This pattern of hatch dates was even more dramatic at the Lake Ontario site. Here, a sample of fish taken in mid-April were determined to have hatched about April 4, while the sample of larval whitefish taken in early May had a mean hatch date of April 23. The first Lake Ontario sample hatched earlier than the first Bay of Quinte samples but the Lake Ontario water temperatures were initially warmer. However, Lake Ontario water temperature warmed more slowly than that in the Bay of Quinte. As a result, the later Lake Ontario sample were found to have hatched at a later date than comparable Bay of Quinte samples (Table 1, Fig. 2).

One interpretation of the above results is as follows. In 1992, larval lake whitefish began to hatch about the same time as in 1991 but the 1992 hatch was much more protracted (Fig. 2b). The fish which hatched and emerged first were subject to the harsh environmental conditions associated with delayed 'ice-out' and spring warming in 1992. These fish appeared to suffer high mortality because they were not captured in late-April and May samples. Indeed, water temperatures declined sharply during a winter storm event (snow

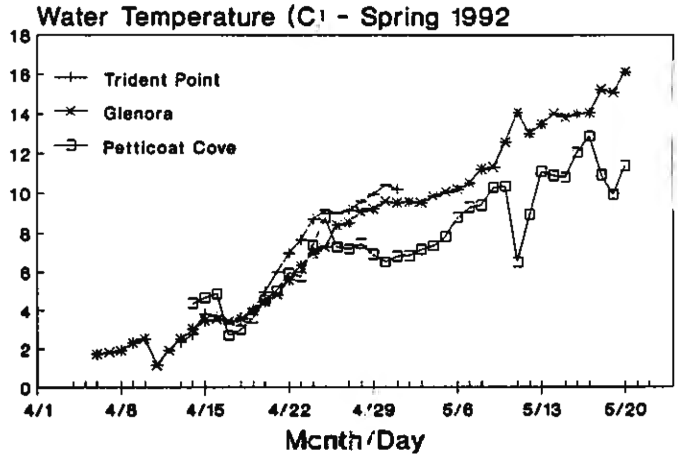

FIG. 2a. Changes in water temperature during the spring 1992, at Trident Point (Bay of Quinte larval whitefish collection site and spawning shoal), Glenora, and Petticoat Point (Lake Ontario larval whitefish collection site and spawning shoal). Water temperatures were recorded continuously with a TempMentor at depths of 2 to 4 m.

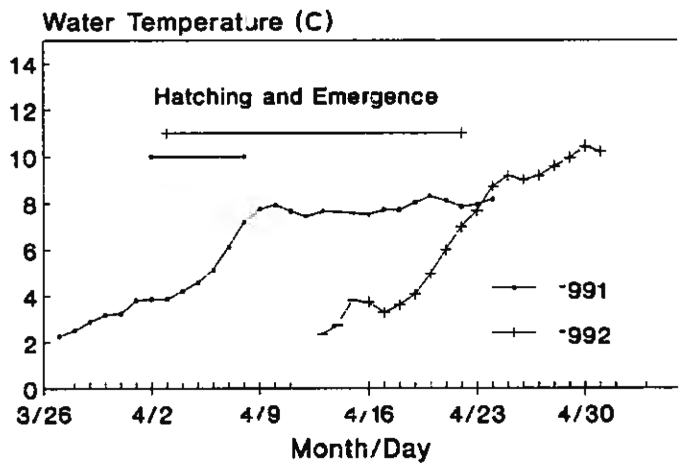

FIG. 2b. Changes in water temperature at the Trident Point, Bay of Quinte sampling site, 1991 and 1992. Periods of lake whitefish hatching and emergence are indicated.

and freezing rain) on April 11, and again from April 16 to 17 during a period of cold east winds and rain (personal observation, Fig. 2b). Those larval fish hatching and emerging after these harsh environmental conditions, and during a time when water temperatures were warming steadily, were the ones that survived to later sampling occasions.

Alternative possibilities to explain the 'disappearance' of larval fish from the early period of hatching and emergence are as follows: (1) the early hatching fish moved out of the sampling area or were no longer vulnerable to the sampling gear, (2) the method of determining hatch dates, by counting otolith microzones, was not accurate. The former possibility is not likely because fish from all samples taken subsequent to the initial sample were determined to have hatched at the same time even though the fish from the very last samples were much larger and older, yet still found in the same location and caught with the same sampling gear. The later possibility is not possible to test within the scope of the current study. The otolith age interpretation method was vali-

Table 1. Summary of sampling dates, water temperatures, numbers of larval lake whitefish captured, mean lengths, weights, and ages, estimated hatch dates, and zooplankton density at three Bay of Quinte and one Lake Ontario sampling sites.

	Sample Date	Mean Water Temperature (°C)	No. Larval Whitefish Caught	Mean Length mm (n)	Mean Weight g (n)	Mean Age (days)	Mean Hatch Date (range)	Zooplankton Density (no./m^3)
Bay of Quinte								
Trident Point	Apr 13	3	56	14.6 (42)	0.0118 (10)	5	Apr 8 (3 to 9)	1284
	Apr 27	10	108	16.6 (41)	0.0160 (10)	9	Apr 18 (15 to22)	973
	May 11	15	99	22.1 (55)	0.0516 (10)	23	Apr 18 (15 to 21)	1273
Sherman's Point	Apr 16	4	75	14.3 (41)	0.0075 (10)	8	Apr 8 (4 to 10)	3386
	Apr 28	10	0	16.1 (41)	0.0168 (10)	10	Apr 18 (16 to 21)	1779
	May 12	16	118	23.1 (71)	0.0614 (10)	24	Apr 18 (17 to 21)	7992
	May 21	19	0					65266
Indian Point	Apr 21	4	104	14.7 (41)	0.0104 (10)	7	Apr 14 (10 to 17)	2429
	Apr 29	7	85	15.8 (41)	0.0144 (10)	10	Apr 19 (17 to 21)	4963
	May 13	10	140	22.9 (81)	0.0604 (10)	23	Apr 20 (17 to 23)	5582
	May 21	18	0					
Lake Ontario								
Petticoat Cove	Apr 14	5	300	14.1 (60)	0.0107 (10)	10	Apr 4 (1 to 9)	119
	May 4	10	81	15.9 (41)	0.0111 (10)	11	Apr 23 (21 to 26)	76
	May 20	12	0					

dated by Hoyle (1992) using samples of known aged fish but only for fish aged 3 to 5 weeks experiencing near optimal environmental conditions. It is possible, that under severe environmental conditions, otolith daily growth rings would not be formed in a consistent fashion. The testing of this possibility would involve raising larval lake whitefish under a variety of conditions (Geffen 1987; e.g. various water temperature and feeding regimes).

As was the case in 1991 (Hoyle 1992), larval whitefish disappeared from Bay of Quinte surface waters during the third week in May 1992 as water temperature warmed above 15 °C. In Lake Ontario, no larval whitefish were observed on May 20 even though water temperatures were still relatively low. A sharp drop in water temperature on May 11 may have resulted in high mortality rates or some other factors may also have influenced larval whitefish distribution in Lake Ontario.

Growth

Growth of larval whitefish was examined for a sample of fish collected on May 13, 1992 at Indian Point, where a comparable sample had been collected in 1991 (May 10). Although hatching and emergence dates for those whitefish which survived in 1992 were delayed compared to 1991, growth of the larval fish was faster (Fig. 3). Nonetheless, the faster growth rate did not compensate sufficiently to allow the 1992 fish to catch up in size to those of 1991 by the time the fish dispersed to deeper water in mid-May, of both years.

Diet Study/Zooplankton Sampling

Bay of Quinte studies - 1991 vs. 1992

Results of the larval whitefish diet and zooplankton sampling studies were very similar to those of 1991 (Figs. 4 and 5). Here, I summarized results for all three Bay of Quinte sites combined, focusing on visits two and three to each site when sample sizes were greatest, to allow comparison to 1991. As in 1991, cyclopoid copepodids were the most numerous prey in larval lake whitefish stomach contents, followed by the small-bodied cladocerans, *Chydorus sphaericus* and *Bosmina longirostris* (Fig. 4). These groups, along with cyclopoid nauplii, were also numerically dominant in zooplankton samples taken in shallow areas inhabited by the larval lake whitefish.

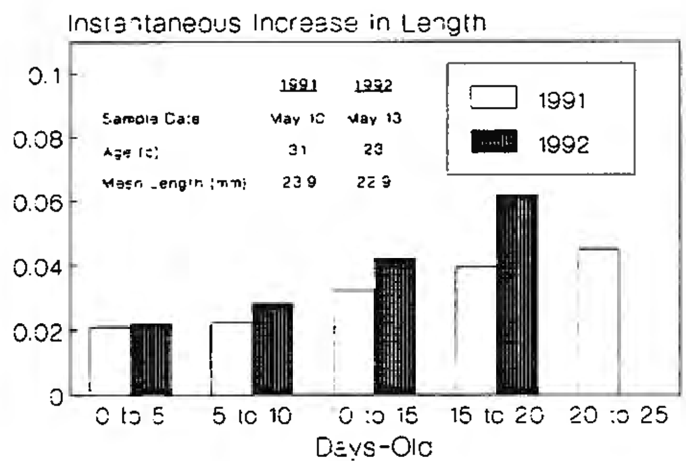

FIG. 3. Comparison of instantaneous rate of increase in larval lake whitefish total length for 5-day time periods for samples collected on roughly the same date in 1991 and 1992.

Cyclopoid copepodids were highly selected for by the larval fish comprising a much greater percentage in the diet, 74% by number, than in the zooplankton community (34%). Although *Bosmina longirostris* and *Chydorus sphaericus* were the second and third most common zooplankton types in the diet (9 and 6%, respectively), they were relatively more common in zooplankton samples (13 and 33%, respectively). Also, although cyclopoid nauplii were abundant in zooplankton samples (10%), they were rarely eaten (1%).

Larval lake whitefish selected the largest zooplankton available (Fig. 5). Cyclopoid copepodids provided both the

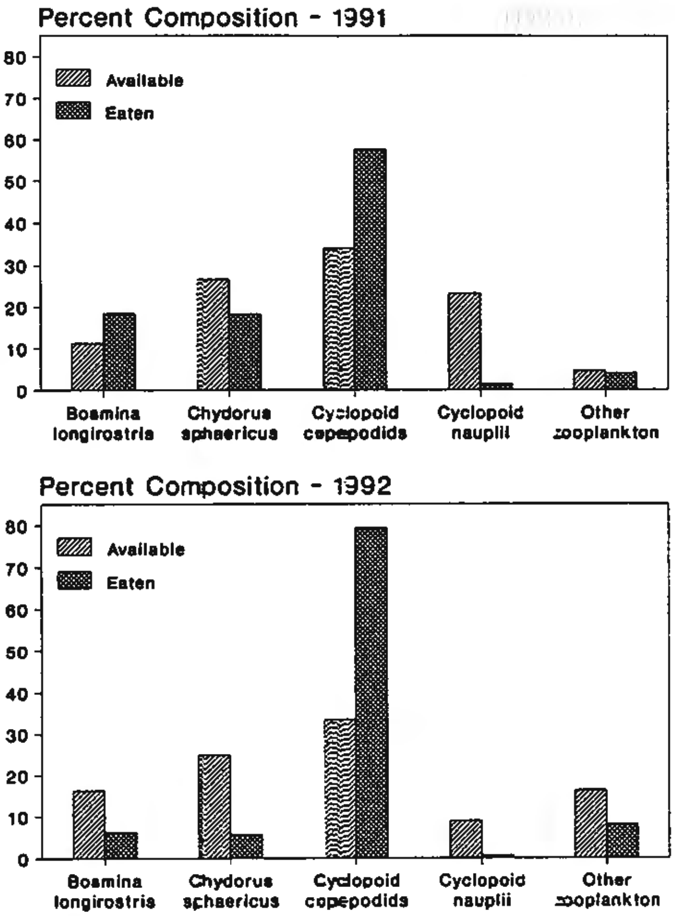

FIG. 4. Percent composition by number of major zooplankton taxa found in stomach contents of larval lake whitefish, and in zooplankton samples taken in the vicinity of the larval fish samples, (a) 1991 and (b) 1992.

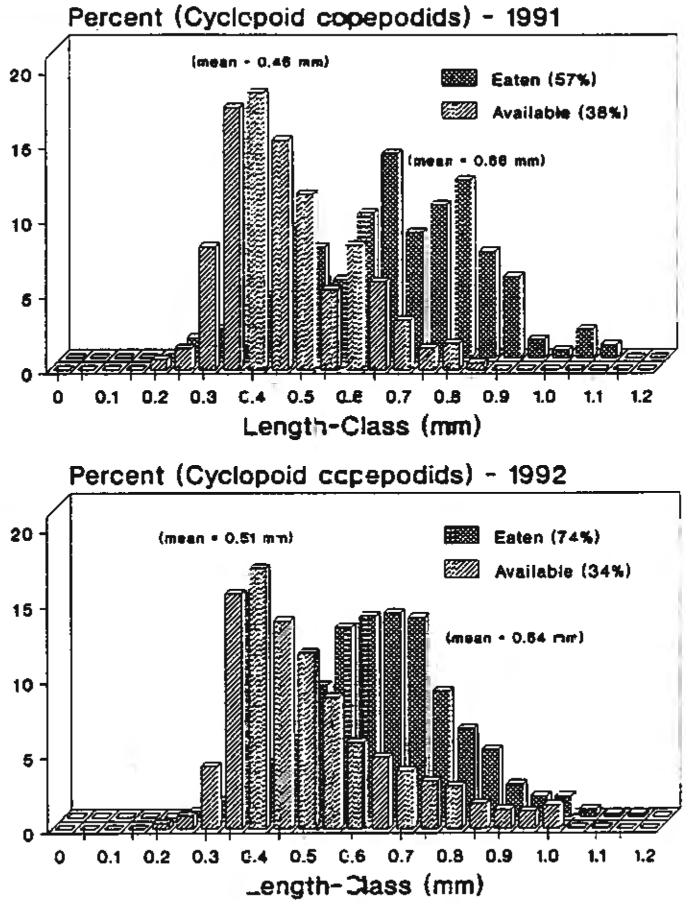

FIG. 5. Percent composition by number of cyclopoid copepodid length-classes in the stomach contents of larval lake whitefish, and in zooplankton samples taken in the vicinity of the larval fish samples. Percentages shown in legend represent the percent composition of this zooplankton taxa in the zooplankton community (available) and in stomach contents (eaten), (a) 1991 and (b) 1992.

largest individuals (mean length = 0.51 mm) and the widest size range (0.3 to 0.7 mm were most common) available to the larval fish. These attributes may account for their prevalence in the diet where cyclopoid copepodids had a mean length of 0.66 mm and where sizes of 0.4 to 0.9 mm were most common). By contrast, although cyclopoid nauplii were common in zooplankton samples, their small size (mean length = 0.19 mm both available and eaten) presumably made them a less attractive food source.

Sherman's Point studies - nearshore vs. offshore sampling

Mean zooplankton densities and sizes (all zooplankton combined and cyclopoid copepodids only, the preferred food of larval whitefish) for each of four visits to nearshore and offshore sampling stations at Sherman's Point are presented in Table 2. Zooplankton density generally increased throughout the study period except for a decline in density from April 16 to 28 at the nearshore sampling station. Zooplankton density was also generally much higher at the offshore sampling station in the absence of larval whitefish, except for early in the study period when whitefish were just beginning to emerge. Mean size of cyclopoid copepodids was also greater at the offshore sampling station. Given that larval whitefish are the only larval fish present at this time of year, these results are consistent with the hypothesis that zooplankton density and size structure was being influenced by larval whitefish predation in the nearshore area.

To test this idea, I derived the expected size distribution of the larval fish diet assuming that size-selective planktivory was responsible for the difference between zooplankton size distributions observed for nearshore (whitefish present) and offshore (whitefish absent) sampling stations (Fig 6). Based on the results presented in Fig. 6a, I assumed that 100% and 0% of the zooplankton over 0.65 mm and under 0.40 mm respectively were consumed by larval whitefish. Zooplankton consumption of size-classes between 0.40 and 0.70 was assumed to be proportional to the difference between offshore and nearshore densities, and calculated as follows:

1 - (nearshore density / offshore density)

for each zooplankton size-class.

The expected and observed zooplankton size compositions in larval whitefish stomachs are plotted in Fig. 6b. The agreement appears to be quite close, and is consistent with the hypothesis that larval whitefish predation can structure zooplankton communities in nearshore areas.

Freeberg et al. (1990) found that larval lake whitefish survival in Lake Michigan was positively correlated with the abundance of large copepod zooplankton in Lake Michigan. Growth and survival was also shown to be positively related to prey density in a laboratory study of Lake Michigan and Lake Huron larval lake whitefish strains (Brown and Taylor 1991). The same may be true for Lake Ontario lake whitefish populations. In the present study, declines in water tem-

Table 2. Mean zooplankton density (no. / m^3) and size (mm, for cyclopoid copepodids only) for three replicate samples taken on each of four sampling dates at nearshore and offshore sites. Sherman's Point, Bay of Quinte.

	Sampling Date	Density (no. / m^3) All zooplankton	Density (no. / m^3) Cyclopoid copepodids (mean size in mm)
Nearshore			
	Apr 16	3386	963 (0.47)
	Apr 28	1779	656 (0.52)
	May 12	7992	3235 (0.45)
	May 21	65266	17315 (0.49)
Offshore			
	Apr 16	3404	1797 (0.54)
	Apr 28	15962	10784 (0.61)
	May 12	25962	6347 (0.57)
	May 21	197280	14512 (0.56)

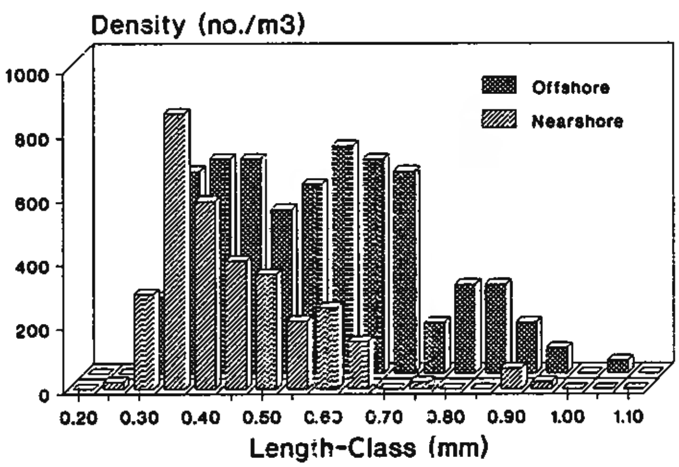

FIG. 6a. Density (no. per m^3) of cyclopoid copepodid length-classes observed at nearshore and offshore sampling stations at Sherman's Point, Bay of Quinte, May 12 1992.

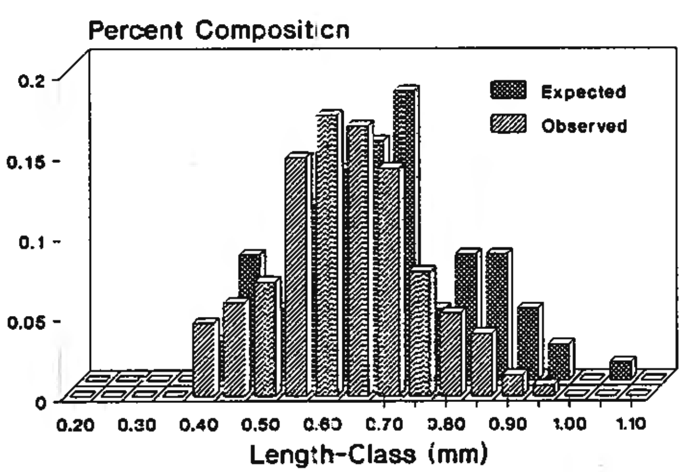

FIG. 6b. Percent composition by number of cyclopoid copepodid length-classes expected and observed in the stomach contents of larval lake whitefish.

perature and zooplankton abundance appear to have resulted in low larval whitefish survival prior to mid-April 1992. Follow-up studies to examine these ideas should include a more frequent sampling schedule.

Spawning Shoal Dive Surveys

Results of the 1992 lake whitefish spawning shoal dive surveys are presented in Table 3. Although the methodology of determining egg density changed from an earlier survey (1990, Hoyle and Melkic 1991), both surveys indicated that egg densities in the Bay of Quinte were greater at Makatewis Island compared with the Trident Point study site. Petticoat Point had not been surveyed previously, and it represents the first confirmed lake whitefish spawning site on Lake Ontario.

As was the case in 1990, no zebra mussels were found on the Bay of Quinte spawning shoals. However, for the first time, zebra mussels were documented on a Lake Ontario lake whitefish spawning shoal (50 per m^2).

Management Implications

A potential threat to lake whitefish populations in eastern Lake Ontario is zebra mussel (*Dreissena polymorpha*). In the present study, zebra mussels were recorded for the first time on lake whitefish spawning shoals in Lake Ontario. Bay of Quinte spawning shoals have yet to be colonized by the mussels. Zebra mussel are filter feeders. subsisting mainly on algae, and have the potential to change zooplankton community structure in Lake Ontario and the Bay of Quinte via their feeding ecology.

Since zooplankton community structure, during the first seven weeks of lake whitefish life, appears to be a major determinant of year-class strength (Freeberg et al. 1990), continued assessment of: (1) larval lake whitefish diet, growth, and survival. (2) zooplankton community structure, and (3) zebra mussel invasion, is strongly recommended.

Acknowledgements

Thanks to larval fish sampling field crews including, Dale Dewey, Steve Lawrence, and Tim Shannon. Larval lake whitefish otoliths were extracted and prepared by Dale Dewey and Tim Shannon, and interpreted by Tim Shannon. Zooplankton and stomach content samples were processed by Bill Geiling. Steve Lawrence and Dawn Walsh assisted with dive surveys which were conducted by Lower Lakes Diving Ltd., Peterborough, Ontario. Tom Stewart reviewed the manuscript.

Table 3. Results of lake whitefish spawning shoal dive surveys, including numbers of eggs and zebra mussels observed.

Survey date		Makatewis Nov. 17	Trident Nov. 20	Petticoat Nov. 23
No. samples		15	15	7
No. eggs				
	Total	64	19	15
	Range	0 - 26	0 - 5	1 - 4
	Mean (SE)	4.3 (1.7)	1.3 (0.3)	2.1 (0.4)
	Density (No./m^2)	17	5	8
No. zebra mussels				
	Mean (SE)	0	0	14.3 (3.7)
	Density (No./m^2)	0	0	57

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Pattern of Boat Launching Activity in Oakville during 1989

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Lake Ontario Fisheries Unit, 1992 Annual Report, Section 5

Parking attendants at Bronte Beach Launch Ramp and Shipyard Park, Oakville, recorded hourly counts of fishing and non-fishing boats launched daily for a sample of days from May to August, 1989. Return times were estimated from average fishing trip length obtained from another study (Stewart et al. 1990). The general pattern for estimated return times throughout the season indicated that Lake Ontario boat angler creel survey may have missed significant fishing activity.

Recommendations

1. Maintain expanded survey times implemented in 1991.
2. Re-analyze historical surveys and account for fishing activity missed prior to 11:00.

Introduction

Prior to 1991, Ontario Ministry of Natural Resources surveys of Lake Ontario boat anglers at launch ramps began at 11:00 and ended at 20:00. Activity after 20:00 was estimated from a count of boat trailers left in the parking lot at the end of the day. Activity before 11:00 was unknown and assumed to be low. This study was conducted to determine if significant effort was being missed outside the scheduled angler survey period.

Methods

Parking attendants at Shipyard Park in Oakville and the Bronte Beach Launch Ramp recorded the number of fishing and non-fishing boats launched hourly for a sample of days between the months of May and August. We stratified by weekend days (Saturday and Sunday) and weekdays (Monday to Friday). Return times were estimated from average trip lengths calculated from angler interviews conducted at Port Dalhousie, Fifty Point and Port Credit during 1989 (Stewart et al. 1990). Sample sizes for May and June were small and as a result data from the 2 sites were combined.

Results and Discussion

Fishing activity missed prior to the 11:00 start time ranged from 4 to 42 percent (Table 1), and differed with day-type (weekend day or weekday) and season (Fig. 1). The proportion of missed fishing activity was calculated based on the assumption that average trip lengths applied to early morning trips and as a result may be over estimated. Missed activity after 20:00 was low and was easily accounted for by counting trailers remaining in the lot at the end of the day. The highest percentage of activity missed was during weekdays in August. This activity would have been missed in angler surveys prior to 1991

Since this study was conducted, the creel day has been expanded to a 12 h period (09:00 to 21:00). Missed activity at the beginning of the day is assumed to be negligible. Previous surveys, although missing some fishing activity, provide a relative measure of changes in the fishery over time. Surveys prior to 1991 should be re-analyzed to account for missed fishing activity.

This study confirms that the expanded survey time implemented in 1991 was appropriate and should be maintained in future surveys.

Acknowledgments

We would like to thank the municipal parking attendants for taking the time to record this information for our use and a special thanks to Gurth Bramall, the City of Oakville Harbour Master.

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STEWART, T.J., P.J. SAVOIE, AND J.N. BOWLBY. 1990. Salmonid Angler Survey of the Western and Central Basins of Lake Ontario, 1989. Lake Ontario Fisheries Unit, 1989 Annual Report, LOA 90.1 (Chapter 12).

TABLE 1. Estimated percent activity outside surveyed creel period.

Month	Day-Type	Prior to AM Start	After Period Ends
May	Weekend	9%	3%
June	Weekday	26%	0%
July	Weekend	10%	12%
	Weekday	28%	10%
August	Weekend	4%	1%
	Weekday	42%	6%

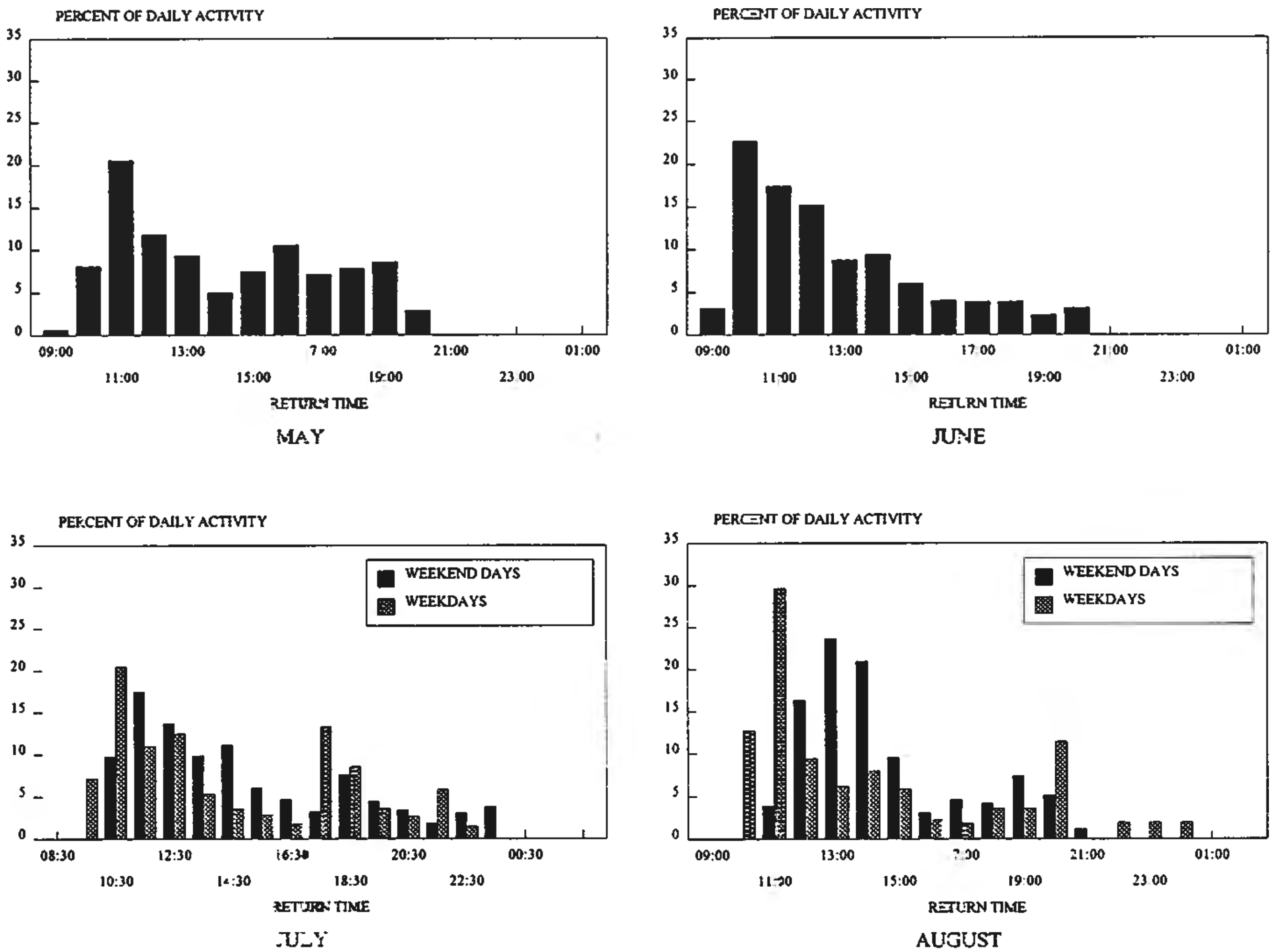

FIG. 1. Distribution of times returning to port for launch daily boat anglers each month. Only weekends were surveyed in May and June.

Lake Trout Rehabilitation in Lake Ontario, 1992.

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Lake Ontario Fisheries Unit, 1992 Annual Report, Section 6

Lake trout population trends in Lake Ontario are described. Stocking in 1992 has decreased by 33% from the previous year, and re-examination of past stocking levels and survival rates indicates that recent effective stocking rates are below those of early 1980s. Angling harvest and lamprey kills were low in 1992, resulting in good adult survival rate. The abundance of mature fish appears to be stable in U.S. waters, while the abundance of immature fish continues to decline. In Canadian waters, the abundance of mature fish may have reached a peak, while there is no evidence of decrease in abundance of immature fish.

Introduction

Rehabilitation of a naturally reproducing population of lake trout is the focus of a major international effort in Lake Ontario. Coordinated through the Lake Ontario Committee of the Great Lakes Fishery Commission, representatives from the cooperating agencies developed the Joint Plan for Rehabilitation of Lake Trout in Lake Ontario (Schneider et al. 1983), identifying a goal, interim objectives and strategies. The present report documents the progress of the rehabilitation effort. The methods used in monitoring and assessment of the lake trout population have been described in earlier reports, and readers interested in more detail should review the appendices in the 1986 Surveillance Report (Schneider et al. 1987).

Stocking

The 1992 stocking of 1.63 million fish represents a 33% decrease from 1991 (Fig. 1). Due to water supply problems at the Allegheny National Fish Hatchery, U.S. stocking was sharply reduced, and part of the 1991 year-class had to be stocked as fall fingerlings. Numbers of the 1992 year-class will also be affected, since only 500,000 are on hand for stocking in spring 1993. The 1992 Canadian stocking of 1.1 million fish was only slightly lower than in 1991, however, 248,000 of those fish were stocked as yearlings in late winter rather than spring. The success of this stocking is yet to be determined.

Sixty-six percent of the stocked fish were of Slate Island strain, stocked by Canadian hatcheries (Fig. 2). A small number of Seneca strain fish were also stocked in Canada for the first time. More than half of the fish stocked from U.S. hatcheries were Lake Ontario strain (hatchery-reared progeny of stocked fish that survived to maturity in Lake Ontario), with smaller numbers of Seneca, Lewis Lake, and Superior strain fish. Lake Ontario x Seneca cross was stocked for the first time.

Recruitment of stocked fish

The use of coded wire tags for marking fish has made it possible to evaluate the effects of rearing density, and time and method of stocking, on the post-stocking survival of lake trout. Experimental stockings have been made in U.S. waters since 1980, and survival in the first year in the lake varied.

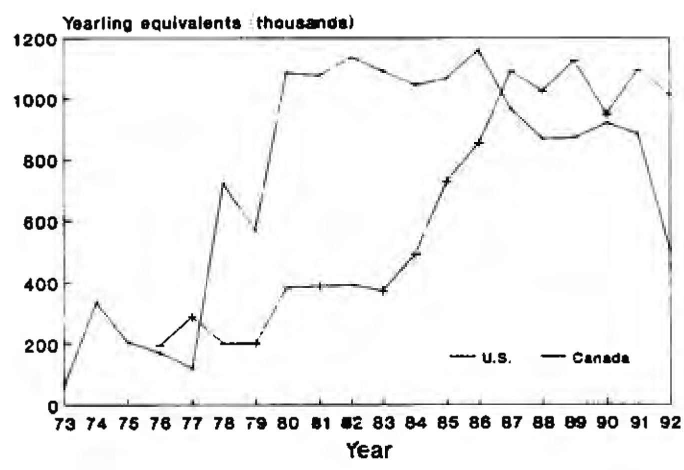

FIG. 1. Total yearling equivalents of lake trout stocked in Canadian and U.S. waters of Lake Ontario in 1992 (1 yearling = 2.4 fall fingerlings)

Fish reared at 40,000 per raceway stocked as yearlings in May were used as the standard for evaluating survival. Results revealed reduced first year survival for (1) fish stocked as fingerlings in the fall, (2) yearlings stocked in March, and (3) yearlings reared at 50,000 per raceway. Indices of survival, based on catches of 2-yr-old fish in bottom trawls in July-August, and catches of 3-yr-old fish in gillnets in September, showed that first year survival of the Superior strain declined during the 1980s, independently of the above factors. Survival was negatively correlated ($p<0.01$) with abundance indices of large (>550 mm) lake trout in the year of stocking. Recoveries of coded wire tags from fish captured with trawls and gillnets, and by anglers, indicate that survival during the first year after stocking was also variable among genetic strains. Using Superior strain fish of the 1979-81 year-classes (reared at 40,000 per raceway and stocked as yearlings in May) as the standard, numbers stocked in the U.S. waters were adjusted to reflect the cumulative effect of all the above factors on first year survival of individual year-classes. The adjusted numbers (Fig. 3) show a 74% decline in effective stocking rate from the 1980 to the 1991 year-class.

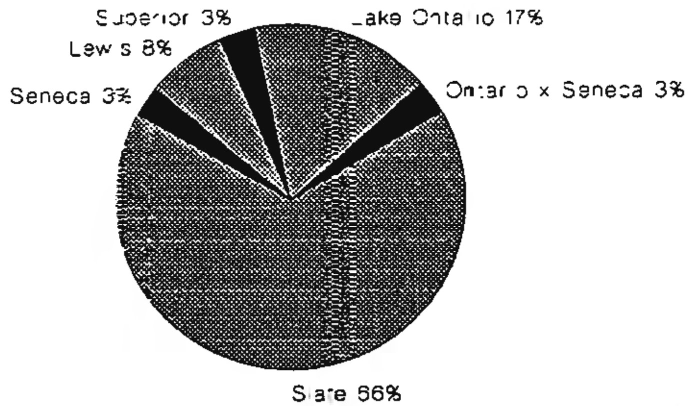

FIG. 2. Overall strain composition of lake trout stocked in Canadian and U.S. waters of Lake Ontario in 1992.

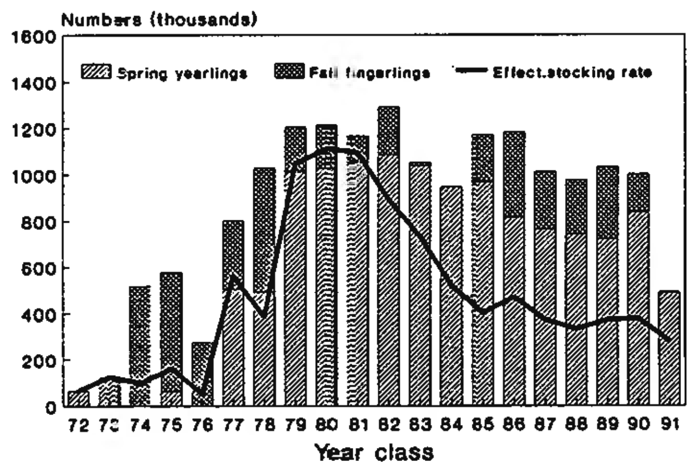

FIG. 3. Effective numbers of lake trout stocked by the U.S. compared with actual numbers stocked. The effective stocking levels were calculated by adjusting the actual numbers for (1) developmental stage at stocking, (2) month of stocking of spring yearlings, (3) rearing density at the hatchery, (4) genetic strain, and (5) abundance of large lake trout. The effective U.S. stocking levels are in contrast to the U.S. stocking levels shown in Fig. 1, which were adjusted only for developmental stage at stocking using a factor which probably overestimates the fingerling-to-yearling survival in recent years. Note also, that data for Fig. 1 were compiled by year of stocking, whereas the data in this figure were compiled by year-class of the stocked fish.

Abundance

Abundance of lake trout is monitored in yearly fall gillnet surveys. In the past we tracked abundance through the Relative Abundance Index, in which catches were adjusted by the bottom area of lake trout thermal habitat. This year we report the total catch from the fall index survey. The total catch is equivalent to catch-per-unit-effort, since the yearly effort in the survey is constant.

The abundance of mature lake trout, in the U.S. waters of rose substantially during the early 1980s (Fig. 4). The population of mature fish peaked in late 1980s due to increased stocking and reduced sea lamprey predation earlier in the decade, and abundance since then has remained stable (females) or slightly reduced (males). We expected a decline in abundance of mature fish between 1991 and 1992, but a low 1992 harvest in the U.S. waters allowed more fish to survive. The abundance of adult fish is expected to decline in the future, because of poor recruitment of recently stocked fish (see Recruitment). This poor recruitment is reflected in the slow but steady decline in abundance of immature fish. This trend is not likely to reverse, though if stocking levels and adult abundances were maintained, the abundance of immature lake trout may stabilize, possibly at some lower level.

In Canadian waters, the period of increase in adult abundance lasted throughout the 1980's and evidence of stabilization did not occur until 1990-1991, four years after the U.S. (Fig. 4). This time lag is consistent with the time lag in stocking histories of the two nations, where Canadian target levels were not reached until late 1980's. The abundance of immature lake trout in Canadian waters appears to be stable, however, based on U.S. experience, immature lake trout should be entering a period of decline, even if the stocking levels are maintained at the recent high levels.

Angling Harvest

Fishing is a major controllable component of lake trout mortality in Lake Ontario, and the harvest by U.S. and Canadian anglers is measured in a series of creel surveys. The coverage of the surveys varies. In the U.S. recent creel surveys (1985-1992) are assumed to account for about 85% of the total lake trout harvest. In Canada all major fisheries in the Western and Central basin are sampled on a yearly basis, however, an important lake trout fishery in the Outlet Basin is sampled once every five years.

The sports harvest of lake trout in the surveyed fisheries in U.S. waters in 1992 was estimated at 31,038 fish (Fig. 5). Including all fisheries and seasons the estimate would be about 36,500 fish. This is a 65% decrease from the previous year, and comparable only to the low harvest in 1988. The low 1992 harvest of lake trout is partly due to a decline in angling effort.

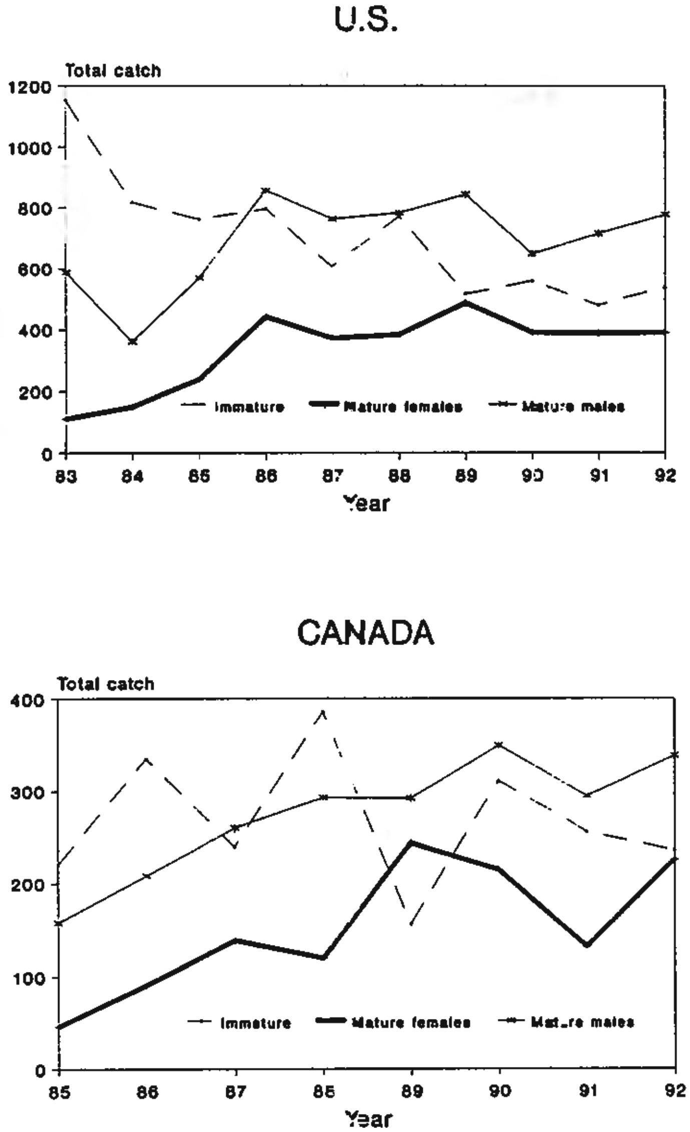

FIG. 4. Abundance of lake trout in U.S. and Canadian waters of Lake Ontario. Total catch in the lake trout gillnet survey is used to track abundance, since the yearly level and distribution of fishing effort in the survey is constant. The differences in total catches between U.S. and Canada are due to differences in fishing effort, and do no imply differences in abundance.

The Canadian harvest is traditionally well below the U.S. level, and in 1992 it decreased from previous years. The total estimate for 1992 is 13,812 fish. This includes an estimate of 3251 fish for all Central and Western basin fisheries, and an estimate of 10,561 fish for all Outlet Basin fisheries including harvest by U.S. anglers in Canadian waters. The Central and Western basin harvest has declined by more than 50% from the high 1990-91 levels. The 1992 harvest in the Outlet Basin was lower than the last measured harvest in 1987 (12,202 lake trout), though we suspect that the harvests in the intervening years has been higher (harvest estimates from Bowlby, OMNR, unpubli., and Savoie and Bowlby 1993).

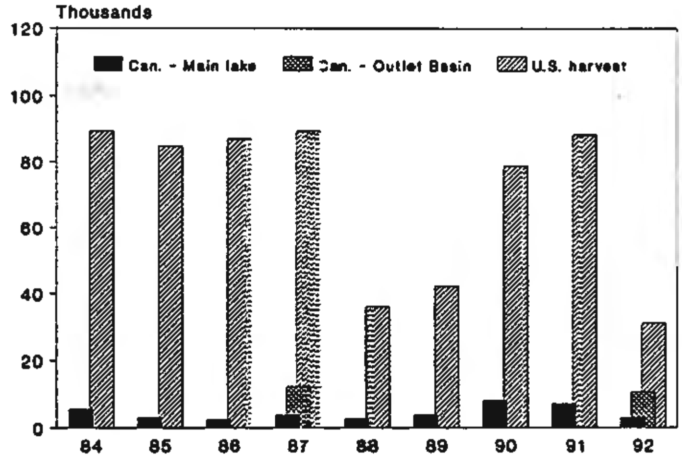

FIG. 5. Lake trout harvest. The U.S. harvest shown here is about 85% of the actual total harvest. The Canadian main lake harvest shown here represents all boat fisheries in Western and Central basins; the Canadian harvest in the Outlet Basin was surveyed only in 1987 and 1992.

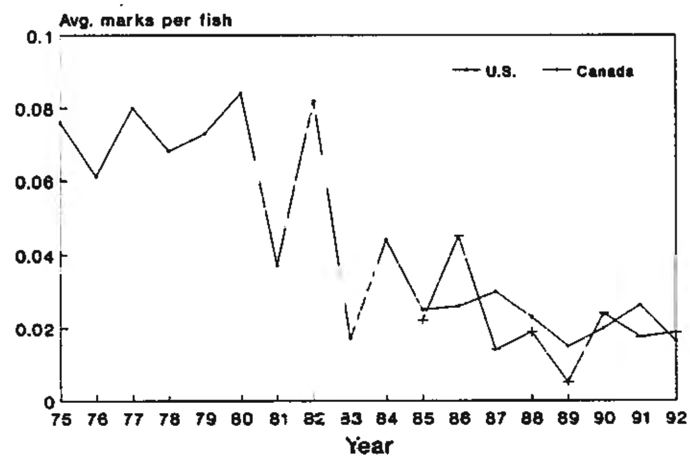

FIG. 6. Incidence of A1 (fresh) lamprey wounds in lake trout larger than 431 mm.

Sea Lamprey Mortality

Density of lake trout carcasses killed by sea lamprey, and the incidence of A1 wounds, are used to monitor the effect of sea lamprey in Lake Ontario. In Canadian waters in 1992, the incidence of A1 wounds in lake trout over 431 mm was 1.9 per 100 fish, virtually unchanged from 1991 (Fig. 6). In U.S. waters the incidence of A1 wounds decreased 39%, from 2.7 to 1.6 per 100 fish. Although yearly changes in wounding rates on the two sides of the lake do not appear to be related, the rates have remained low since 1987. The average age and length of fish with A1 wounds in 1992 are the highest observed to date (6.9 yr, 708 mm).

Lake trout carcass densities have been measured in U.S. waters in fall bottom trawling surveys since 1982. The results provide a direct measure of lake trout mortality due to lamprey attacks. In 1992, sixteen lake trout carcasses were recovered in late fall from 275 ha of bottom. Nine of the carcasses bore a lamprey wound, and of the remaining seven, six were too decomposed to determine the cause of death. One fish apparently died of natural causes other than lamprey.

Carcass densities in the 30-99 m depth stratum form the longest and most complete data series (Fig. 7). In 1992, density of lake trout killed by sea lamprey was 0.055 ha^{-1}, which is 61% lower than in 1991, and amongst the lowest ever observed. The average age and length of carcasses declined compared to 1991 (Fig. 8). Generally, the size and age of carcasses is positively correlated with the size and age of fish bearing A1 wounds. The discrepancy seen in 1992 may be due to the small number of recovered carcasses.

Expanding carcass densities by the bottom area in U.S. waters, and using a model to account for fish killed and decomposed before and after the survey, we estimate the total U.S. lamprey kill in 1992 to be 34,000 fish. This is a reduction of 66% from 1991.

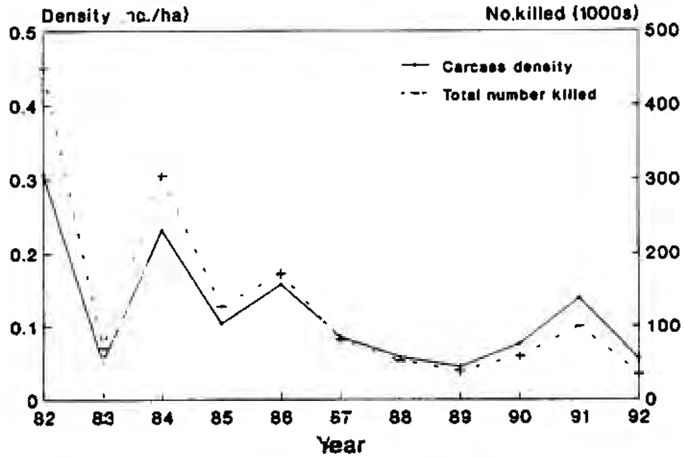

FIG. 7. Densities of carcasses observed in fall bottom trawl survey in the 39-99 m depth stratum, and estimated total number of lake trout killed in the U.S. waters.

Adult survival

Adult lake trout survival is monitored in fall gillnet surveys. Discussion here is limited to U.S. data due to the long-term use of coded wire tags, which permits accurate aging of fish. Estimation of survival rates from catch curves requires the assumption of constant recruitment. The catches are therefore adjusted to compensate for year-class strength. In the past, the number of stocked fish was used as a measure of year-class strength, and as the adjustment factor. Recent variable (and generally poor) survival of lake trout during their initial years in the lake suggested that abundance at some later stage in life would be a better measure of year-class strength. Combined gillnet CUEs at ages 2 and 3 yr were therefore used as the adjustment factor.

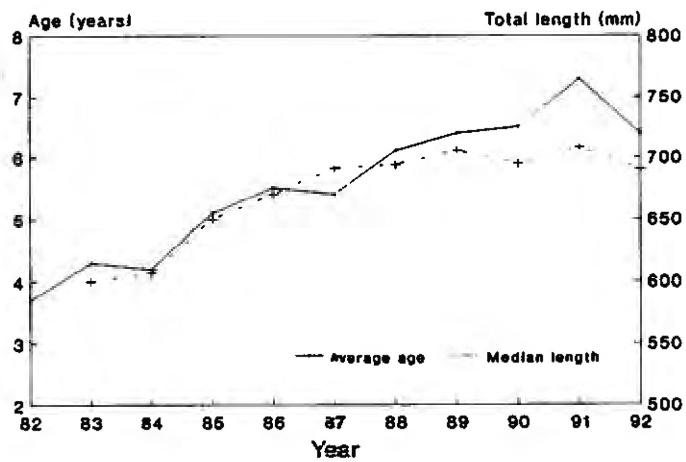

FIG. 8. Size and age of carcasses observed in fall bottom trawling survey in the 39-99 m depth stratum.

The 1992 survival of lake trout between ages 7 and 11 yr in U.S. waters was 47% (Fig. 9). This is an improvement over the 43% survival measured in 1991, but it was still below the peak value measured in 1989. We did expect some improvement in adult survival in 1992. Although sea lamprey took 40,000 more fish in fall 1991 than in fall 1990, the angling harvest in 1992 was 60,000 fish lower than in 1991.[1] Overall, there appears to be a continual improvement in survival. This is evident not only from the trend in survival estimates, but also in the flattening of the dome of the catch curve, in the highest average age of mature females (6.7 yr) observed in 1992, and in the increasing numbers of older fish represented in our samples.

Survival of lake trout in Canadian waters cannot be reliably measured yet. Extensive use of coded wire tags started only in 1987, and the first individuals from this group, aged 6 yr in 1992, are just now at the start of the age bracket in which we measure survival. We assume that the survival in Canadian waters is higher, due to the lower angling harvest. This assumption is supported by the fact that the largest (and presumably oldest) lake trout in the fall gillnet surveys are routinely taken in Canadian waters.

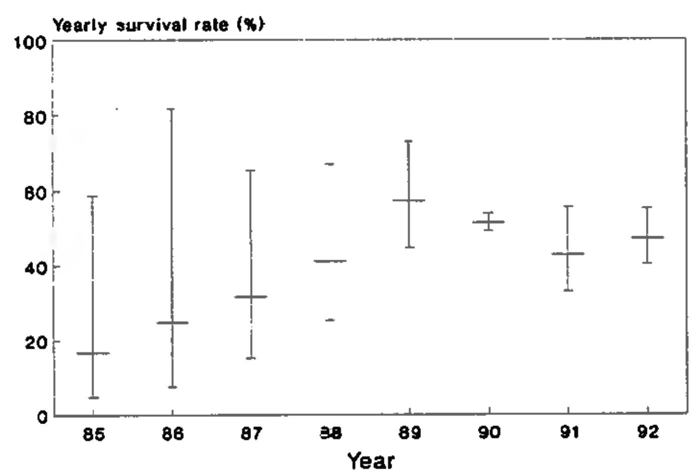

FIG. 9. Survival of adult lake trout. The estimates and 95% confidence limits are based on yearly catch curves, ages 7 to 11.

Growth and Condition

The condition of lake trout is assessed by calculating the weight of a 600 mm lake trout from weight-length regression (Fig. 10). The weight thus calculated has declined by 16%

1 We measure survival from September to September. Lamprey mortality occurs in the fall, and therefore previous calendar year's lamprey mortality and the current year's harvest contribute to the total annual mortality.

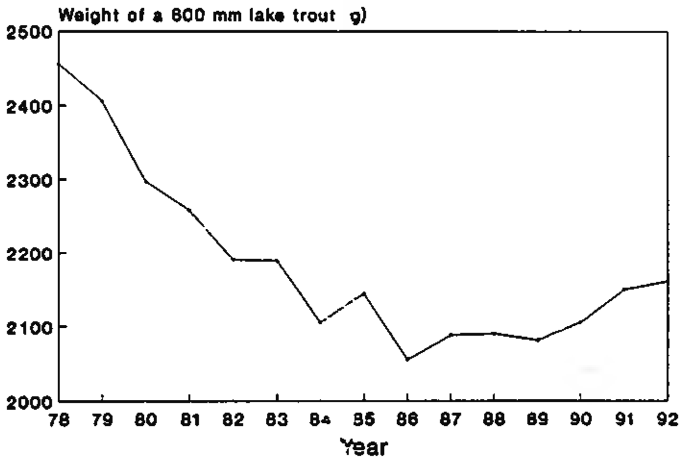

FIG. 10. Weight of a 600 mm lake trout, calculated from yearly weight-length regressions.

between 1978 and 1986, and increased again by 5% between 1986 and 1992.

The 600 mm length is close to the size at which lake trout become mature. Because the average onset of maturity has changed through time, the meaning of the weight-length relationship at this size may be confounded by changes in energy partitioning associated with reproduction. Therefore we compared changes in weights of fish based on regressions from individual 100 mm size classes. The comparisons showed that the increase in weight since 1986 is generally true only for the larger fish (700 and 800 mm) while the weights of smaller fish have been fluctuating. While the interpretation of size trends in young fish is confounded by size at stocking and strain, their growth in length and weight is related to the abundance of prey fish, and particularly small alewife (J. Elrod, unpublished data).

Forecast

1. Dwindling stocks of pelagic prey (O'Gorman et al. 1993, Schneider and Schaner 1993) demand some reduction or modification in predator pressure. Depending on the final outcome of fisheries management reviews by OMNR and NYSDEC, lake trout stocking may be reduced from the current target of 1 million yearlings per nation per annum. Due to difficulties at the Allegheny National Fish Hatchery, the New York stocking levels were already reduced in recent years, and numbers stocked by the U.S. in 1992 were only 50% of the target.
2. The harvest by both nations in 1992 was below the planned limit of 60,000 fish per nation. In the U.S. waters in 1993 a new slot limit will afford greater protection for adult lake trout, preventing the excessive harvests noted in 1990 and 1991. In the Canadian waters the harvest of lake trout has always been well below the allowable limit. We anticipate that angling harvests will remain within planned targets for both nations in 1993.
3. The estimated number of lake trout killed by sea lamprey in U.S. waters (34,000) is far below the anticipated level (100,000 per nation). Rates of A1 wounds in Canada suggest a similarly low lamprey mortality in 1992.
4. The lower lamprey and angling mortalities in 1992, and the continued low angling mortality anticipated for 1993, should result in continued improvement in adult survival rates in 1993.
5. Survival of hatchery stocked fish in U.S. waters has sharply declined (comparable data for Canadian waters are not available). This decline is closely associated with higher abundance of older lake trout. Consequently, as long as numbers of older, larger fish remain at the current levels, relative survival of stocked yearlings will likely remain depressed. The reductions in angling and lamprey mortalities do suggest that in the short term the adult lake trout population may stabilize at the current levels. However, poorer recruitment of stocked fish, and possible reductions in stocking levels to accommodate declining prey stocks will likely result a smaller lake trout population.

Acknowledgements

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The Boat Fishery in the Outlet Basin in 1992

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Lake Ontario Fisheries Unit, 1992 Annual Report, Section 7

Interviews of completed trip anglers were conducted at 12 access sites in the Outlet Basin of Lake Ontario from April 6, 1993 to September 20, 1993. On-water interviews determined the proportion of anglers from access points where no interviews were conducted. Surveyed sites accounted for 31,899 angler-hours which was only 38.4% of the total effort observed on the Outlet Basin. Anglers from other Canadian ports accounted for another 26,707 angler-hours (32.1%); anglers from American ports accounted for 24,481 angler-hours (29.5%). The growth in the fishery during the last five years has been substantial. Smallmouth bass dominated the catch of non-charter anglers, whereas, lake trout dominated the catch of charter anglers at surveyed sites. Charter anglers almost exclusively targeted lake trout. Lake trout dominated the harvest (10,561). Charter anglers kept 99.3% and non-charter anglers kept 76.8% of the lake trout that were caught. Lake trout rehabilitation was not threatened by these harvest levels. The quality of lake trout fishing is still excellent compared against other standards of catch rate. Brown trout catch was disappointingly low (431). This translates to a return rate of about 1 fish per 1000 stocked.

Recommendations

1. Consider redistribution of stocked brown trout to other parts of Lake Ontario to improve returns to anglers.

Introduction

The boat angling survey in the Outlet Basin (Canadian portion) of Lake Ontario has been scheduled only once every five years because of the relatively small size of the basin and its fishery. The last published survey was conducted in 1987 (Mathers 1988). The salmonid harvest in the Outlet Basin was responsible for 4% of the lake-wide (Canadian) harvest, and this fishery was responsible for only 1.8% of the total effort (Savoie and Bowlby 1991). However, the lake trout harvest in 1987 was 1.5 times greater in the Outlet Basin (Mathers 1988), than the total for fall shore fisheries (Savoie and Bowlby 1992), and charter, marina, and launch-daily boat anglers in Lake Ontario (Bowlby and Savoie 1992). Accordingly, assessment of this component of the angling fishery was important to determine impacts on our attempts to rehabilitate lake trout in Lake Ontario.

As well, in the five years from 1987 to 199[illegible], 582,508 brown trout were stocked by OMNR into the Outlet Basin. This represents a significant portion (29.4%) of the brown trout stocked by OMNR in this period. For assessment of brown trout stocking, this survey complemented surveys of shore anglers along the Outlet Basin conducted during fall 1991 and spring 1992.

This paper reports the results of the 1992 boat angling survey in the Outlet Basin (Canadian portion). The objectives of this survey were to describe changes to the character of the fishery since 1987, the assessment of lake trout harvest for impacts on rehabilitation, and the assessment of brown trout stocking.

Methods

This survey was designed with i) a completed trip interview component to obtain catch and effort data, and ii) an on-water component to estimate the proportion of catch and effort originating from locations where no access interview was conducted.

Interviews of completed trip anglers were conducted at 12 access sites (Fig. 1) from April 6, 1993 to September 20, 1993. This time span was divided into two 12-week seasons. Two weekdays (Monday - Friday) and two weekend days (Saturday and Sunday) were sampled each week. Each sampling day was divided into four 3-hour periods from 9:00 to 21:00. In addition, anglers were separated into three fishing modes, as follows: i) Lake Ontario charter anglers, ii) Lake Ontario non-charter anglers and iii) St. Lawrence River and Cataraqui River anglers. Only the results of Lake Ontario anglers were presented here. Thus, analysis was based on stratification by access site, season, day type, period of the day, and fishing mode. Access sites were marinas or launch ramps or both (Table 1). For example, in Collins Bay there were three marinas, a motel with charter boat dockage, and a public launch ramp. We placed a boat in the middle of Collins Bay so that anglers on their way to any of these dockages could be interviewed. At all other sites the interviews were land based. Although data to separate marina anglers from launch ramp anglers was recorded it was not used for analysis here.

An unbalanced design was chosen to optimize the number of interviews and biological samples from high activity sites while retaining some information from low activity sites. The

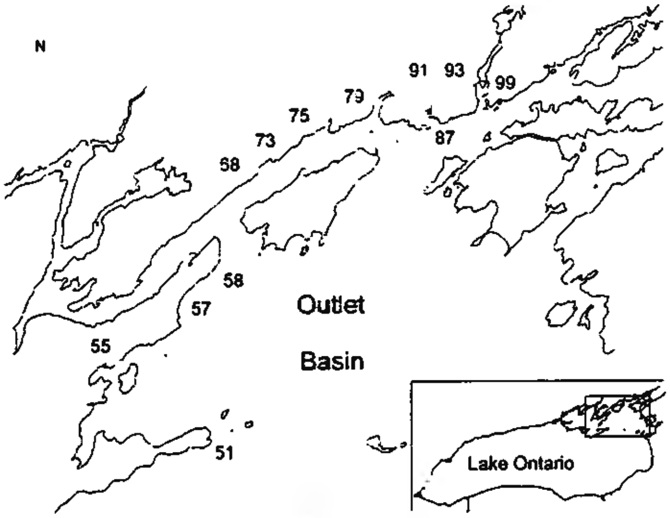

FIG. 1. Location of access sites in the Outlet Basin of Lake Ontario surveyed during 1992. See Table 1 for name of access sites.

TABLE 1. Sampling design of angler survey in the Outlet Basin of Lake Ontario during 1992.

Access site	Site number	Facility[1]	Number of samples	Duration of samples (h)
Long Point	51	R,D	24	2.50
Waupoos	55	R,M	24	2.50
North Marysburgh	57	R	24	1.00
Prinyer's Cove	58	R,M	24	1.00
Bath, West Ramp	68	R	35	0.75, 1.25[2]
Millhaven	73	R	18[3]	0.75, 0[2]
Celanese Plant	75	R	35	0.75, 1.25[2]
Collins Bay	79	R,M,D	72	2.50
Portsmouth Olympic Harbour	87	R,M	72	2.50
West Street	91	R	36	0.75
Confederation Basin	93	M	36	0.75
Rideau Marina	99	R,M	36	0.75

1 - R = ramp; M = marina; D = private or government dock.
2 - Season 1, season 2.
3 - No samples in season 2.

TABLE 2. Estimates of angler effort at surveyed access sites in the Outlet Basin of Lake Ontario in 1992.

Access site	Non-charter	Charter	Total
Long Point	1718	0	1718
Waupoos	633	0	633
North Marysburgh	344	0	344
Prinyer's Cove	0	0	0
Bath, West Ramp	1286	0	1286
Millhaven	749	0	749
Celanese Plant	0	0	0
Collins Bay	8355	7844	16199
Portsmouth Olympic Harbour	8471	2136	10607
West Street	257	0	257
Confederation Basin	0	0	0
Rideau Marina	108	0	108
Total	21919	9980	31899

survey technician worked a 9-hour day and this led to the second and third periods being sampled twice as often as the first and the fourth periods. As well, some sites were sampled more often than others and some sites were sampled for a longer duration than others (Table 1). The greatest sampling intensity was at Collins Bay and Olympic Harbour.

A site was sampled during one period on any given day. Sometimes more than one site was sampled within a period. As well, travel time between sites prevented complete activity counts for any sites within a period. The catch, harvest, and effort were weighted according to the duration a site was surveyed. Where more than one site was sampled within a period, the order of sampling sites within that period was varied on subsequent samplings. At Millhaven, the ramp was closed near the end of the first season. During the second season, it was not sampled and more time was spent at other nearby sites.

Data entry, and summarization of data at the level of a single sample was performed by CREESYS (ver. 3.3) software (Lester and Trippel 1985). Programs written in SAS (ver. 6.03) were used to weight the catch, harvest, and effort according to the duration a site was surveyed. Then further summarization using the strata listed above were performed by programs written in SAS.

The on-water component was done with the aid of conservation officers during regular patrol on the Outlet Basin. For each boat interviewed, the number of anglers, angling location, and their port of origin were recorded. Coverage of the Outlet Basin by the conservation officers was evenly distributed and, therefore, assumed to be representative of the fishery. The proportion of anglers from access points where no interviews were conducted was used to expand catch statistics estimated for access sites where interviews were conducted.

Results and Discussion

At access sites, 519 non-charter and 75 charter anglers were interviewed. Conservation officers interviewed another 112 anglers on water. The first interviews at access sites were on April 18, 1992. Ice may have reduced fishing activity earlier in April.

Effort

Non-charter anglers accounted for 68.7% of the effort (Table 2) at surveyed access sites in the Outlet Basin. Collins Bay and Portsmouth Olympic Harbour accounted for most of the non-charter effort and all of the charter effort at these sites; 84.0% of the effort from surveyed sites came from these sites (Table 2). No effort was observed at Prinyer's Cove, Celanese Plant or West Street, although boat trailers were occasionally seen at these and other unsurveyed ramps. Surveyed sites accounted for 31,899 angler-hours which was only 38.4% of the total effort observed on the Outlet Basin. Anglers from other Canadian ports accounted for another 26,707 angler-hours (32.1%); anglers from American ports accounted for 24,481 angler-hours (29.5%). This represents more than double the 1987 effort (Mathers 1988). In 1987, the survey was from May 16 to September 18. However, the increased duration of the survey (about one month of activity) in 1992 could not account for this increase in effort. Thus, the growth in the fishery during the last five years has been substantial. Many anglers and charter operators expressed the

TABLE 3. Catch and harvest statistics for surveyed access points in the Outlet Basin of Lake Ontario during 1992.

Species	Catch	Harvest	Catch rate (no. h^{-1})	Harvest rate (no. h^{-1})
Non-charter				
American eel	5	0	0.0003	0.0000
Chinook salmon	5	5	0.0003	0.0003
Rainbow trout	5	5	0.0003	0.0003
Brown trout	173	65	0.0079	0.0030
Lake trout	1288	989	0.0588	0.0451
Northern pike	1118	78	0.0510	0.0036
Carp	5	0	0.0003	0.0000
Bullhead	74	68	0.0034	0.0031
Channel catfish	16	0	0.0007	0.0000
Rock bass	1561	5	0.0712	0.0003
Smallmouth bass	6217	576	0.2836	0.0309
Largemouth bass	1138	0	0.0519	0.0000
Sunfish	27	0	0.0012	0.0000
Yellow perch	2000	43	0.0913	0.0020
Walleye	304	105	0.0139	0.0048
Freshwater drum	14	8	0.0006	0.0004
Charter				
Chinook salmon	75	75	0.0075	0.0075
Brown trout	11	11	0.0011	0.0011
Lake trout	3088	3066	0.3094	0.3072
Smallmouth bass	43	0	0.0043	0.0000
Freshwater drum	11	0	0.0011	0.0000

opinion that effort (directed towards salmonids) was down from 1991 due to lower catches. Charter effort declined from 1990 to 1991 in the Outlet Basin (Michaelsen 1993), and so the salmonid component of the fishery may have peaked by 1990.

The on-water survey indicated our access survey adequately covered the available access sites. Most of the effort from unsurveyed Canadian ports was from private docks.

Catch and Harvest

Smallmouth bass dominated the catch of non-charter anglers, whereas, lake trout dominated the catch of charter anglers at surveyed sites (Table 3). Charter anglers almost exclusively targeted lake trout. Some bass charters originating from Wolfe Island were observed during the on-water survey but these anglers, for the most part, fished the St. Lawrence, and only occasionally entered the Outlet Basin. Lake trout dominated the harvest. Charter anglers kept 99.3% and non-charter anglers kept 76.8% of the lake trout that were caught (Table 3). The total catch and harvest of lake trout (expanded to anglers from all ports; Table 4) was lower in 1992 than 1987 (Mathers 1988), despite an overall increase in effort over the same period. However, lake trout catch rate by anglers who targeted lake trout (0.414 fish/h) was slightly higher than in 1987. In comparison to the salmonine catch rate for launch daily anglers in western Lake Ontario when it peaked in 1986 (Daniels and Kristmanson 1987), the salmonine catch rate for charter anglers in the Outlet Basin (0.318 fish/h) was 23.4% greater. Although lake trout catch rates may have declined in the past two or three years (according to some anglers and charter operators), the quality of fishing was still excellent compared to other standards of

TABLE 4. Expanded catch and harvest in the Outlet Basin of Lake Ontario by charter and non-charter anglers from Canadian and American ports during 1992.

Species	Catch	Harvest
American eel	14	0
Chinook salmon	209	209
Rainbow trout	14	14
Brown trout	481	200
Lake trout	11396	10561
Northern pike	2911	203
Carp	14	0
Bullhead	192	178
Channel catfish	42	0
Rock bass	4065	14
Smallmouth bass	16305	1762
Largemouth bass	2965	0
Sunfish	70	0
Yellow perch	5210	113
Walleye	791	273
Freshwater drum	65	21
Total	44759	13549

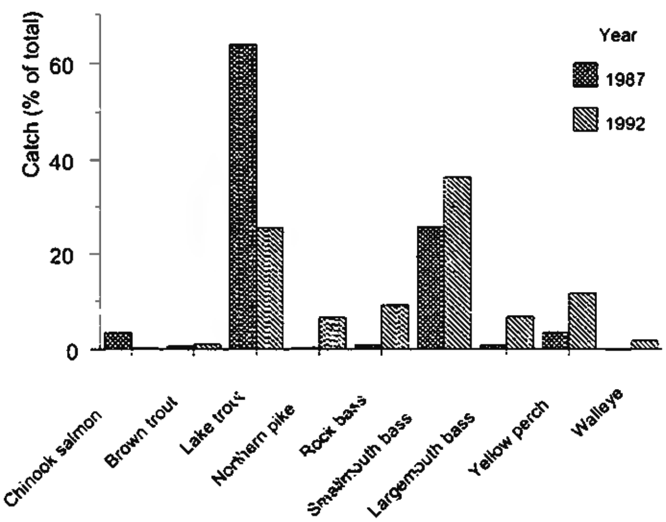

FIG. 2. Comparison of 1987 and 1992 species catch distributions of angler surveys in the Outlet Basin of Lake Ontario.

catch rate. Lake trout rehabilitation was not threatened by these harvest levels.

Brown trout catch was disappointingly low (Table 4) considering the large numbers that have been stocked in recent years. Only 67% percent of the observed brown trout were stocked by OMNR. This translates to a harvest return rate of about 1 fish per 1000 stocked.

The increase in effort in 1992 over 1987 appears to be directed towards smallmouth bass and other warmwater species (Fig. 2). Smallmouth bass catch was about triple in 1992 (Table 4) compared to 1987 (Mathers 1988), but harvest was quite similar in both years. Release rates were high with most warmwater species (Table 4), indicating that more anglers now "fish for fun" than in 1987.

As with effort, the greatest catch was from Collins Bay

TABLE 5. Catch by charter and non-charter anglers for access sites in the Outlet Basin of Lake Ontario during 1992. See Table 1 for name of access sites.

Species	Access site								
	51	55	57	68	73	79	87	91	99
American eel	0	0	0	0	0	0	5	0	0
Chinook salmon	0	0	0	0	0	58	22	0	0
Rainbow trout	0	0	0	0	0	5	0	0	0
Brown trout	16	0	0	0	108	60	0	0	0
Lake trout	146	0	0	0	0	3346	883	0	0
Northern pike	32	261	0	0	0	105	719	0	0
Carp	0	0	0	0	0	5	0	0	0
Bullhead	0	68	0	0	0	5	0	0	0
Channel catfish	16	0	0	0	0	0	1442	0	0
Rock bass	0	0	0	0	0	119	11	0	0
Smallmouth bass	437	0	0	275	0	1085	4431	0	0
Largemouth bass	0	103	0	0	0	56	979	0	0
Sunfish	16	0	0	0	0	0	0	0	0
Yellow perch	97	0	0	259	0	1113	531	0	0
Walleye	16	0	0	0	0	128	159	0	0
Freshwater drum	0	0	0	0	0	19	5	0	0

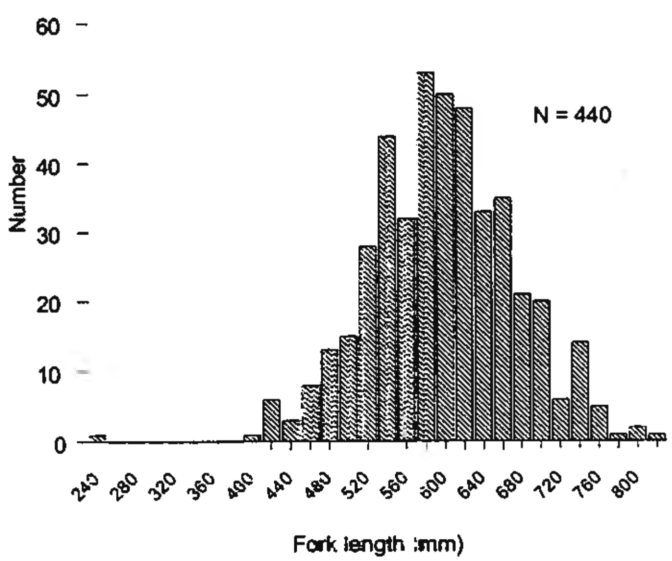

FIG. 3. Length distribution of angler-caught lake trout in the Outlet Basin of Lake Ontario during 1992.

TABLE 6. Mean fork length and weight of fish caught by anglers in the Outlet Basin of Lake Ontario during 1992. Sample size is indicated by the numbers in parentheses.

Species	Fork length (mm)	Weight (kg)
Chinook salmon	551 (9)	2.90 (8)
Brown trout	511 (6)	2.42 (6)
Lake trout	592 (440)	2.18 (7)
Northern pike	663 (15)	2.63 (9)
Small mouth bass	320 (37)	0.57 (37)
Yellow perch	218 (8)	-
Walleye	540 (12)	1.75 (12)

(79; Table 5) and Portsmouth Olympic Harbour (87; Table 5). Both cold-water and warmwater anglers used these ports.

Biological Characteristics of the Catch

The length distribution of lake trout in the survey was similar in 1992 (Fig. 3) and 1987 (Mathers 1988). The mean size of selected species in the survey was presented in Table 6.

Acknowledgments

The access survey was performed by David Featherstone and Richard Kalendra of Envirosphere Limited. The on-water survey was performed with the help of Bruce Chenier, Mark DesLauriers, Dave Jones, Mike MacDonald, Robert Orok, Tom Stewart, Rick Todd, and John Wagstaff. Sandra Michaelsen assisted with data management and analysis.

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Yellow Perch Population Dynamics Near Brighton, Lake Ontario

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Commercial harvest and assessment index gillnetting data were used to examine factors regulating Lake Ontario yellow perch (*Perca flavescens*) population dynamics from the mid-1970's to 1992 in the waters off Brighton, Ontario. Commercial harvest peaked in the early 1980's when two strong year-classes of yellow perch (1977 and 1978) recruited to the fishery as 3 and 4-yr-olds. Mean length of yellow perch declined dramatically in the commercial harvest from 1981 (204 mm), the year of peak harvest, to 1982 (188 mm). Mortality of the 1977 and 1978 year-classes from age 4 to 5 was extremely high, averaging 85%, as a result of the commercial 'fishing-up' process, but declined for subsequent year-classes. The capacity of the commercial fishery to impact yellow perch populations in the Brighton area was reduced markedly in 1984 with the introduction of quota management, minimum size limits on yellow perch, and mesh size restrictions on gillnets. The capacity was reduced further in subsequent years with 'buy-outs' of commercial fish licenses, yellow perch quota reductions, and shortened fishing seasons. By far the strongest yellow perch year-class, 1977, was coincidental with the last catastrophic alewife (*Alosa pseudoharengus*) die-off in Lake Ontario during the winter of 1976/77. Yellow perch abundance and growth in their first year of life declined for several year-classes following 1977, and were negatively correlated with young-of-the-year (YOY) alewife abundance. Trends in yellow perch population dynamics since the early 1980's were much less clear. Large numbers of small perch were observed in some years but these fish were not recruited to marketable-sized fish in subsequent years. Fluctuating growth rates since the early 1980's cannot account for the current shortage of large yellow perch. Rather, high mortality rates seem to be the most significant factor.

Recommendations

1. Maintain the long-term yellow perch index netting site at Middle Ground.
2. Analyze historic yellow perch commercial harvest data (e.g. size and age composition) for Quota Zone 1, and relate results to the Middle Ground index netting data series.
3. Routinely interpret yellow perch age (from assessment index nets and the commercial fishery) from other areas of Lake Ontario, including the Bay of Quinte, to contrast regional variation in yellow perch growth rates, and to provide better population status information for managers.
4. Conduct studies to determine habitat and prey selection patterns of YOY alewife and yellow perch in Lake Ontario.
5. Collect top predator (e.g. lake trout and walleye) stomach content data at times of the year when, and where, potential predator distribution patterns overlap with yellow perch populations (e.g. spring spawning concentrations).

Introduction

The yellow perch (*Perca flavescens*) is one of the most important commercial species in Lake Ontario. The majority of the commercial harvest comes from eastern Lake Ontario including the Bay of Quinte. In 1991, this species provided the highest revenue (over $300,000) and the third highest harvest (100,000 kg) of all commercial species.

Historical Perspective

Historically, the commercial harvest of yellow perch from Lake Ontario fluctuated around 50 to 60 thousand kg, and was determined primarily by the marketability of yellow perch and the availability of higher priced species such as lake trout, lake whitefish and walleye (Christie 1973). Yellow perch commercial harvest increased dramatically beginning in the late 1960's. The increase in the Bay of Quinte commercial harvest was thought to be related to the decline in abundance of the more desirable species, and to the development of the white perch gillnet fishery which, at the time, used the same mesh sizes. In contrast, increased yellow perch commercial harvest in Lake Ontario proper could not be accounted for by increased fishing effort, and was thought to be related to real increases in yellow perch abundance. Commercial fisherman reported catching yellow perch in areas not previously inhabited, and to have found spawning concentrations of fish along extensive areas of shoreline not previously used for spawning (Christie 1973, Christie et al. 1987). The Lake Ontario commercial harvest of yellow perch peaked at over 500,000 kg in the early 1980's then declined dramatically, finally stabilizing at about 100,000 kg for the last several years (Fig. 1).

Assessment of Yellow Perch Populations

An assessment gillnet site was established at Middle Ground near Brighton, Ontario in the 1970's to provide biological attribute and abundance data for Lake Ontario yellow perch (Fig. 2). The Middle Ground site, located within commercial harvest Quota Zone 1 (Ontario Ministry of Natural Resources, former Napanee District commercial harvest quota zones, Fig. 2), provides the best source of long-term data available to examine trends in yellow perch population dynamics.

Quota Management

Active management of the Lake Ontario yellow perch commercial fishery began in 1984 with the introduction of harvest quotas, minimum yellow perch size (7.5 inches total length) and gillnet mesh size restrictions (2 5/8 inches stretched mesh; this restriction was relaxed to 2 1/4 inches in 1991), and season reductions. The total yellow perch quota allocation to the commercial industry, which was initially based on the extremely high harvest levels of the early 1980's, did not limit yellow perch harvest in most areas through much of the 1980's.

Since 1984, further changes to the yellow perch commercial fishery, including license 'buy-outs', yellow perch quota reductions, and shortened seasons (summarized in Table 1), have resulted in significant reductions in quota allocation and harvest. These measures were directed mainly at the gillnet fishery which historically accounted for most of the yellow perch harvest, and which more recently began to experience incidental catch problems as Lake Ontario lake trout and walleye populations expanded. Thus, the capacity of the commercial fishery to impact yellow perch populations, particularly in the Brighton area (Quota Zone 1) was reduced markedly (Table 1).

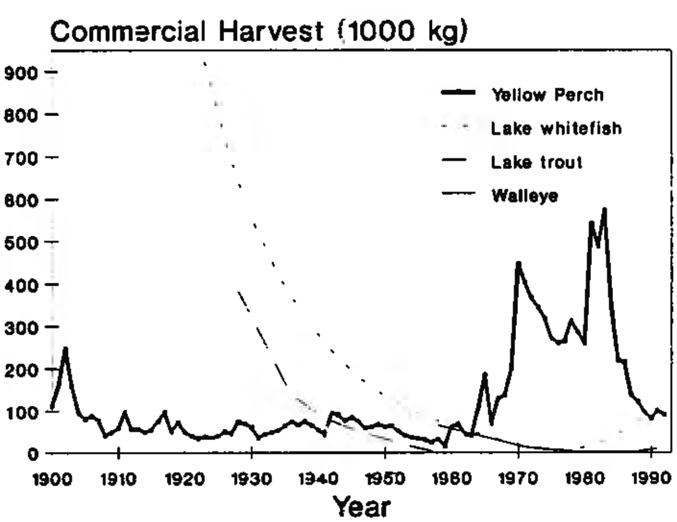

FIG. 1. Commercial harvest of yellow perch from 1900 to present from the Canadian waters of Lake Ontario. The commercial harvest of lake trout, lake whitefish, and walleye are shown as smoothed curves representing their respective declines from peak commercial harvests.

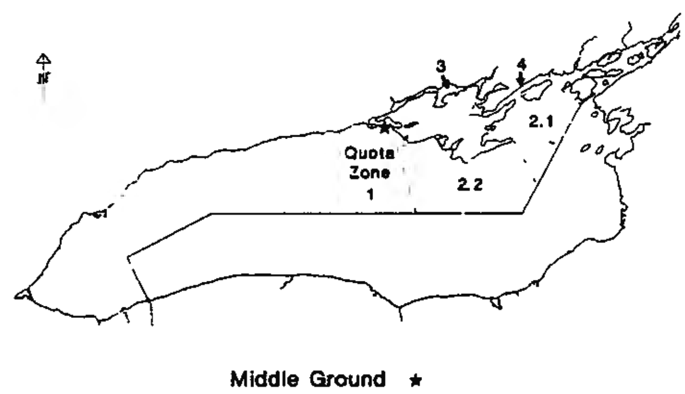

FIG. 2. Location of the long-term assessment index gillnetting site at Middle Ground, near Brighton, on Lake Ontario. Commercial harvest quota zones (Ontario Ministry of Natural Resources, former Napanee District Quota Zones: 1, 2.1, 2.2, 3, 4, and 5) are also indicated.

Interspecific Interactions With Alewife

Factors regulating Lake Ontario yellow perch population dynamics are not well understood. Alewife (*Alosa pseudoharengus*) have been implicated as a negative force influencing recruitment and growth of yellow perch (Smith 1968, Abraham 1983, Eck and Wells 1987) and other fish species (Smith 1970, Crowder 1980, O'Gorman et al. 1987) in the Great Lakes.

Study Objectives

In this report, I document trends in the Lake Ontario yellow perch commercial harvest, and by focusing on the relatively long-term assessment data series at Middle Ground, I also examine and discuss some of the factors which have, and may currently be regulating yellow perch population dynamics.

Methods

Commercial Harvest Data

Yellow perch commercial harvest data were summarized for the Canadian waters of Lake Ontario, 1900 to present. The harvest data were also summarized separately for commercial harvest Quota Zone 1 in order to examine the ability of this area to reflect annual trends in yellow perch commercial harvest for the rest of the lake. Yellow perch size distribution data from the Quota Zone 1 commercial harvest (1980 to 1982 only) were also examined.

Assessment Index Netting

Hoyle (1992a) described the field sampling protocol for the Middle Ground index gillnetting site.

Three-yr-old female yellow perch traditionally made up the majority of the catch in our index nets, and as such, provided much of the data for this report including indices of yellow perch year-class strength and growth (note that female yellow perch also make up the vast majority of the commer-

TABLE 1. Changes in the Lake Ontario yellow perch commercial fishery 1984 to 1992. The number or season before and after the score (/) are for the whole lake and for Quota Zone 1, respectively. Note that, since 1984, no gillnets can be used in Quota Zone 3. Therefore, the number of gillnet licenses and seasons refer to Quote Zones 1, 2, and 4 but the quota and harvest statistics refer to Quota Zones 1, 2, 3, and 4.

	1984	1992
No. gillnet licenses	86/11	34/2
Licensed gillnets (m)	420750/63250	170500/22000
Gillnet season (small mesh)	All year	Jan 1-Apr 30[1]; Jul 27-Aug 31 Jul 1-Dec 31[1] Jan 1-Apr 30[2] Sep 1-Dec 31[2]
Quota (kg):		
All gear	429287/56798	190355/27075
Gillnets	279453/29245	94393/3562
Harvest (kg):		
All gear	351540/ n/a	86859/3605
Gillnets	n/a / n/a	60110/1321

1. Quota zone 2, see Fig. 2
2. Quota zone 4

cial harvest). Yellow perch greater than 7.5 inches total length were used to index the abundance of commercially vulnerable fish, although the 7.5 inches minimum size limit was not legislated until 1984.

Age and Growth

Yellow perch age was interpreted from scales by one experienced individual. Scale imprints on acetate slides were viewed under a microfiche reader, and checks, including those associated with annuli, were digitized using a digitizing tablet. Growth was determined by back-calculation of fish lengths from measurements of scale annuli. Geometric mean regressions were used to show that annual increments of yellow perch fork length were proportional to annual increments between annuli on scales for each sampling year (total sample size = 857, n varied from 35 to 105 among years, $r = 0.88$ to 0.93, $p<0.05$).

Growth was reported and compared across years in two ways: (1) mean length of 3-yr-old females back-calculated to the beginning of their fourth growing season, and (2) instantaneous rate of increase in length of 3-yr-old females during their first year of life.

Mortality

Total annual mortality was calculated by year-class for female yellow perch from age 4 (modal age-class + 1) to 5 as:

$$1 - (\text{CUE-at-age 5} / \text{CUE-at-age 4}),$$

where CUE = catch-per-unit-effort in assessment index gillnets.

Interspecific Interactions with Alewife

Annual estimates of alewife population size (adults and yearlings) were obtained from O'Gorman and Schneider (their Table 2, 1986). These estimates were derived from bottom trawls conducted during the spring, since, 1978 in U.S. waters of Lake Ontario. I used correlation analysis (log-log relationships) to examine the relationships between alewife (adult abundance and year-class strength) and yellow perch (growth and year-class strength).

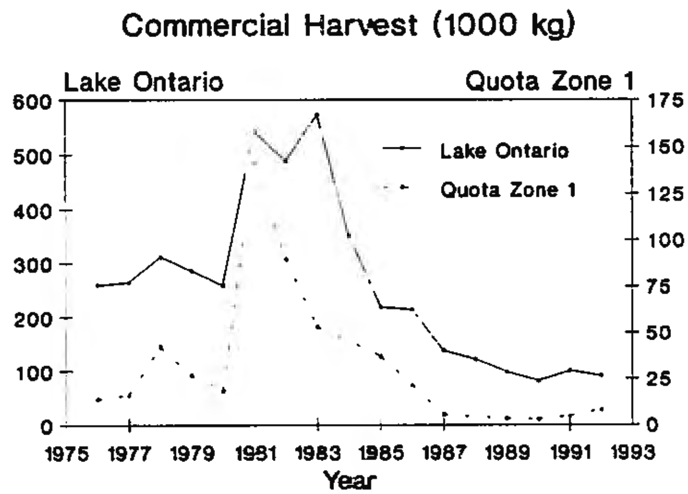

FIG. 3. Commercial harvest of yellow perch from the Canadian waters of Lake Ontario and from commercial harvest Quota Zone 1, 1976 to 1992.

Results

Harvest and Abundance

The commercial harvest of yellow perch in Quota Zone 1 (Middle Ground area, Fig. 2) increased dramatically in 1981, rapidly declined to a low in 1991 then increased slightly during the past two years (Fig. 3). The commercial harvest of yellow perch in Quota Zone 1 seemed to parallel the total harvest for Lake Ontario but there were some important exceptions.

Total Lake Ontario commercial harvest was sustained at peak levels for three years in the early 1980's, dropping off beginning in 1984, the year in which quota management was introduced (Table 1). By way of contrast, the peak commercial harvest in Quota Zone 1 (1981) could not be sustained beyond one year, and dropped off prior to quota management. The contribution of yellow perch harvested in Quota Zone 1 to the total Lake Ontario harvest averaged less than 9% from 1976 to 1980, increased dramatically to 26%

in 1981, then declined to less than 4% during the 1987 to 1990 time period.

There were significant differences between total yellow perch CUE in assessment index gillnets at Middle Ground and the local commercial harvest (Fig. 4). While the high total catch in 1980 index nets was comprised of a relatively high proportion of large yellow perch (i.e. 7.5 inches), the peak catches in 1981 and 1986 were comprised of small fish.

Catch-per-unit-effort of marketable-sized yellow perch (7.5 inches) in index nets more closely paralleled the local commercial harvest but index net catches peaked one year sooner (1980), and declined faster than the commercial harvest (Fig. 4).

Length distribution

Yellow perch length distributions in index gillnets and in the commercial harvest are shown for the years 1980 to 1982 in Fig. 5). Large yellow perch were selected by the commercial fishery. The mean fork length of yellow perch in the commercial harvest was similar in 1980 (mean = 205 mm, n = 90) and 1981 (mean = 204 mm, n = 210) but declined dramatically in 1982 (mean = 188 mm, n = 328). The mean fork length of yellow perch in index nets increased slightly from 1980 (mean = 156 mm, n = 271) to 1981 (mean = 158 mm, n = 292), and then declined in 1982 (mean = 153 mm, n = 470).

Prior to 1982, few fish less than 7.5 inches (about 180 mm fork length) were harvested (5 to 6% in 1980 and 1981). In 1982, 41% of yellow perch harvested were less than 7.5 inches.

Year-class strength

The large yellow perch commercial harvests and index netting catches in the early 1980's were comprised mainly of the 1977 year-class. This year-class showed up as 2-yr-olds in 1979 index nets (Fig. 6), peaked as 3-yr-olds in 1980 but had disappeared by 1984 (no 7-yr-olds observed). The 1978 year-class was the second largest year-class observed in the data series (Fig. 7).

Total annual mortality for these two year-classes from age

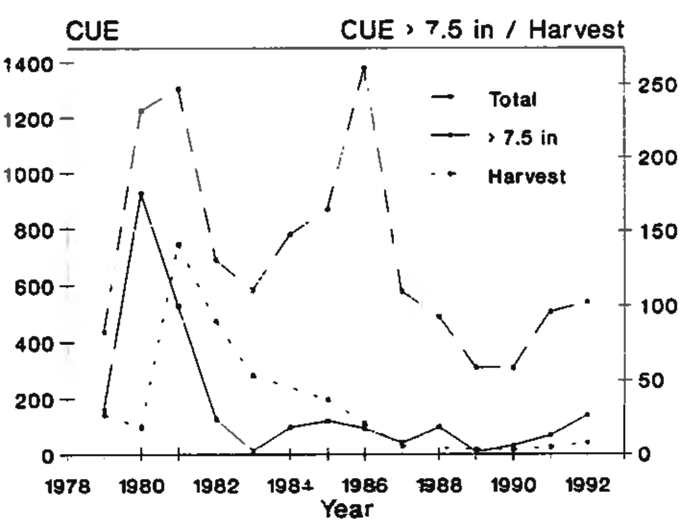

FIG. 4. Catch-per-unit-effort (CUE) of all yellow perch (left hand y-axis) and for those greater than 7.5 inches total length (right hand y-axis) in assessment index gillnets at Middle Ground, 1979 to 1992. The yellow perch commercial harvest from Quota Zone 1 is also shown for comparison (right hand y-axis, same axis as for CUE greater than 7.5 inches).

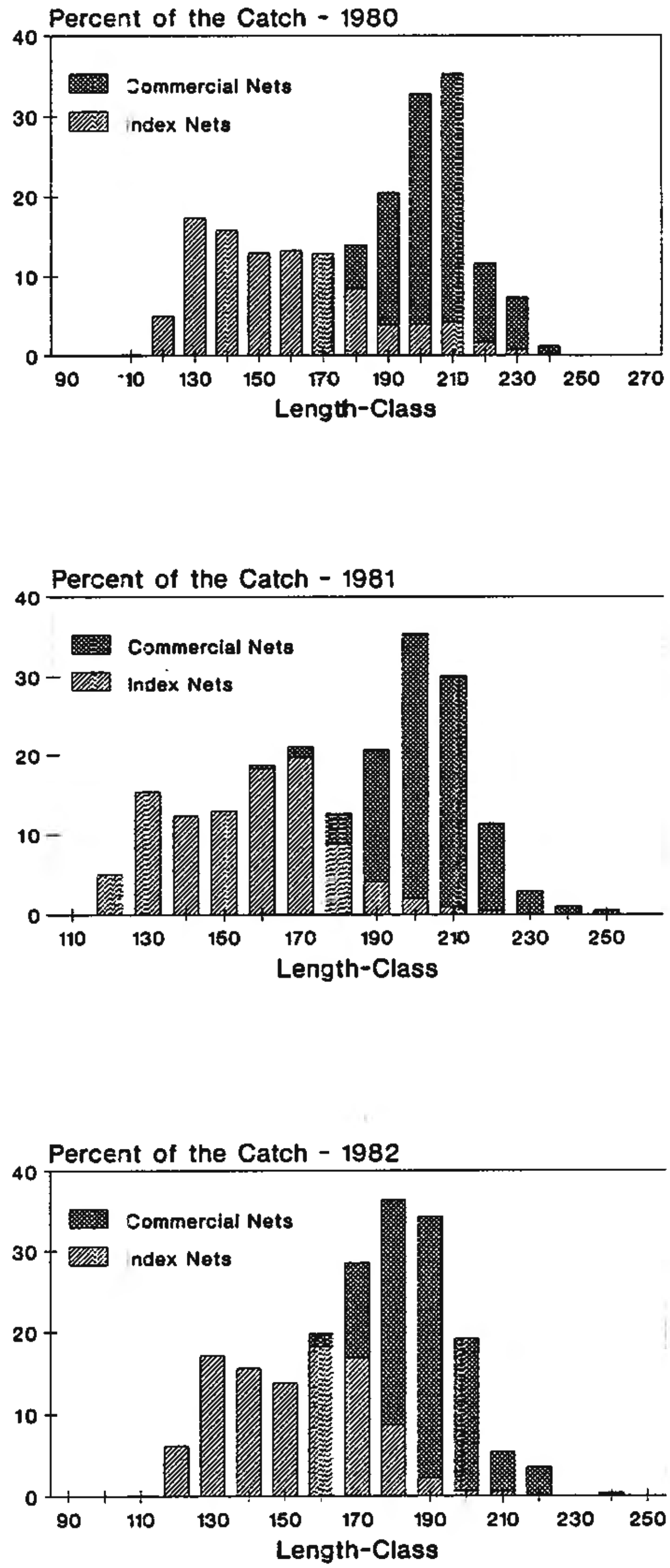

FIG. 5. Length-frequency distribution of yellow perch in the commercial gillnet fishery (Quota Zone 1) and assessment index gillnets (Middle Ground)) during August: 1980 (top panel), 1981 (middle), and 1982 (bottom).

4 to 5 averaged 85%. The yellow perch commercial harvest peaked when these two year-classes (1977 and 1978) were most vulnerable to the fishery in 1981 and 1982. By way of comparison, total annual mortality for the 1979 and 1980 cohorts of yellow perch (only years with sufficient data to estimate mortality) were 67 and 43% respectively.

Since 1988, no yellow perch greater than 5-yrs-old have been observed in assessment index nets at Middle Ground.

Growth

Growth of the 1977 year-class was fast, second only to the 1976 cohort, and provided large numbers of commercially harvestable fish by 1980 (mean fork length of 3-yr-old female yellow perch = 158 mm, Fig. 7). Growth of subsequent year-classes declined so that, combined with high annual mortality and smaller year-classes, contributions to marketable size-classes also declined. For example, 15% of 3-yr-old female yellow perch from the 1977 year-class were greater than 7.5 inches at the beginning of their forth growing season. This figure dropped to 7% for the 1978 year-class and finally to 0% for the 1979 and 1980 year-classes.

Analysis of instantaneous rate of increase in length revealed that year-class differences in observed fork lengths of 3-yr-old female yellow perch occurred during the first year of life. A log-log plot of instantaneous rate of increase in length (during first year of life) vs. yellow perch year-class strength (CUE of 3-yr-old female yellow perch, three years later) indicated a significant *positive* relationship for 1977 to 1989 cohorts (r = 0.68, p<0.05, Fig. 8).

Instantaneous rate of increase in length declined when measured for the 1977 year-class at successive ages (2 to 6-yrs-old, Fig. 9). The decline was not near as apparent for other year-classes.

The 1976 yellow perch year-class was very small but fast growing (Figs. 7 and 8).

Interspecific Relationships with Alewife

Results of the correlation analysis to examine the relationships between alewife (adult abundance and year-class strength) and yellow perch (growth and year-class strength) are shown in Table 2. There were significant inverse relationships between alewife year-class strength (measured as yearlings in the following year and reported by O'Gorman and Schneider 1986) and yellow perch year-class strength (Fig. 10) and growth in the first year of life for the 1977 to 1981 cohorts (r = -0.95 and -0.77 respectively, p<0.05). The correlation between *adult* alewife abundance and yellow perch year-class strength over the years 1977 to 1982 was not quite significant (r = -0.55, 0.1<p<0.05), and there was no correlation between *adult* alewife abundance and yellow perch growth in their first year of life (r = -0.20, p>0.2).

Discussion

Quota Zone 1/Middle Ground vs. Lake-Wide Trends

Observed trends in yellow perch commercial harvest (Quota Zone 1) and abundance (Middle Ground index gillnets) followed the same general pattern of commercial harvest for the rest of Lake Ontario, from the mid-1970's to present. However, it must be emphasized that there were some important differences. For example, the increase in the Quota Zone 1 commercial harvest in the early-1980's was greater relative to the rest of Lake Ontario but the peak

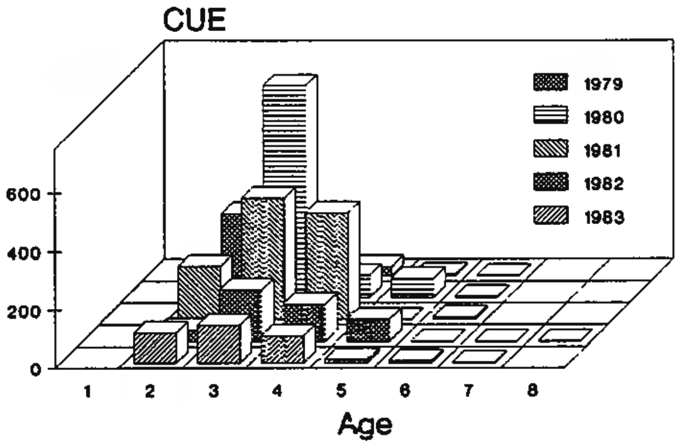

FIG. 6. Age-class distribution of female yellow perch caught in assessment index gillnets, 1979 to 1983.

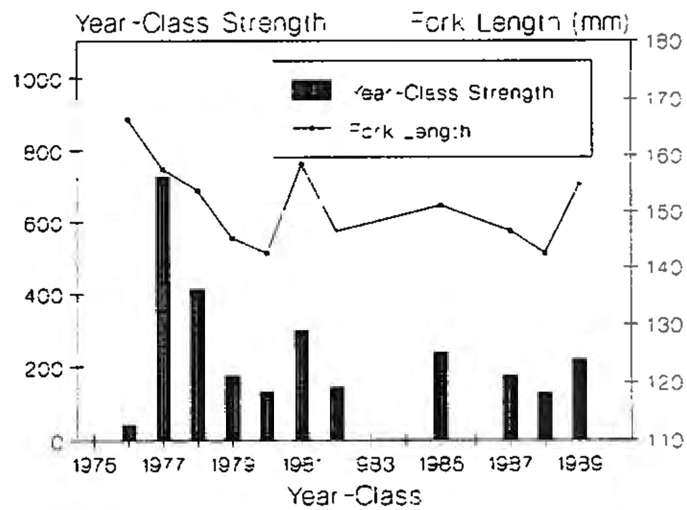

FIG. 7. Yellow perch year-class strength, 1976 to 1989 (1983, 1984, and 1986 not available), as represented by the CUE of 3-yr-old female yellow perch caught three years later in assessment index gillnets at Middle Ground, and mean fork length of 3-yr-old female yellow perch, back-calculated to the beginning of their forth growing season.

TABLE 2. Correlations (log-log relationships) between alewife (year-class strength, 1977 to 1981, and adult abundance, 1977 to 1982) and yellow perch (year-class strength and growth). Annual estimates of alewife population size (adults and yearlings) were obtained from O'Gorman and Schneider (their Table 2, 1986). Alewife year-class strength was measured as yearling abundance in the following year. Yellow perch year-class strength was the CUE of 3-yr-old females, three years later. Yellow perch growth was measured for 3-yr-old females as the instantaneous rate of increase in length in their first year of life.

	Yellow perch: Year-class strength	*Yellow perch:* Growth
Alewife:		
Year-class strength	-0.95 (p<0.05)	-0.77 (p<0.05)
Adult abundance	-0.65 (n.s)	-0.20 (n.s)

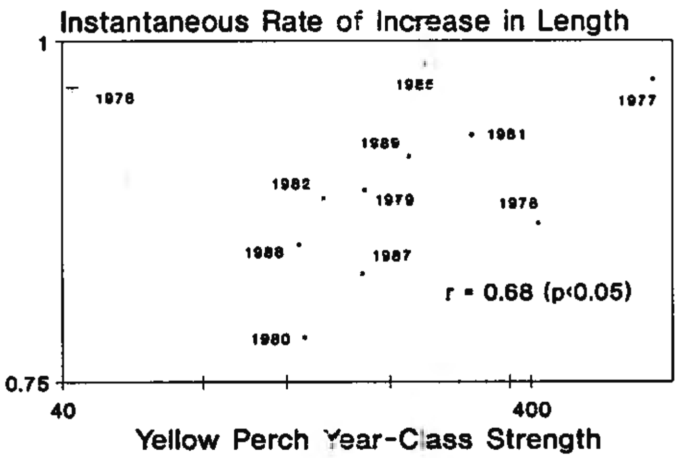

FIG. 8. Log-log plot of instantaneous rate of increase in length during the first year of life, and year-class strength measured as CUE in assessment index gillnets for 3-yr-old female yellow perch 1976 to 1989 (correlation does not include 1976, data for 1983, 1984, and 1986 not available).

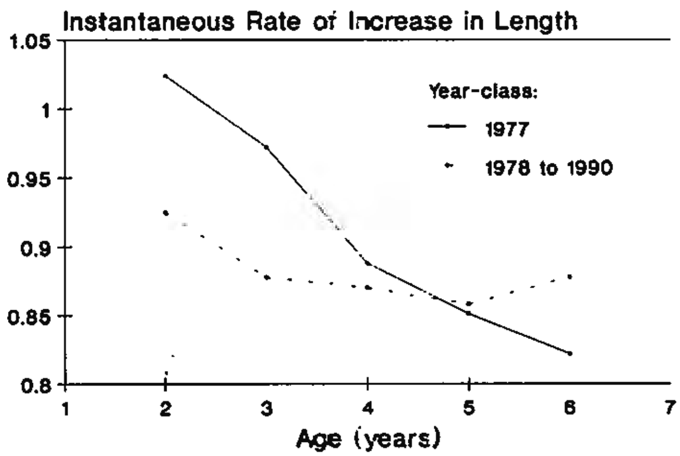

FIG. 9. Instantaneous rate of increase in length during the first year of life, measured at successive ages, for the 1977 year-class, and for the mean of all year-classes combined (1978 to 1990).

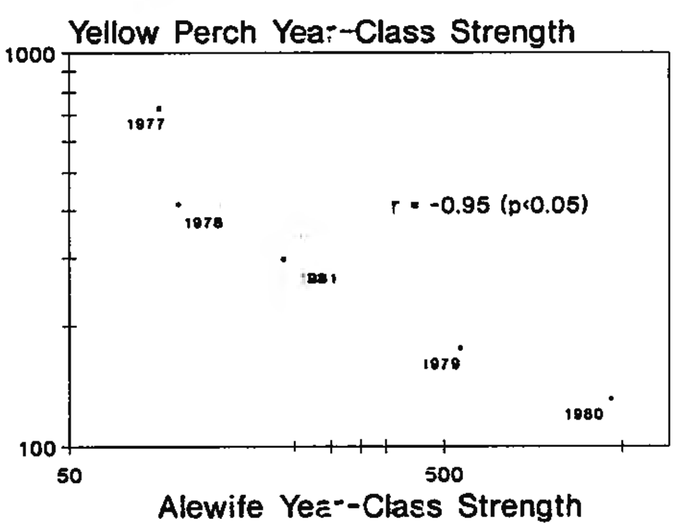

FIG. 10. Log-log plot of alewife year-class strength, measured as yearlings by O'Gorman and Schneider (1986). vs. yellow perch year-class strength measured as 3-yr-old female yellow perch CUE, 1977 to 1981.

harvest could not be sustained beyond a single year in the Brighton area. Thus, although the factors influencing yellow perch population dynamics in the Middle Ground area may also be operating lake-wide, the effects of these factors were much more dramatic in the Brighton area.

Factors Regulating Yellow Perch Population Dynamics

Commercial fishing

The results presented here indicate that the commercial fishery over-exploited yellow perch populations in the Brighton area in the early 1980's. Although the 7.5 inch total length minimum size limit did not come into regulation until 1984, few fish less than 7.5 inches were harvested prior to 1982 (5 to 6% in 1980 and 1981). In 1982 however, 41% of yellow perch in the commercial harvest were less than 7.5 inches. If the minimum size limit had been in place two years sooner (i.e. in 1982), an even more dramatic decline in commercial harvest would have been observed in Quota Zone 1 in 1982 and 1983.

The decline in mean length following the year of peak commercial harvest (1981), along with the observation that annual mortality was very high (85%) at this time, indicates that the commercial fishery had a significant impact on the yellow perch population. The 'apparent decline in growth rate' (Lee's phenomenon, Ricker 1992) observed for the 1977 yellow perch year-class at successive ages, most certainly resulted from the commercial fishery selecting for the fastest growing individuals.

Since 1984 the capacity of the commercial fishery to impact yellow perch populations in the Brighton area (Quota Zone 1) has been reduced markedly. The gillnet fishery in particular, which was responsible for most of the yellow perch harvest in the early 1980's, has had quota reductions of over 70% and season restrictions, from year-round fishing to a single month.

Interspecific Interactions with Alewife

O'Gorman and Schneider (1986) reported that alewife were abundant in Lake Ontario in 1976 but a massive die-off greatly reduced their numbers in the winter of 1976-1977. The alewife population quickly recovered with adult abundance increasing nearly seven-fold during 1978 to 1981.

Thus, the two largest yellow perch year-classes, observed in the present study, were produced following the alewife die-off of 1976/77. Eck and Wells (1987) described a 12-yr index netting data series (1973 to 1984) on Lake Michigan in which the two strongest year-classes of yellow perch (1983 and 1984) were produced when alewife (yearling and older) were least abundant.

Predation or competition? — Alewife have been implicated as a significant factor affecting yellow perch abundance both due to predation by adult alewife on larval yellow perch during nearshore spawning runs (Kohler and Ney 1980, Abraham 1983, Brandt et al. 1978), and by competition for limited food resources (Kohler and Ney 1981, Stewart et al. 1981, O'Gorman et al. 1987). If competition between alewife and yellow perch is a factor, it would most likely be for zooplankton. However, it is not clear at what life stages competition would occur. All life stages of alewife consume zooplankton, although larger alewife tend to consume larger zooplankton (O'Gorman et al. 1991). Zooplankton consumption by yellow perch in Lake Ontario would likely be important primarily in their first year of life.

Release from predation by adult alewife on yellow perch larvae may have contributed to the strong 1977 and 1978 yellow perch year-classes, but the correlation between adult alewife abundance and yellow perch year-class strength over the years 1977 to 1982 was not significant.

The lack of a correlation between *adult* alewife abundance and yellow perch growth in their first year of life suggests that interspecific competition was not important at these life stages.

The significant *positive* relationship between yellow perch abundance and growth rate in the first year of life indicated that food resources were not limiting in years producing strong year-classes. However, yellow perch abundance and growth in their first year of life were low when young-of-the-year (YOY) alewife were abundant suggesting that interspecific competition for food (zooplankton) was a factor regulating yellow perch population dynamics, at least during the late-1970's and early 1980's in the Brighton area.

Brandt (1980) found that adult and YOY alewife segregate both spatially and in terms of prey selection. Nash and Geffen (1991) demonstrated a high degree of overlap both spatially and temporally, between the larvae of alewife and yellow perch at offshore sampling stations in Lake Michigan. Nash and Geffen (1991) suspected that much higher overlap would occur in nearshore areas, and that interspecific interactions could occur if alewife and/or yellow perch densities were high enough to deplete resources. Habitat and prey selection by YOY alewife may be more similar to that of YOY yellow perch than to adult alewife, but to my knowledge, this has not been studied for Lake Ontario.

The 1976 yellow perch year-class — The 1976 yellow perch year-class was very small but fast growing. Alewife abundance in 1976 was not measured but was thought to be high (O'Gorman and Schneider 1986, see also Ridgway et al. 1990). Alewife year-class strength was probably low in 1976 because of the inverse relationship between adult alewife abundance and recruitment when adult abundance is high (O'Gorman and Schneider 1986). This would explain the fast growth rate and low abundance of the 1976 yellow perch year-class.

Other Factors

Alewife population dynamics and commercial fishing can account for observed trends in yellow perch population dynamics in the Brighton area, in the late 1970's and early 1980's. Since the mid-1980's, the potential impact of the commercial fishery on the yellow perch population has been greatly reduced. In addition, Lake Ontario alewife biomass has declined steadily since the mid-1980's (Anonymous 1992). Yet yellow perch populations, particularly large individuals, remain at low abundance levels. Yellow perch recruitment and growth have been good in some recent years but mortality is high such that few fish over 5-yrs-old are now caught. Other factors must now be important in regulating yellow perch populations.

Lake productivity — Another factor which may now be influencing yellow perch populations in Lake Ontario relates to lake productivity. Christie (1972) linked cultural eutrophication and the proliferation of invertebrates associated with the shoreline growth of the sessile filamentous green algae, *Cladophora*, beginning after the early 1950's, to expanding Lake Ontario yellow perch populations of the late 1960's and early 1970's. A report of a special multi-agency Task Group charged with providing a technical evaluation of the status of the Lake Ontario ecosystem in 1992, concluded that the lake has undergone significant declines in productivity during the 1980's (Anonymous 1992). Thus, Lake Ontario may not now have the capacity to support populations of yellow perch as large as those of the early 1980's.

Predation — The possibility exists that size-selective predation by top predators may also be influencing yellow perch population dynamics. Stocking records indicate that top predator biomass in Lake Ontario increased dramatically in the early 1980's, peaked in 1986, and has remained constant since then (LeTendre and Savoie 1992). But currently available data do not generally support the idea that predation is a significant factor (Lake Ontario Fisheries Unit, unpublished data). Further work in this area, including sampling top predators (e.g. lake trout and walleye) stomach content data at times of the year when and where their distributions overlap with yellow perch, is warranted.

Minns et al. (1986) reported that predation by native walleye (*Stizostedion vitreum*) populations in the Bay of Quinte may be controlling yellow perch population dynamics. Walleye populations have expanded out of the Bay since the Minns et al. (1986) report, and are now very abundant in eastern Lake Ontario (Hoyle 1992a). Alewife are currently the dominant prey item in the eastern Lake Ontario walleye diet (Lake Ontario Fisheries Unit, unpublished data) but if alewife were to decline, walleye may switch to other prey species in the future. Kohler and Ney (1981) observed that when alewife were less abundant, pelagic predators including walleye, ate more yellow perch than when alewife were more abundant.

Christie (1972) suggested that expanding Lake Ontario cormorant populations may be exerting some pressure on native forage species. The current magnitude of predation by this avian piscivore on Lake Ontario yellow perch populations is not known but anecdotal information suggests that cormorant predation may at least be of local significance in Brighton area embayments including Presqu'ile Bay.

Outlook for the Future

O'Gorman et al. (1987) argued that a major decline in Lake Ontario alewife stocks should result in a resurgence of yellow perch, as was the case in Lake Michigan (Eck and Wells 1987). This outcome may not be as likely to occur today in the face of a suite of other pressures on Lake Ontario yellow perch populations. Given the discussions about the factors influencing yellow perch population dynamics presented above, it may be unrealistic to manage future yellow perch populations with the expectation of significantly higher sustainable yields than those currently being realized. Certainly, the peak yellow perch harvest levels observed during the early 1980's could not now be sustained. Instead, future management of Lake Ontario yellow perch populations must consider a host of factors operating at different life stages including: (1) commercial fishing which selects adult yellow perch greater than 7.5 inches in total length, (2) interspecific interactions, including those with fluctuating alewife populations which may limit yellow perch recruitment through predation by adult alewife on larval yellow perch, and through competitive interactions between the YOY members of both species, (3) declining lake productivity resulting in less yellow perch habitat and food production, (4) and finally, the potential for increased levels of predation by Lake Ontario's top predators.

Acknowledgements

Thanks to those responsible for conducting the long-term yellow perch index netting program at Middle Ground, including biologists and field crews. A special thanks to the field crews of the new 1992 Eastern Lake Ontario Index Netting Program. Phil Smith provided me with an historical perspective of the Lake Ontario yellow perch commercial fishery. Jeff Church did the yellow perch age interpretations. Mike Rawson, Phil Smith, and Tom Stewart provided many useful suggestions to improve the manuscript.

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Assessment of the Launch Daily Boat Fishery for Salmonines in Western Lake Ontario, 1992.

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Lake Ontario Fisheries Unit, 1992 Annual Report, Section 9

In 1992, anglers were interviewed at six boat launch ramps around the Canadian portion of western Lake Ontario during April to September, to obtain effort, catch and harvest information. Boat trailers were counted at all significant launch ramps to estimate fishing effort. Angler effort was estimated at 609,326 rod-hours, an 8% decline from 1991. The estimated salmonine catch was 79,811 fish (a 40% decline from 1991), while the harvest was 43,955 fish, a 34% decline from 1991. In 1992, 45% of the salmon and trout caught by launch daily anglers were released. Chinook salmon harvest rates dropped by 23% from 1991, but were still 22% higher than observed in 1990. Coho salmon harvest rates dropped by 72% compared to the previous year. Chinook salmon dominated the fishery lake wide. Port Dalhousie and Hamilton had a higher component of brown trout and coho salmon in the harvest than the other surveyed ramps. The south shore of western Lake Ontario (Queenston to Bronte) offered boat anglers a more diverse fishery in terms of species mix and seasonal opportunities. The Port Credit area was primarily a mid-summer chinook salmon fishery extending into the fall season. The north shore, from Bluffers Park to Cobourg, was a mid-summer fishery for chinook salmon and rainbow trout. As one progressed clockwise around the west end of Lake Ontario from Port Dalhousie to Port Darlington, the spring component of the fishery was significantly reduced, while rainbow trout became an increasingly important component of the boat harvest, ranging from just under 7% to almost 28% respectively. The Brighton/Wellington area supported a spring fishery for lake trout and mid-summer fishery for chinook salmon and lake trout.

Recommendations

1. Determine if the reduced sampling intensity, in recent years, can adequately index seasonal and spatial variations in the harvest for poorly represented species such as lake trout, brown trout, and Atlantic salmon.
2. Synthesize the historical western Lake Ontario angler data to: a) apply recent refinements in analytical methodology to all years, b) determine the impact of weather (recorded on creel log forms) on effort, catch and harvest trends, c) provide a more detailed analysis of trends for the biological attributes of the salmonine harvest, d) determine the influence of derby timing and rule changes on angler activity patterns and harvest.
3. Assess the accuracy of angler fish identification, in order to determine if the catch data is suitable as a species specific index of salmonine abundance.

Introduction

The salmonine fishery in Canadian waters of western Lake Ontario has been monitored since 1977. Early surveys were restricted to specific fishing derbies. Annual surveys (April to September, inclusive) of the "launch daily" boat fishery in western Lake Ontario were first implemented in 1985 (Daniels and Savoie 1986). These surveys have been restricted to anglers who trailer their boats to launch ramps. Shore and marina based fisheries were not monitored. This report provides the 1992 update for the launch daily boat fishing effort, catch and harvest, in Canadian waters of western Lake Ontario. Some aspects of the biological components of this survey have been reported elsewhere in this annual report (Bowlby et al., 1993a, 1993b). For the purpose of this report, western Lake Ontario was defined as west of Point Petre, Prince Edward County, Ontario (Fig. 1).

Methods

Detailed survey protocols were reported by Savoie (1992a, 1992b). The 1992 survey was based on completed trip angler interviews at six boat launching ramps; Port Dalhousie, Hamilton, Port Credit, Bluffers Park, Port Darlington and Wellington (Fig. 1). Biological sampling of the harvest included; fork length, weight, fin clips and regeneration, scales, and otoliths. Two technicians monitored three access points each. The survey day was divided into morning (09:00 to 15:00) and afternoon (15:00 to 21:00) shifts. Two weekend day and two weekday shifts were surveyed per week. At the six surveyed sites, fishing and non-fishing boating activity was recorded. A count of boat trailers remaining in the parking lot at 21:00 was used to estimate missed evening fishing activity, after correcting for the proportion of non-fishing boats.

FIG. 1. Location of surveyed ramps during the 1992 launch daily boat creel for Canadian waters of western Lake Ontario

Boat trailers parked at the six surveyed ramps, along with an additional thirty one ramps from Queenston (Niagara River) to Wellington (Prince Edward County) were counted each weekend between the hours of 10:00 and 15:00. The boat trailer counts at the six surveyed ramps and thirty one unsurveyed ramps were used to expand estimates of fishing effort to all ramps.

Results and Discussion

Update for 1992

The 1992 launch daily boat angling effort was estimated at 609,326 rod-hours (Table 1) Salmonine catch and harvest was estimated at 79,811 and 43,955 fish respectively. In 1992, 45% of the salmon and trout caught by launch daily boat anglers were released. An estimated 2,747 non-salmonine fish were harvested; mostly yellow perch and rock bass. The 1992 catch and harvest rates (CUE and HUE) by species are summarized in Table 1.

July and August accounted for 56% of the boating activity (Fig. 2). The six surveyed ramps represented 40% of the

TABLE 1. Launch daily boat angler catch statistics for western Lake Ontario in 1992.

Species	Catch	Harvest	C.U.E.*	H.U.E.*
		Salmonine		
Unknown salmonine	1,463	0	0.0024	N/A
Coho salmon	3,367	1,771	0.0055	0.0029
Chinook salmon	47,042	29,016	0.0772	0.0476
Rainbow trout	15,063	7,867	0.0247	0.0129
Atlantic salmon	1,266	578	0.0021	0.0009
Brown trout	5,070	2,290	0.0083	0.0038
Lake trout	6,541	2,433	0.0107	0.0040
Total salmonine	79,811	43,955	0.1310	0.0721
		Other		
Alewife	378	63	0.0006	0.00010
Northern pike	273	28	0.0004	0.00005
White sucker	59	0	0.0001	N/A
Common carp	511	0	0.0008	N/A
Brown bullhead	272	0	0.0004	N/A
Channel catfish	1,491	24	0.0024	0.00004
White perch	451	24	0.0007	0.00004
White bass	423	0	0.0007	N/A
Rock bass	835	686	0.0014	0.00113
Smallmouth bass	3,739	137	0.0061	0.00023
Largemouth bass	347	187	0.0006	0.00031
Sunfish	606	297	0.0010	0.00049
Crappie	53	0	0.0001	N/A
Yellow perch	1,557	1,095	0.0026	0.00130
Walleye	389	206	0.0006	0.00034
Freshwater drum	1,720	0	0.0028	N/A
Unknown	106	0	0.0002	N/A
Total non-salmonine	13,210	2,747	0.0217	0.00451

* Boat angler effort was estimated at 609,326 rod-hours, based on 2,296 completed trip interviews.

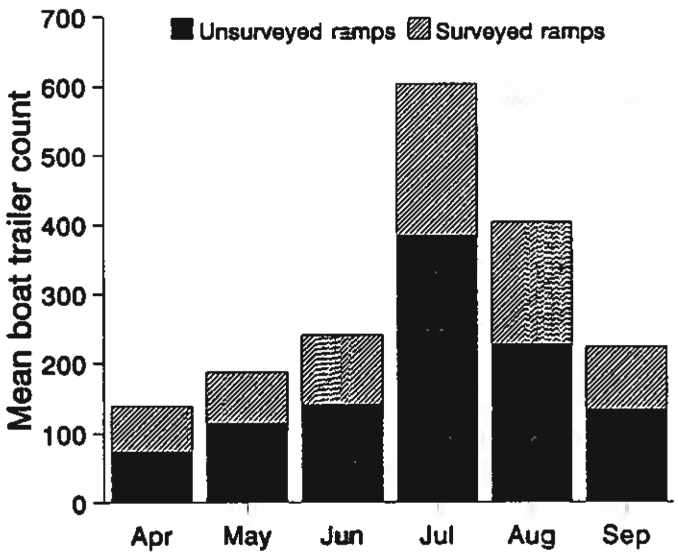

FIG. 2. Mean boat trailer counts by month for 1992, at ramps accessible to the public in western Lake Ontario.

launch daily boating activity within the study area (Fig. 3). The area from Queenston (Niagara River) to Bluffers Park (Scarborough) accounted for over 78% of the activity. In 1992, the launch daily boating activity at Wellington was comparable to Port Credit and Port Dalhousie, which are associated with much larger population centers.

Regional Differences

Regional differences in seasonal boat fishing activity and species composition of the harvest (Figs. 4 and 5) were influenced by fishing derbies and salmonine distribution patterns. The Toronto Star Great Salmon Hunt derby (July 6 to August 30, 1992) with weigh-in stations from St. Catharines to Wellington (including all six surveyed ramps) had the greatest influence on boat fishing activity in Canadian waters of western Lake Ontario and explained, in part, the July and August peak in fishing activity (Fig. 2). Other, more local, derbies influence regional fishing characteristics.

Of the six surveyed sites, the spring and fall peaks in boating activity was unique to Port Dalhousie (Fig. 4a). The St. Catharines Game and Fish Association Salmon Derby (April 11 to May 10, 1992) with weigh-in stations extending from Niagara Falls to Bronte, was the major factor accounting for the spring boating activity at Port Dalhousie. The Lake

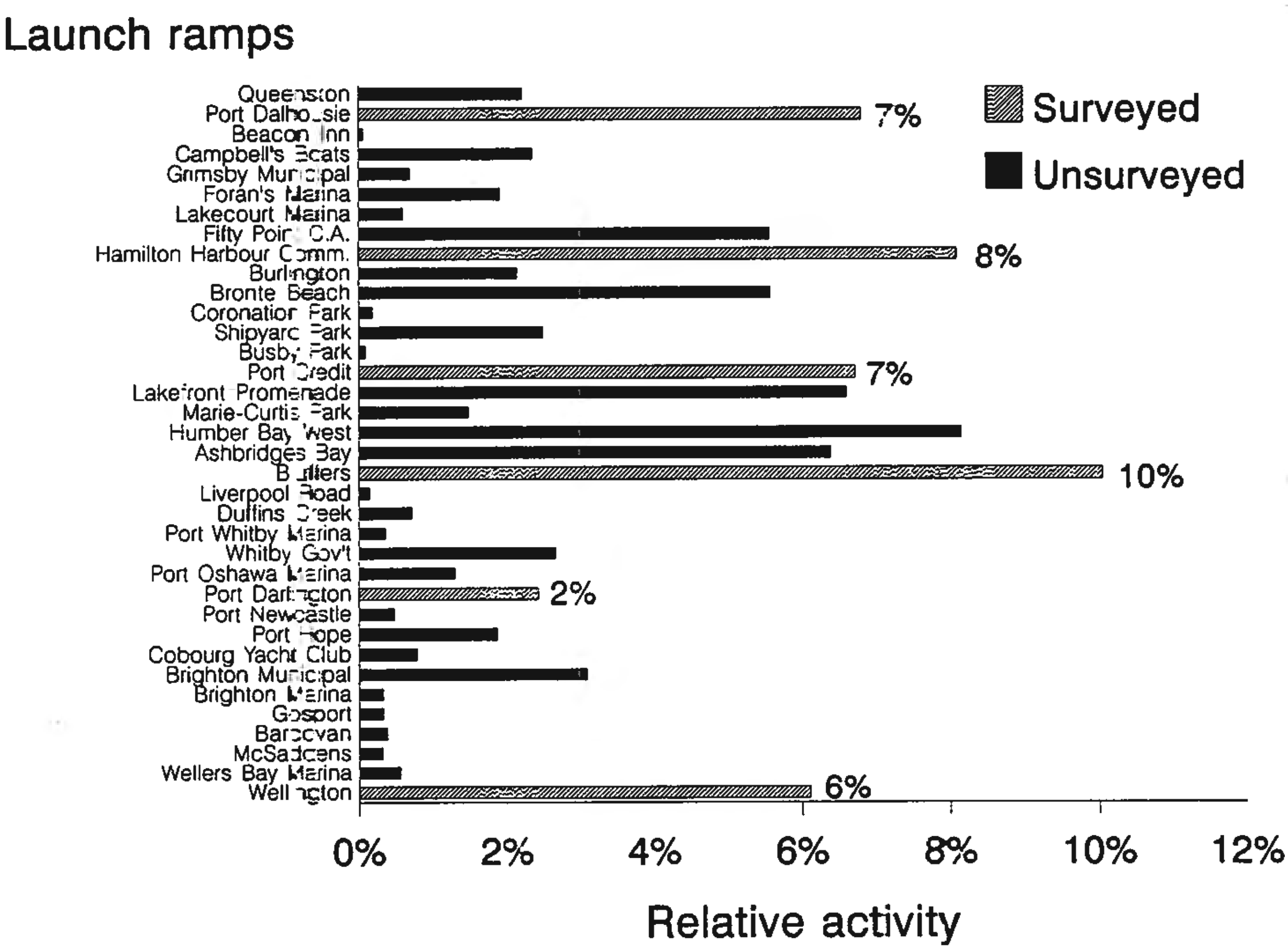

FIG. 3. The 1992 relative distribution of boating activity, at ramps accessible to the public, in western Lake Ontario.

Ontario Fishing Classic (an international fishing derby from April 18 to 26, 1992) with weigh-in stations from Bronte (Ontario) to Henderson Harbor (New York), had an impact on the fishing activity along the entire south shore of Lake Ontario. The spring and fall brown trout fishery in Port Dalhousie harbour was also an important drawing card for shore and boat anglers (Savoie, 1992c, 1993). Almost all (98%) of the brown trout harvested at Port Dalhousie were during the spring and fall periods. Brown trout comprised 27% of the harvest at Port Dalhousie (Fig. 4b). The good chinook salmon fishery, extending into September, also accounted for the late fall peak in fishing activity.

The Hamilton activity pattern reflected the influence of previously mentioned derbies, in addition to the Chinook Classic derby (June 8 to June 16, 1992) with weigh-in stations from Bronte to Grimsby (Fig. 4c). Of the six surveyed ramps, Hamilton had the highest proportion of coho salmon (8.2%) in the harvest (Fig. 4d).

At Port Credit the fishing activity was influenced by the Toronto Star Great Salmon Hunt but was also extended into the fall, reflecting the influence of the Credit River chinook stocking, as salmon staged at the river mouth prior to the spawning run (Fig. 4e). The heavy reliance of chinook salmon to the Port Credit fishery was evident in the fact that they comprise almost 77% of the harvest (Fig. 4f).

Bluffers Park and Port Darlington ramps had very similar seasonal activity patterns and species composition of the harvest. The Toronto Star Great Salmon Hunt and the Oshawa-Whitby This Week Salmon Derby concentrated the fishing activity in July and August. In 1992, the fall fishery at Bluffers Park and Port Darlington dropped off dramatically (Figs. 5a and 5c). Rainbow trout were a significant component of the fishery for these two ramps, comprising 25% and 28% of the harvest, respectively (Figs. 5b and 5d). Streams in the vicinity of Port Darlington supported major runs of rainbow trout. The combined harvest of coho salmon, Atlantic salmon, brown trout and lake trout, contributed less than 5% of the species mix at either Bluffers Park or Port Darlington (Figs. 5b and 5d).

The seasonal activity pattern at Wellington reflected the interest in the spring lake trout fishery and the influence of the Toronto Star Great Salmon Hunt derby in the summer (Fig. 5e). The spring fishing activity at Wellington was targeting lake trout, where they comprised almost 95% of the harvest from April to mid-May. The Wellington area was unique, in that lake trout comprised almost 32% of the harvest (Fig. 5f).

Port Dalhousie and Hamilton had a higher component of brown trout and coho salmon in the harvest than the other surveyed ramps. The south shore of western Lake Ontario (Queenston to Bronte) offered boat anglers a more diverse fishery in terms of species mix and seasonal opportunities. The Port Credit area was primarily a mid-summer chinook salmon fishery extending into the fall season. The north shore, from Bluffers Park to Cobourg, was a mid-summer fishery for chinook salmon and rainbow trout. As one progressed around the west end of Lake Ontario from Port Dalhousie to Port Darlington, the spring component of the fishery was significantly reduced, while rainbow trout harvest became increasingly important, ranging from just under 7% to almost 28% respectively (Figs. 4 and 5). The Brighton/Wellington area supported a spring fishery for lake trout and mid-summer fishery for chinook salmon and lake trout.

Trends

Fishing in 1992 was influenced by an unusually cool summer with considerable precipitation. Launch daily boat angling effort declined by 8% from 1991 to 1992. In 1992 the total salmonine catch declined by 40%, while the harvest declined by 37% from the previous year. In 1992, 45% of the salmon and trout caught by launch daily boat anglers were released. The 1992 catch and harvest rates declined by 35% and 32%, respectively, as compared to 1991.

In Canadian waters of western Lake Ontario, launch daily boat angler effort, catch and CUE, increased in the early 1980's to a peak in 1986 (Stewart et al. 1990). These increases were coincident with increased stocking (LeTendre and Savoie 1991). Since 1985, effort (Fig. 6) and stocking rates have remained relatively constant (LeTendre and Savoie 1991). HUE has been declining since 1984 (Fig. 7). Only HUE can reliably be presented on a species specific basis, since angler identification of released fish is often suspect. From a peak in 1984, the salmonine HUE has dropped by 51%. Chinook salmon HUE may have leveled off since 1989 but has dropped by 45% from the 1986 peak (Fig. 8a). Note that the 1992 chinook salmon HUE was almost 22% higher than observed in 1990. Rainbow trout HUE has declined by 71%, from a peak in 1984. It is interesting that in 1988 and 1990, lower HUEs for chinook salmon were coincident with higher HUEs for rainbow trout; this did not happen in 1992 (Fig. 8a). Coho salmon harvest rates declined by 72% compared to the previous year, and have declined by 95% since 1982. The dramatic decline of harvested coho is primarily the result of stocking strategies favoring chinook salmon (Letendre and Savoie 1991). The full impact of the discontinuation of the Canadian coho stocking program, in February of 1991, is expected to be reflected in the 1993 fishing season. The lake trout and brown trout HUE trends have fluctuated considerably since 1982 (Fig. 8b). The high HUE variability for these two species is likely attributable to the fact that they are primarily early spring and fall fisheries, more influenced by the vagaries of weather and near-shore water temperature fluctuations. The apparent increase in the 1992 Atlantic salmon HUE may not be real since they were not adequately represented in our survey. During the entire 1992 field season, only eight Atlantic salmon were observed out of a total 1,315 salmonines identified. There may also be problems with misidentification of Atlantic salmon by survey technicians.

Salmonid stocking has been relatively constant since 1984 (LeTendre and Savoie, 1991). Over the same period, fishing effort has shown only a modest decline (Fig. 6). The decline in HUE may be related to declining abundance of salmonines, suggesting a density dependent influence on survival. In a fishery that is so strongly influenced by derbies, and where 40% to 50% of the fish caught were released, we favour using angler harvest data to index species specific components of the salmonine community. Derby anglers selectively harvest the bigger fish in their catch. They also express species biases, which are often influenced by derby rules. We believe angler catch rates (CUE) could better index salmonine abundance. Unfortunately, angler identification of released fish has often been suspect. To determine if our historical catch data is suitable as a relative index of salmonine abundance, we propose (in 1993) to assess the reliability of the angler's fish identification. While this may provide us with a relative index of abundance, there remains

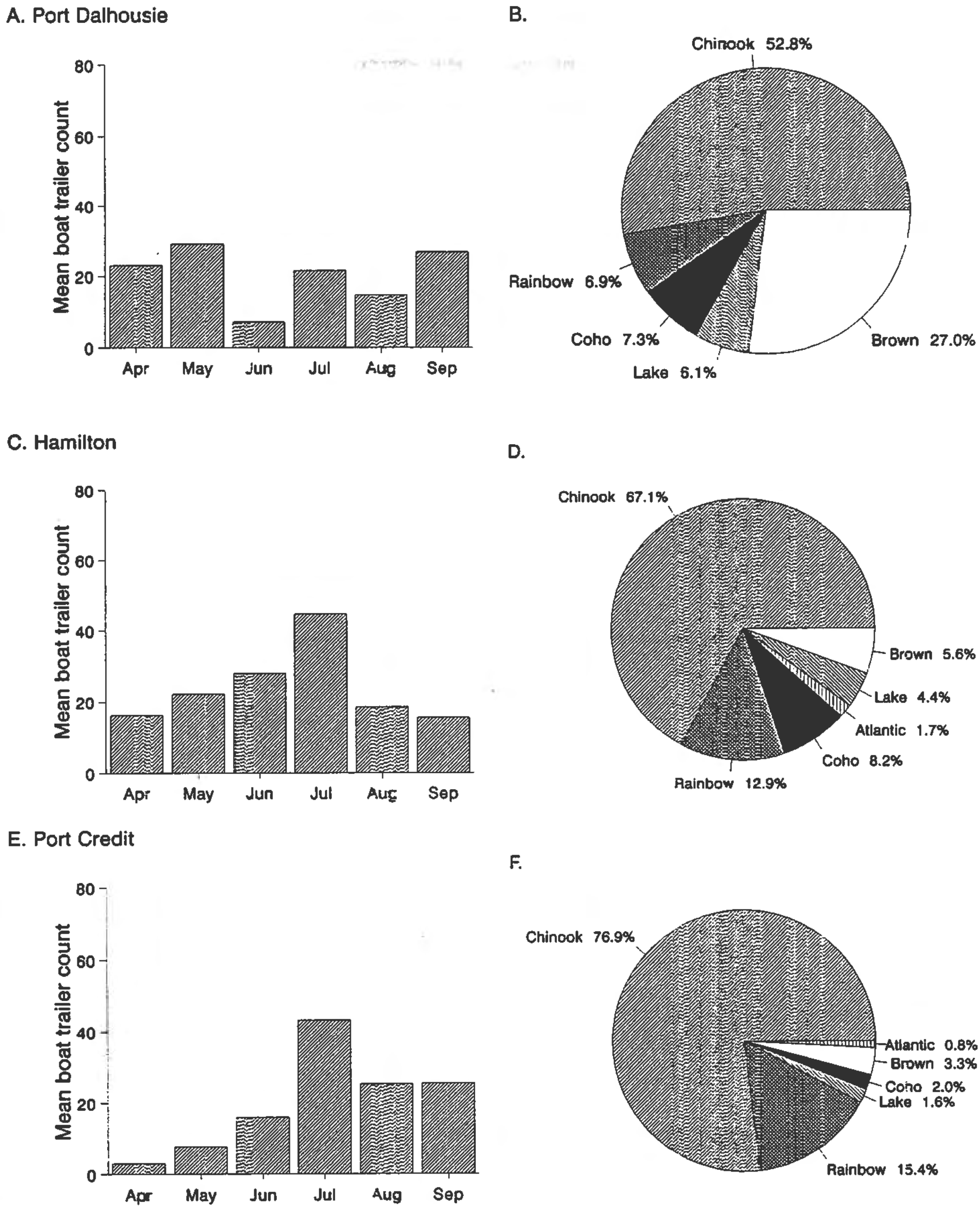

FIG. 4. Mean boat trailer counts by month, and species composition of the harvest, for surveyed ramps at Port Dalhousie, Hamilton and Port Credit.

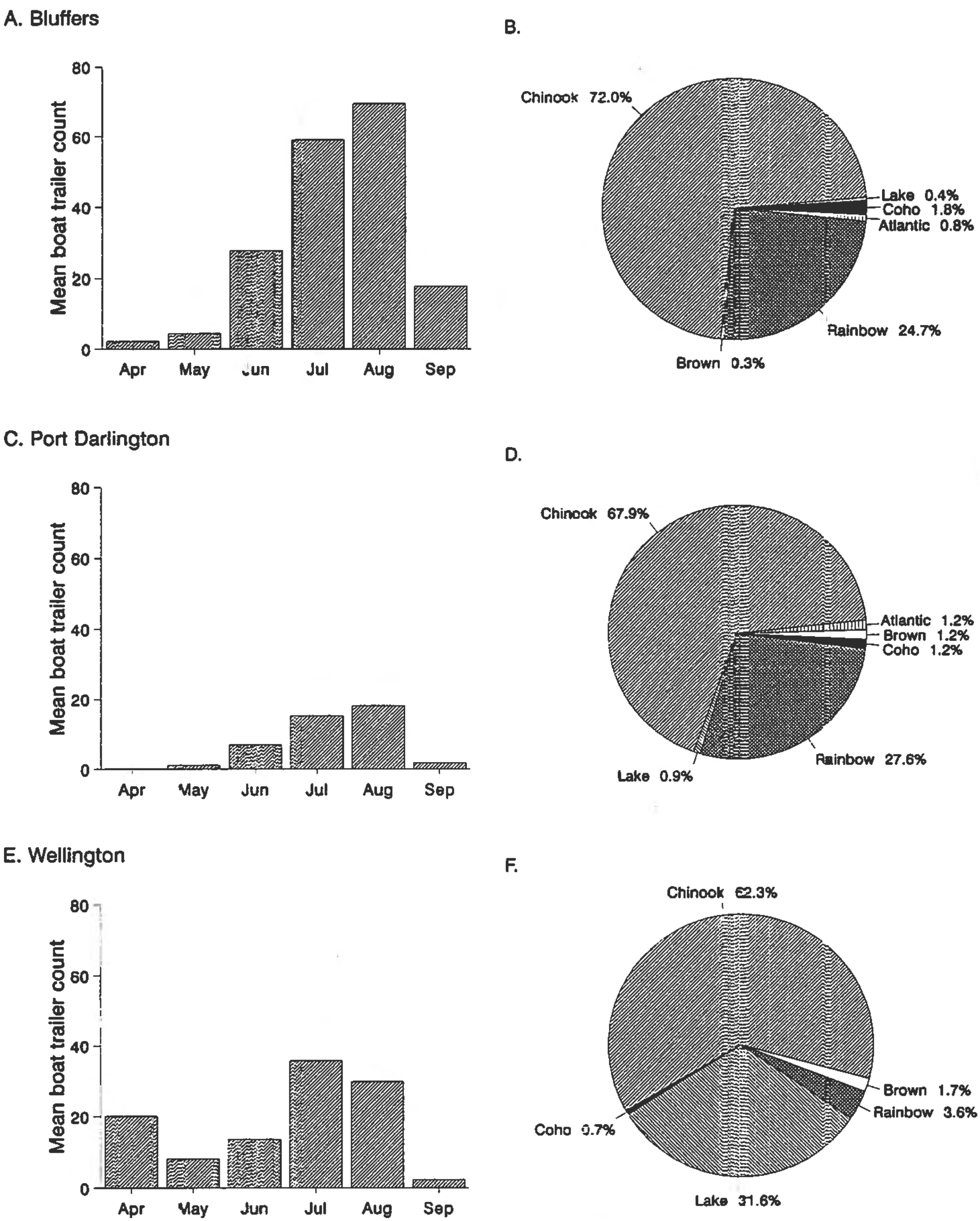

FIG. 5. Mean boat trailer counts by month, and species composition of the harvest, for surveyed ramps at Bluffers Park, Port Darlington and Wellington.

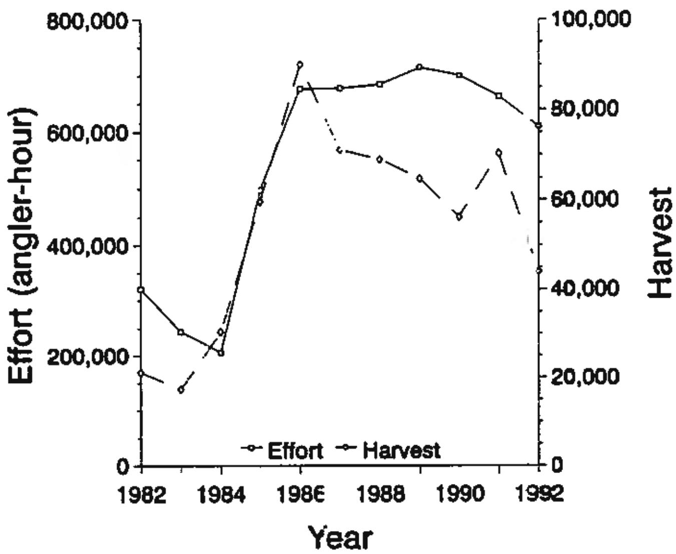

FIG. 6. Effort and harvest trends for the western Lake Ontario launch daily boat fishery.

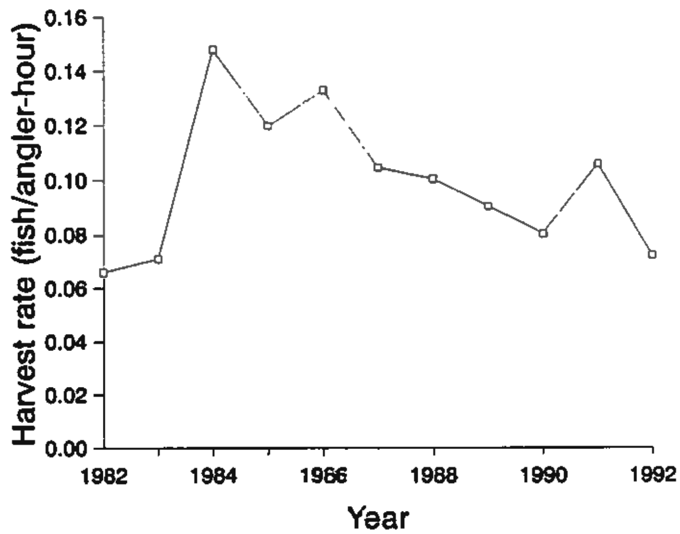

FIG. 7. Trend in total harvest rates (HUEs) for the western Lake Ontario launch daily boat fishery

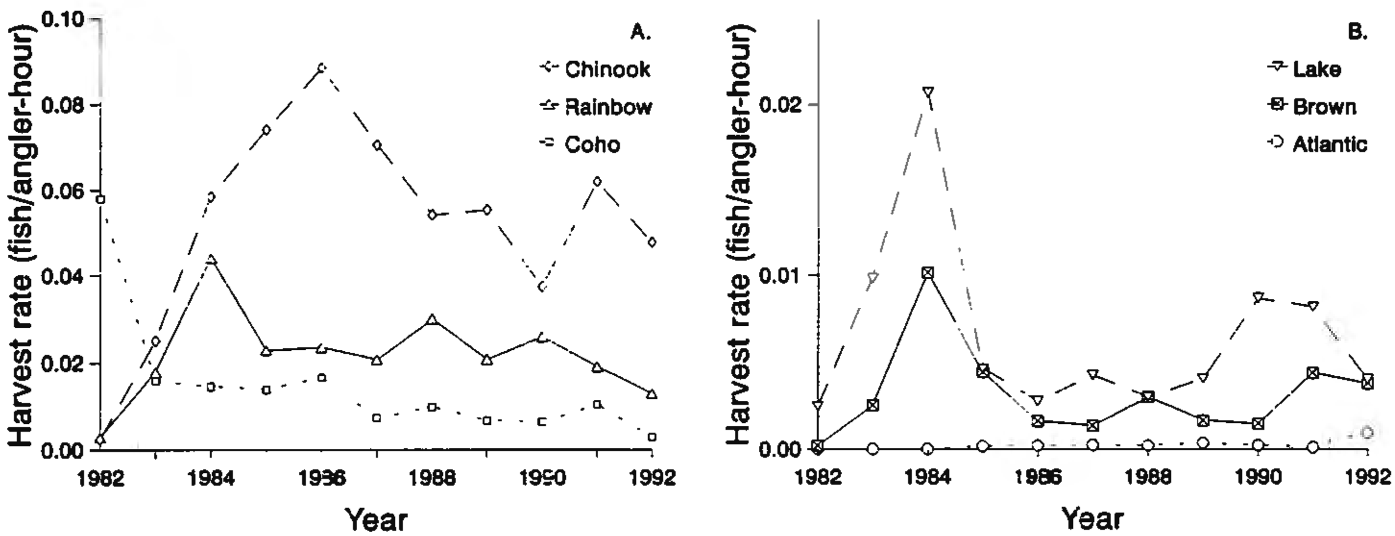

FIG. 8. Species specific trends in harvest rates (HUE) for the western Lake Ontario launch daily boat fishery.

a need for an independent estimate of absolute salmonine abundance.

This survey was primarily intended to monitor patterns of resource use and provide return-to-creel information for stocked fish. It has also been useful in collecting demographic and behavioral information relating to the launch daily boat angling fishery. We propose to synthesize the historical western Lake Ontario angler data, to: 1) apply recent refinements in analytical methodology to all years, 2) determine the impact of weather (recorded on creel log forms) on effort, catch and harvest trends, 3) provide a more detailed analysis of trends for the biological attributes of the salmonine harvest, 4) determine the influence of derby timing and rule changes on angler activity patterns and harvest.

Acknowledgments

The authors would like to acknowledge Sandra Michaelsen for her work in conducting most of the weekend boat trailer counts and for data entry and editing. We also thank Dave Featherstone (Envirosphere Ltd.) and Andy Cook for the field data collection. Tom Stewart contributed significantly to improvements in the manuscript.

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Lake Ontario Charter Boat Angling Effort Survey.

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Lake Ontario Fisheries Unit, 1992 Annual Report, Section 10

Randomly selected Charter Boat Association members were sent postcard questionnaires annually since 1986. The questionnaires were designed to obtain information on the number of Lake Ontario charter boat trips taken and ports used. Estimated effort of affiliated charter operators decreased by 75% over the last four fishing seasons from 313,606 rod-hours in 1989 to 90,570 rod-hours in 1992. We speculate that the decline was due to a decrease in both charter boat fishing effort and membership affiliation. Ontario Charter Boat Association members were responsible for the majority of the activity. Port Credit and Bluffers Park have consistently accounted for most of the charter boat activity with July, August and September being the busiest months.

Recommendations

1. Conduct a marina survey in 1993 to determine catch rates and the proportion of active charter operators that remain affiliated with charter boat associations.

Introduction

The charter boat fishery is sensitive to changes in both the economy and fishery characteristics, and is thus a good indicator of economic benefits derived from fisheries resource use. Charter boat activity is not surveyed during routine fishery monitoring programs which concentrate on launch daily anglers. Since 1986, Lake Ontario charter boat mail surveys have been used to monitor charter boat fishing effort. Completed trip interviews of marina based charter boats, and a mail survey in 1989, showed that charter boat effort represented 28% of the total boat fishing effort in Canadian waters of Lake Ontario (Stewart et al. 1990).

The information obtained from the mail survey supplements annual access point surveys of private boat anglers to monitor trends in recreational fishing effort and harvest on Lake Ontario. This report provides results of the Lake Ontario mail surveys of affiliated charter boat association members for the years 1990 to 1992 and examines recent trends.

Methods

Membership lists from the Ontario Charter Boat Association (OCBA), the Independent Charter Boat Association (ICBA), and the Eastern Ontario Charter Boat Association (EOCBA) were obtained each year[1]. From these lists, a random sample of approximately 50% of the captains were sent a postcard questionnaire asking them for the number of boat trips they conducted on Lake Ontario and ports used, by month, from April to September.

The reported number of trips were then expanded to estimate total number of trips using the following formula:

$$[(n/r) + (N-n)/n]$$

where n = number of questionnaires sent, r = number of questionnaires received and N = total membership.

Stewart et al. (1990) reported fishing effort of affiliated and unaffiliated charter boats combined based on a determination of the proportion of charter operators belonging to associations. In recent years, this proportion may have changed, therefore, we re-examined the 1989 survey and compare only fishing effort of affiliated charter boat operators for the years 1987-1992.

Results and Discussion

Reported charter boat port locations for 1990 to 1992 are identified in Figure 1. Port Credit and Bluffers Park accounted for the major percentage of charter boat activity for the past three years with July, August and September being the busiest months. Members of the OCBA accounted for most of the charter boat activity, with 67% in 1990, 83% in 1991 and 76% in 1992.

Affiliated charter boat fishing effort declined 75% from 313,606 rod-hours in 1989 to 90,570 rod-hours in 1992 (Fig.

[1] No membership list from the EOCBA was obtained in 1992 as the Association disbanded prior to the 1992 fishing season.

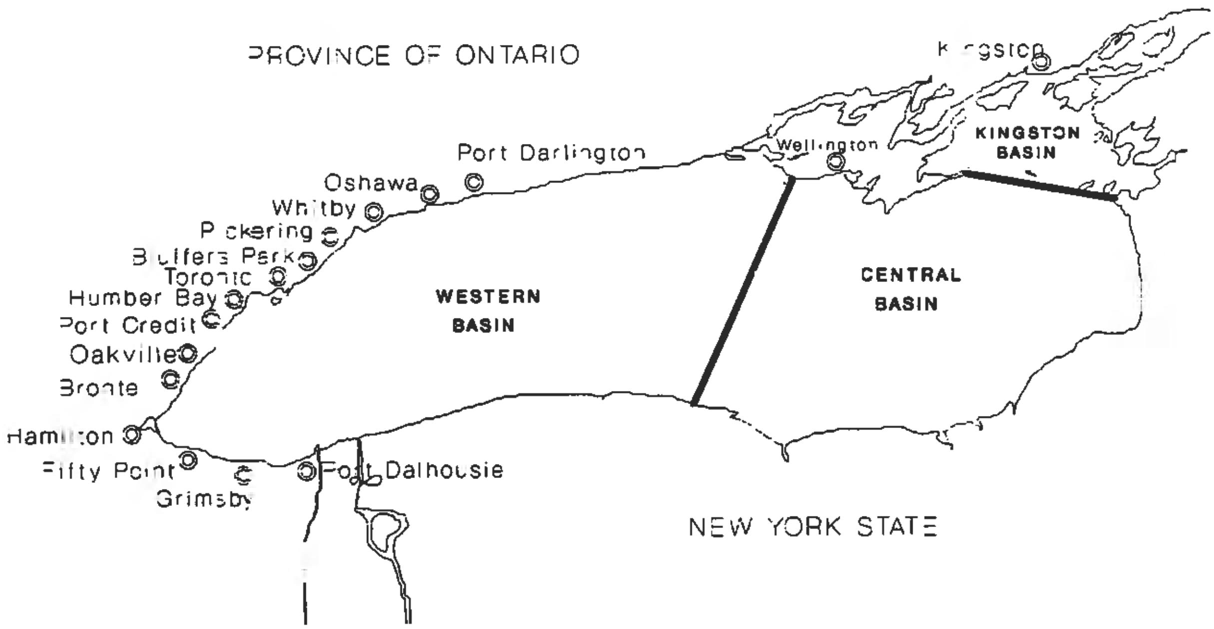

FIG 1. Reported charter boat port locations for 1990 to 1992.

2). Membership declines paralleled this drop, with the exception of 1991, when membership remained high but fishing effort declined. The sharp decline in charter boat fishing effort is likely due to a number of factors. Based on comments from charter operators responding to our questionnaire, poor weather and poor fishing contributed to the decline in 1992. In general, Lake Ontario boat fishing effort and catch success has declined in recent years. The launch daily angling effort, our primary index of Lake Ontario salmonid boat fishing effort, decreased by 15% from a high in 1989. Salmonid harvest rates have dropped by 51% from a high in 1986 (Savoie and Bowlby 1993). The slow-down in the economy may have also contributed to the decline in fishing effort. We suspect that some charter operators may have chosen not to join a charter association in order to save money, thus accelerating the apparent decline in charter activity. Also, charter fishing may have been a luxury that fewer people could afford in recent years. It is important to monitor charter activity to better understand these changes. We recommend that a marina survey be conducted in 1993 to determine catch rates and the proportion of active charter operators that remain affiliated with charter boat associations.

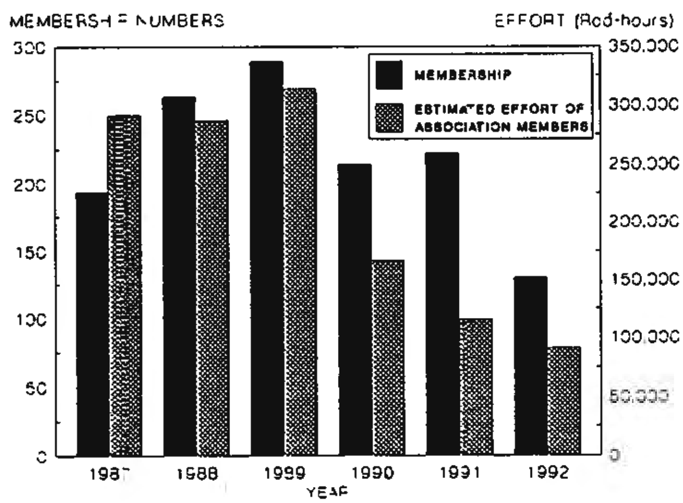

FIG 2. The number of Lake Ontario charter boats affiliated with associations, and their estimated fishing effort from 1987 to 1992.

Acknowledgements

The authors would like to thank all the charter boat operators who responded to our questionnaire. Jim Bowlby and Jim Hoyle provided comments on an earlier draft.

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Lake Ontario Stocking and Marking Program for 1992

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This report summarizes the characteristics of fish stocked into Lake Ontario from Canadian and American sources for 1992. Stocking trends since 1968 for both countries are also summarized herein. Information such as numbers of fish, stocking location, egg source, strain, age and size at stocking, and marks applied is provided. Since 1984, American and Canadian fisheries managers have been adhering to a stocking cap of 8.2 million (+/- 5%) fish for Lake Ontario until 1992. The total number of salmon and trout stocked into Lake Ontario from all sources in 1992 was 7,342,843. The Province of Ontario waters received 2,313,843 salmonids, and New York waters received 5,029,000 In addition, 51,700 walleye were stocked by private groups in New York waters of Lake Ontario and 3,154 walleye were stocked in Ontario waters. New York State managers are continuing their experiments with triploid (sterile) chinook salmon, Seeforellen trout (strain of large brown trout) and Skamania trout (summer run rainbow trout).

Introduction

The Lake Ontario fish stocking and marking program report is prepared annually as a joint New York Department of Environmental Conservation (NYDEC) and Ontario Ministry of Natural Resources (OMNR) effort. The report is prepared to summarize numbers of fish planted into Lake Ontario and identifying marks used by both agencies.[1]

Results

Tables 1 and 2 provide statistics on numbers of fish stocked in 1990, 1991 and 1992. Tables 3(a,b) and 4(a,b) provide information on numbers of fish stocked into Lake Ontario from 1968 through 1992 by both agencies. Table 5 identifies the deviations from the 1992 proposals and explains the reasons for the changes.

Appendix A and B contain detailed information about the areas of Lake Ontario that received hatchery fish in 1992. These appendices contain species information including strain, hatchery or origin, age and size at stocking, and marks applied. Tables of proposed stocking by both agencies have not been presented this year. Ongoing public consultation in New York and Ontario concerning the status of the Lake Ontario ecosystem will be completed before stocking levels can be determined.

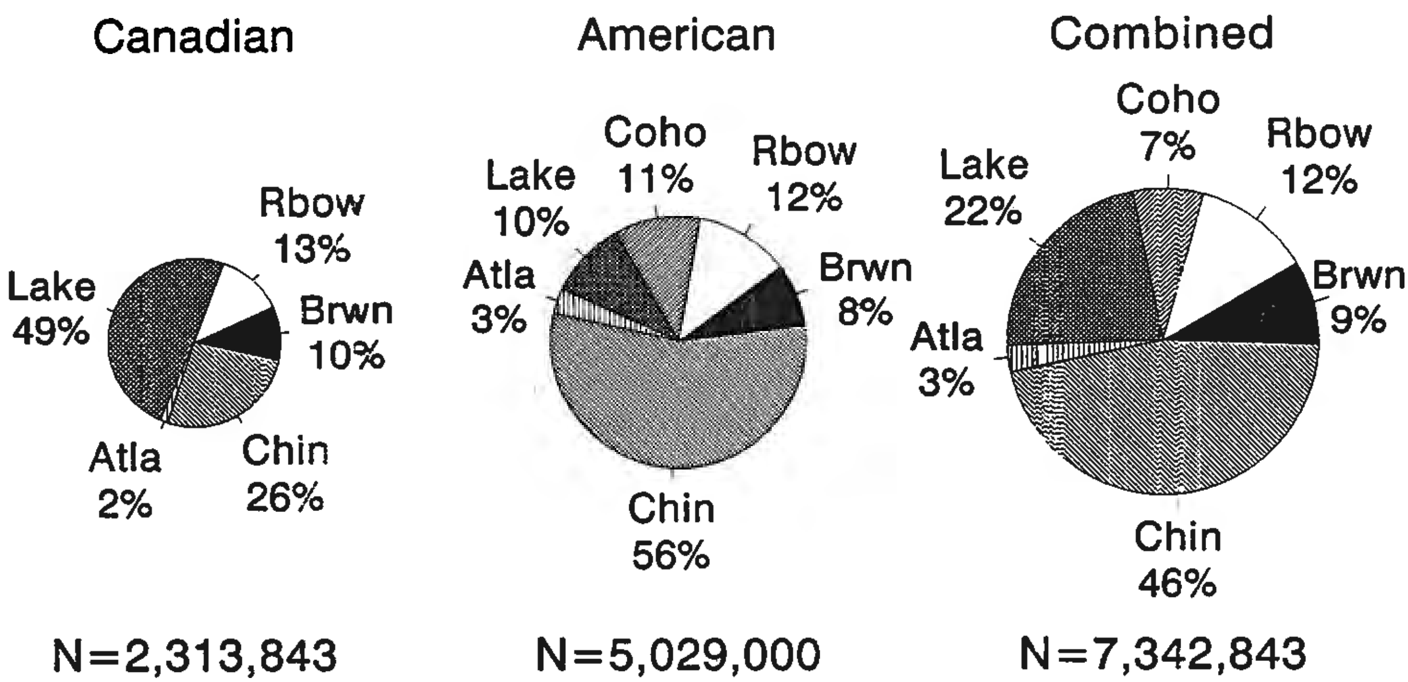
Comparison of the OMNR and the NYDEC Lake Ontario stocking is shown as abundance of each species by percent in Fig. 1 and as actual numbers by age group in Fig. 2. Trends in the total number of fish planted by both agencies are shown in Fig. 3 and trends by species, of fish stocked by both agencies combined, is depicted in Fig. 4.

The 1992 Lake Ontario fish stocking by government agencies consisted of salmon and trout only. Private groups in New York raised and stocked walleye from fry provided by NYDEC's Oneida Hatchery. The total number of salmon and trout stocked in all Lake Ontario waters combined was 7,342,843. The stocking of 2,313,843 salmonids in Province of Ontario waters was approximately the number proposed. The New York stocking of 5,029,000 salmon and trout was below the proposed target. The 51,700 walleye stocked by private groups in New York was lower than in 1991.

The NYDEC stocking total of salmon and trout declined considerably from 1991 to 1992 (LeTendre and Savoie 1992). There were several species fluctuations. The positive aspects of species increases were the large increase in Washington steelhead yearlings (+139,100) and fingerlings (+35,000) and chinook salmon spring fingerlings (+85,000). These excesses were all from better than expected survival at the Salmon River hatchery. Species that were reduced such as lake trout (-313,000 yearlings and -160,000 fingerlings) are not expected to improve before 1995.

The OMNR stocking total decreased by 540,218 (19%) from 1991 to 1992. There were OMNR stocking increases

[1]Most fish were raised in provincial fish culture stations or State fish hatcheries. Exceptions in 1992 included: lake trout provided by United States Fish and Wildlife Service from the Allegheny National Fish Hatchery. Private groups raised walleye fry provided by the NYDEC and OMNR and stocked them as fingerlings. Sir Sanford Fleming College in Lindsay Ontario, collected chinook salmon eggs from the Credit River and stocked fingerlings into Cobourg Creek.



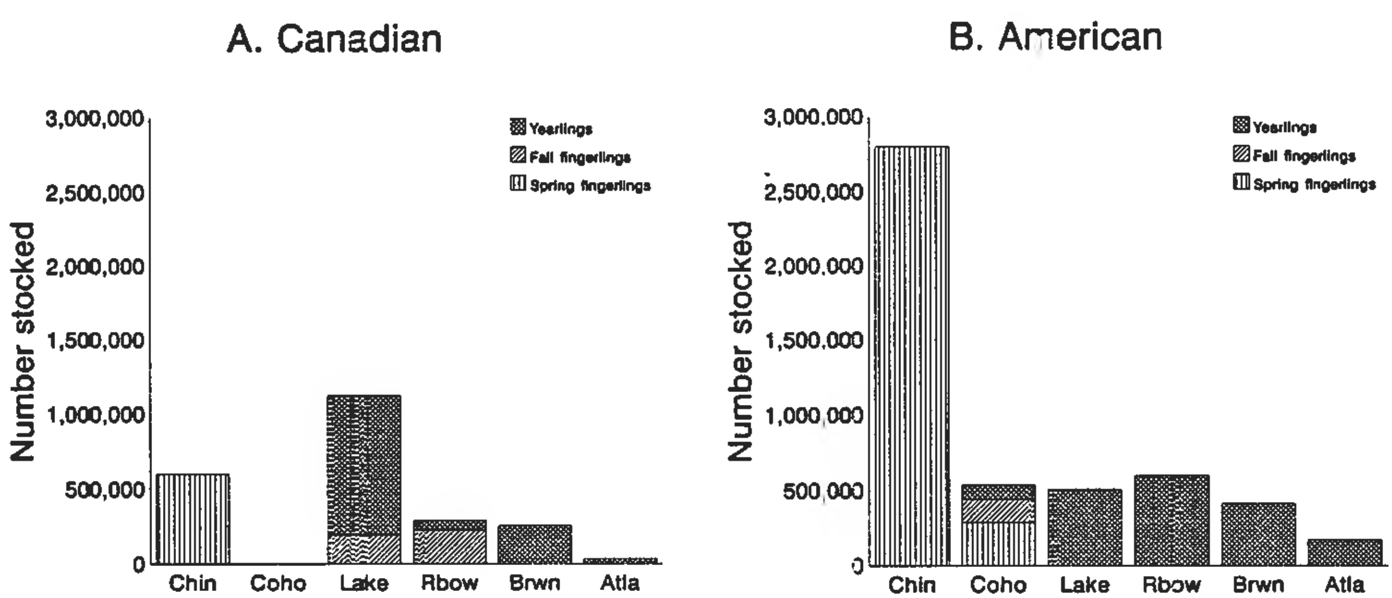


FIG. 2. Lake Ontario salmonid species mix stocked from Canadian and American sources in 1992 presented by age group.

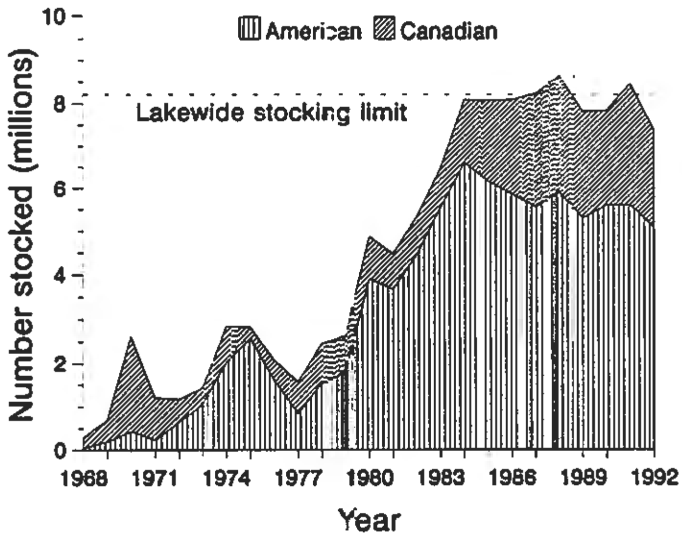


FIG. 3. Lake Ontario stocking trends (all species combined) from Canadian and American sources. Includes yearlings, all fingerlings, some fry and II+ fish. Also includes American stocked walleye beginning in 1986.

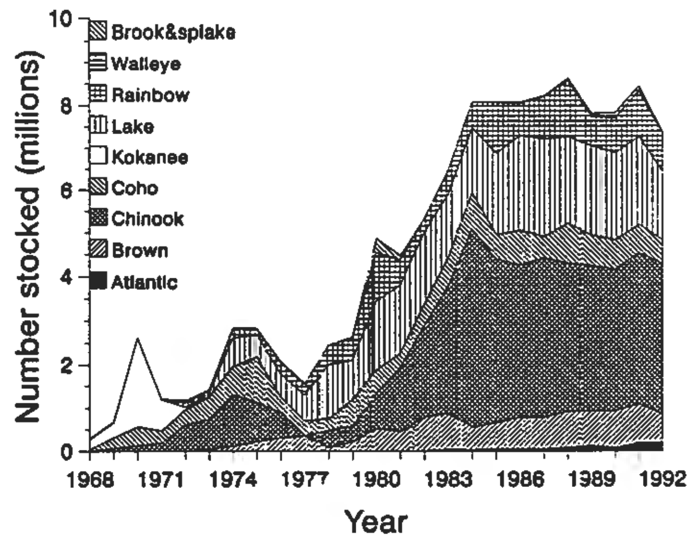


FIG. 4. Lake Ontario stocking trends, by species, for combined Canadian and American plantings. Includes all yearlings, all fingerlings, some fry and II+ fish. Canadian splake (1968–1976) are included with American brook trout (1980, 1981).

TABLE 1. Salmon and trout stocked in Province of Ontario waters of Lake Ontario in 1990, 1991 and 1992.

Species	Age	Number stocked 1990	Number stocked 1991	Number stocked 1992
Brown trout	Yearling	386,718	380,914	257,366
	Fall Fingerling	0	145,039	0
	Subtotal	386,718	525,953	257,366
Coho salmon	Yearling	169,289	148,006[a]	0
	Fingerling	67,575	2,950	0
	Fry	0	275,511	0
	Subtotal	234,864	426,467	0
Lake trout	Yearling	948,574	1,092,196	931,226
	Fingerling	0	0	195,074
	Subtotal	948,574	1,092,196	1,126,300
Chinook salmon	Fingerling	541,187	593,631[a]	604,755
Rainbow trout	Yearling	104,994[a]	125,070	64,378
	Fingerling	0	62,249	226,286
	Subtotal	104,994	187,319	290,664
Atlantic salmon	Yearling	51,181[a]	28,495	34,758
	Fingerling	9,865[a]	0	0
	Subtotal	61,046	28,495	34,758
	LAKE TOTAL	2,233,543	2,854,061[a]	2,313,843

[a] Corrected since the 1991 report (LeTendre and Savoie 1992)

TABLE 2. Salmon and trout stocked in New York waters of Lake Ontairo in 1990, 1991 and 1992.

Species	Age	Number[a] stocked 1990	Number[a] stocked 1991	Number[a] stocked 1992
Brown trout	Yearling	461,150	381,880	415,170
Coho salmon	Yearling	110,000	97,000	94,100
	Fingerling	331,620	131,750	445,000
	Subtotal	441,620	228,750	539,100
Lake trout	Yearling	795,600	818,090	507,580
	Fingerling	310,000	160,000	0
	Subtotal	1,105,600	978,090	507,580
Chinook salmon	Fingerling	2,720,000	2,835,000	2,798,215
Rainbow trout:				
Washington Steelhead	Yearling	412,200	519,300	430,000
	Fingerling	180,000	215,000	0
	Subtotal	592,200	734,300	430,000
Domestic	Yearling	94,110	81,550	84,850
	Fingerling	33,600	28,900	0
	Subtotal	127,710	110,450	84,850
Skamania	Yearling	0	32,000	84,780
	Rainbow Species Total	719,910	876,750	599,630
Atlantic salmon	Yearling	33,320	178,000	169,305
	LAKE TOTAL	5,481,600	5,478,470	5,029,000

[a] Stocking includes surplus fingerlings

for all salmonids with the exception of brown trout and coho salmon. The decreases were the result of the termination of the coho salmon rearing program and reductions in brown trout stocking as a result of hatchery closures in 1991.

There were 3,154 walleye stocked into the Frenchman's Bay, east of Toronto, in 1992. These are the first walleye stocked into Lake Ontario waters by OMNR.

The 1992 stocking, by American and Canadian agencies combined, was 308,957 fish (4%) below the proposed targets for 1992 and 857,157 (10%) below the agreed 8.2 million (+/- 5%) stocking cap for Lake Ontario.

Discussion

Since 1984, New York and Ontario fisheries managers have attempted to adhere to a stocking cap of 8.2 million fish (+/- 5%) for Lake Ontario (Fig. 3). However, in 1992 stocking declined below agreed levels as a result of hatchery closures in Ontario and water quality problems affecting the lake trout survival at Allegheny National Fish Hatchery in New York.

As stocking numbers of various species have been modified in recent years, some developments require clarification. Changes by each agency are as follows:

NYDEC

Chinook Salmon

Management efforts in recent years have been aimed at reducing numbers of chinook salmon returning to the Black River and straying into the St. Lawrence River. This process is aimed at reducing snatching and downstream straying while upgrading steelhead and Atlantic salmon angling opportunity in the Black River. The targeted number of 2.7 million chinook are still stocked but have been moved west of the eastern basin of Lake Ontario.

Management techniques have been used to produce small lots (35,000 in 1991, 1,115 in 1992) of triploid chinook salmon at Salmon River Hatchery. Triploidy is a condition

TABLE 3a. Number of salmon and trout (x 1000) stocked in Province of Ontario waters of Lake Ontario waters of Lake Ontario from 1968 through 1980.

Species	Age[a]	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Coho	Y	0	138	148	160	122	272	438	226	166	313	201	156	77
Coho	F	0	0	0	0	0	0	0	0	0	0	0	130	172
Chinook	f	0	0	0	89	190	0	225	0	0	0	393	147	18
Lake	Y	0	0	0	0	0	0	0	0	194	288	200	201	383
Rainbow	Y	12	1[illegible]	10	[illegible]8	107	28	30	7	108	110	114	201	149
Rainbow	F	0	0	0	0	0	30	94	0	0	0	10	0	0
Rainbow	f	0	0	0	0	0	0	0	22	0	0	0	0	180
Splake	Y	24	25	0	0	48	39	26	0	6	0	0	0	0
Kokanee	f	0	2[illegible]	45	50	61	0	0	0	0	0	0	0	0
Kokanee	fry	228	334	1982	678	0	0	0	0	0	0	0	0	0
TOTALS		264	527	2185	995	528	369	813	255[b]	474[b]	[illegible]11[b]	918	835	979

TABLE 3b. Number of salmon, trout and walleye (x 1000) stocked in Province of Ontario waters of Lake Ontario from 1981 through 1992.

Species	Age[a]	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Coho	Y	169	112	142	106	191	183	188	207	204	169	148[c]	0
Coho	F	165	0	76	0	0	90	129	104	87	66	3	0
Coho	f	0	0	0	0	0	0	84	76	0	0	0	0
Coho	fry	0	0	0	0	0	0	0	0	0	0	276	0
Chinook	f	12	270	125	662	703	598	514	516	541	497	594[c]	605
Lake	Y	387	391	372	493	729	852	1066	1024	1124	949	1092	931
Lake	F	0	0	0	0	0	0	56	0	0	0	0	195
Brown	II+	0	0	0	1	1	1	0	0[d]	0[c]	0	0	0
Brown	Y	0	0	123	122	136	283	256	387	360	387	381	257
Brown	F	0	48	0	0	27	14	62	0	0	0	145	0
Brown	f	7	0	0	0	0	0	0	0	0	0	0	0
Rainbow	Y	81	68	105	110	106	200	306	264	1[illegible]8	105[c]	125	64
Rainbow	F	0	0	0	0	0	0	0	111	0	0	62	226
Atlantic	Y	0	0	0	0	0	0	0	27	61	51[c]	28	35
Atlantic	F	0	0	0	0	0	0	1	22	[illegible]5	10[c]	0	0
Walleye	F	0	0	0	0	0	0	0	0	0	0	0	3
TOTALS		821	889	943	1494	1893	2221	2662	2738	25[illegible]1	2234	2854	2314

[a] II+: Two year old fish.
Y: Yearlings, stocked between January and June usually 5" to 9".
F: Fall fingerlings, stocked between September and December usually 3-1/2" to 6".
f: Spring fingerlings, stocked May and June usually 2-1/2" to 3".
fry: 1 to 2 month old fish

[b] Does not include stocking of [illegible]5,000 rainbow trout eggs in 1975 or lake trout eggs stocked in 1976 (90,000) and 1977 (200,000).

[c] Corrected since the 1991 report (LeTendre and Savoie 1992)

[d] There were 346 and 275 adult brown trout stocked (spent brood stock) in 1988 and 1989, respectively.

TABLE 4a. Number of salmon and trout (x 1000) stocked in New York waters of Lake Ontario from 1968 through 1980.

Species	Age[a]	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Coho	Y	25	119	294	122	230	215	147	452	178	39	40	175	0
Coho	F	15	0	0	0	0	25	69	361	0	0	40	169	299
Chinook	f	0	70	140	100	426	691	963	920	593	0	0	222	788
Chinook	F	0	0	0	0	0	9	0	0	0	0	0	0	0
Lake	Y	0	0	0	0	0	66	128	0	63	0	505	492	1012
Lake	F	0	0	0	0	0	0	517	513	274	298	538	193	182
Brown	Y	0	0	0	0	0	60	81	108	157	163	94	219	257
Brown	F	0	0	0	0	0	0	42	113	154	195	0	0	272
Rainbow	Y	0	0	0	0	0	0	19	0	54	50	41	41	85
Rainbow	F	0	0	0	0	0	0	10	99	104	67	125	167	411
Steelhead	Y	0	0	0	0	0	0	50	0	29	27	147	117	263
Brook	F	0	0	0	0	0	0	0	0	0	8	0	0	326
TOTALS		40	189	434	222	656	1066	2026	2566	1606	847	1530	1795	3895

TABLE 4b. Number of salmon, trout and walleye (x 1000) stocked in New York waters of Lake Ontario from 1981 through 1991.

Species	Age[a]	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Coho	Y	0	307	396	289	351	194	80	300	197	110	97	94
Coho	F	0	60	51	454	25	268	0	176	213	187	132	155
Coho	af	0	0	0	0	0	0	0	0	0	144	0	0
Coho	f	0	0	0	0	0	85	0	80	0	0	0	290
Chinook	f	1468	1808	2759	3878	3022	2849	3111	2848	2752	2720	2835	2798
Lake	Y	1031	1054	1086	1045	984	1012	818	768	778	796	818	508
Lake	F	112	205	11	0	202	370	367	247	232	310	160	0
Lake	II+	3	0	0	0	0	0	0	0	0	0	0	0
Brown	Y	365	503	479	408	440	442	418	404	407	461	382	415
Brown	F	89	153	100	0	0	0	0	46	38	0	0	0
Brown	f	0	98	132	0	0	0	0	0	0	0	0	0
Rainbow	Y	76	38	108	93	84	80	91	77	94	94	82	85
Rainbow	F	147	96	105	105	105	23	40	150	25	34	0	0
Rainbow	f	0	0	140	0	549	0	0	0	0	0	29	0
Steelhead	Y	260	114	112	293	334	407	443	407	384	412	551	515
Steelhead	F	0	5	0	0	10	55	129	308	75	180	40	0
Steelhead	f	0	0	0	0	0	0	0	0	0	0	175	0
Brook	F	106	0	0	0	0	0	0	0	0	0	0	0
Atlantic	Y	0	0	49	25	55	55	58	32	50	33	178	169
Atlantic	F	0	0	0	0	13	0	7	6	15	0	0	0
Walleye	af	0	0	0	0	0	20	3	63	72	125	122	52
SALMONIDS		3657	4441	5528	6590	6174	5840	5562	5849	5260	5482	5479	5029
WALLEYE		0	0	0	0	0	20	3	63	72	125	122	52
TOTALS		3657	4441	5528	6590	6174	5860	5565	5912	5332	5607	5601	5081

[a] II+: Two year old fish
Y: Yearlings, stocked between January and June usually 5" to 9".
F: Fall fingerlings, stocked between September and December usually 3-1/2" to 6".
af: Advanced spring fingerlings, usually stocked after June but prior to September.
f: Spring fingerlings, stocked May and June usually 2-1/2" to 3".

in which there is an extra chromosome in the cell nucleus, resulting in sterile fish. Experimentation is being conducted to determine if triploid fish will refrain from migrating upstream at spawning time. This technique could be utilized to reduce possible excessive densities in certain tributaries following the anticipated prohibition of salmon snagging. Technical problems caused this effort to fail in 1992.

Coho Salmon

Efforts to maintain a broodstock of coho salmon at Salmon River Hatchery have been successful. However, hatchery water temperature problems have resulted in less than desirable coho for stocking. The coho are being stocked as summer fingerlings, fall fingerlings and yearlings to determine the most productive stocking size.

In 1991 a pipeline from Salmon River reservoir upgraded the summer and winter water quality at the hatchery and the stocking policy is expected to revert to all coho stocked as yearlings (unless the summer or fall fingerling stocking is more productive).

Brown Trout and Steelhead

NYDEC staff are always striving to improve angling. As part of this approach we have experimented with stocking Seeforellen brown trout (beginning 1988) and Skamania steelhead (beginning 1986). The Seeforellen brown trout are being finclipped and stocked at two sites (Shore Oaks and Oswego) each year to determine if we can produce some very large brown trout. The purpose of the Skamania program stocking is to produce more nearshore summer angling opportunity. The Skamania program is also experimental and is planned for stocking four sites with marked fish each year. All four sites were stocked in 1992, with a total of 84,780 Skamanias. Salmon River and Black River stockings are expected to provide brood fish.

Results of both experimental strain stocking programs are not expected until at least 1994.

TABLE 5. Important deviations from the proposed stocking numbers by the OMNR and the NYDEC in 1992.

Species	Agency	Number (x1000)	Age[a]	Reason
Lake trout	NYDEC	-512 -180	Y f	Water problems at Allegheny National Fish Hatchery
	OMNR	-35 -5	Y f	Poorer survival than expected Poorer survival than expected
Coho salmon	NYDEC	-151 +155 +290	Y F af	Policy for coho salmon stocking size continues to undergo review and change
Chinook salmon	NYDEC	+98	f	Better than anticipated survival at Salmon River Hatchery
	OMNR	-45	f	Poorer survival than expected
Rainbow trout	NYDEC	-15	Y	Statewide shortage of yearlings
	OMNR	+4 +166	Y F	Better survival than expected Replacement for loss of coho salmon, and retaining Brown trout fingerlings until 1993
Steelhead trout	NYDEC	+55	Y	Better than anticipated survival of yearlings
Brown trout	OMNR	-100	F	Retained in hatchery for stocking as yearlings in 1993
Atlantic salmon	NYDEC	-30	Y	Statewide shortage due to lower than expected survival
	OMNR	+3	Y	Surplus fish from research growth experiment

[a] Y: Yearlings, stocked between January and June, usually 5" to 9".
F: Fall fingerlings, stocked between September and December usually 3-1/2" to 6".
f: Spring fingerlings, stocked May and June usually 2-1/2" to 3".
af: Advanced spring fingerlings, usually stocked after June but prior to September

OMNR

Chinook Salmon

Additional space at Ringwood Fish Culture Station (FCS) as a result of dropping coho salmon made the target of 650,000 fingerlings attainable for the first time. Unfortunately, chinook salmon at Ringwood suffered from lower egg survival than expected. Egg survival seemed to be related to individual males or females. During fall 1992 eggs from each female were incubated separately, and more eggs were collected, and so the production for 1993 should be close to the target. Two new shoreline stocking sites at waterfront parks in Toronto were added in 1992 to bolster the fall shore and boat fisheries.

Rainbow Trout

Additional rainbow trout were supplied to Lake Ontario as replacement for coho salmon which were dropped in 1991. As a result rainbow trout were stocked at two locations in the St. Catharines area. In addition, because of evidence of natural reproduction of rainbow trout in the Credit River and Bronte Creek (Bowlby *et al.* 1993), some fish were stocked into the Humber River. Most rainbow trout were stocked as fall fingerlings so that all fingerling brown trout on hand could be stocked as yearlings in 1993. With the closure of Deer Lake FCS the average size rainbow yearling stocked into Lake Ontario has become larger and more consistent than past years.

Atlantic Salmon.

The number of Atantic salmon stocked by OMNR was 30% lower than the target of 50,000 because OMNR was unable to obtain eggs from a landlocked strain. As a result only the LaHave River strain (anadromous) was stocked in 1991 and 1992. This will be the only strain stocked as yearlings in 1993. Efforts to find a new egg supply will continue.

Brown Trout

Brown trout yearling stocking declined to 66% of the 1991 level as a result of the closure of Codrington FCS. About 145,000 of this year class were stocked as fall finglerlings in 1991. Some brown trout fall fingerlings were proposed for 1992, but, by stocking rainbow trout as fall fingerlings, space was made in Ringwood FCS to hold all brown trout to yearlings . We felt that survival of rainbow fall fingerlings would be better than brown trout fall fingerlings because rainbow trout are stocked into streams with few competitors or predators, whereas brown trout are stocked directly into Lake Ontario. The OMNR rainbow trout strain (Ganaraska) has a greater tendancy to migrate downstream than then OMNR brown trout strain (Ganaraska).

Lake Trout

In line with proposed changes to the plan for lake trout rehabilitation, OMNR stocked only Slate Island (Lake Superior) and Seneca Lake strains in 1992. OMNR is currently developing a brood stock of Seneca Lake lake trout which may come into production in 1996. In the meantime, Mishibishu Lake and Michipicoten Island strains (both Lake Superior strains) will also be stocked into Lake Ontario starting in 1994 or 1995.

References

BOWLEY, J., L. HALYK, AND J. BISSET. 1993. Assessment of stocked brown trout, rainbow trout, coho salmon and chinook salmon in Lake Ontario. *In* Lake Ontario Fisheries Unit 1992 Annual Report, LOA 93.1 (Section 3). Ontario Ministry of Natural Resources.

LETENDRE, G.C., P.J. SAVOIE. 1992. Lake Ontario Stocking and Marking Program for 1991. *In* Lake Ontario Fisheries Unit 1991 Annual Report (Section 15). Ontario Ministry of Natural Resources.

Glossary of Terms and Abbreviations

Steelhead: a migratory rainbow trout, technically, one which undergoes the parr-smolt transformation and migrates to Lake Ontario from the stream in which it was planted, or hatched in the case of wild fish.

Domestic Rainbow trout: a rainbow trout that is not known to exhibit a parr-smolt transformation and, therefore, is planted directly into the lake since it would not be expected to migrate to the lake if planted in a stream.

Atlantic salmon: includes the ocean run strain of fish generally referred to as Atlantic salmon and the lake dwelling strain called landlocked salmon.

Mark:	Body part removed or tag added for identification
LV:	Left Ventral fin clip
Ad-LV:	Adipose and Left Ventral fins clipped
RV:	Right Ventral fin clip
Ad-LP:	Adipose and Left Pectoral fins clipped
LV-RV:	Both Ventral fins clipped
RP:	Right Pectoral fin clip
LP:	Left Pectoral fin clip
LV-LM:	Left Ventral fin and Left Maxillary bone clip
CWT:	Coded Wire Tag (60-42-14, the first two numbers are the agency code; i.e., 60, 23 and 63 are agency codes for USFWS, NYDEC and OMNR respectively, the third through sixth numbers identify individual lots of fish)

Some figures and tables use the following species name abbreviations:

Coho:	Coho salmon
Chin:	Chinook salmon
Atla:	Atlantic salmon
Rbow:	Rainbow trout
Sthd:	Steelhead trout
Koka:	Kokanee salmon
Splk:	Splake
Lake:	Lake trout
Brwn:	Brown trout
Brok:	Brook trout
Wall:	Walleye

APPENDIX A
Salmon, trout and walleye stocked in Province of Ontario waters of Lake Ontario in 1992.

Location	Month Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age Months	Ave. Weight	Mark	Number Stocked
				CHINOOK SALMON FINGERLINGS				
Ashbridges Bay	05	91	Ringwood	Lake Ontario	06	4.9	none	32,163
Bluffers Park	05	91	Ringwood	Lake Ontario	06	4.9	none	32,163
Bowmanville Cr.	05	91	Ringwood	Lake Ontario	06	5.0	none	28,298
Bronte Cr.	05	91	Ringwood	Lake Ontario	06	5.0	none	70,187
Burlington Canal	05	91	Ringwood	Lake Ontario	06	4.4	none	69,761
Cobourg Cr.	02	91	SSFC *	Lake Ontario	03	4.0	none	4,200
	04	91	SSFC *	Lake Ontario	05	12.4	none	3,000
	05	91	Ringwood	Lake Ontario	06	5.5	none	28,308
COBOURG CR. TOTAL								35,508
Credit R.	05	91	Ringwood	Lake Ontario	06	4.8	none	130,576
Oshawa Cr.	05	91	Ringwood	Lake Ontario	06	5.1	none	28,301
Port Dalhousie	05	91	Ringwood	Lake Ontario	06	5.4	none	131,176
Wellington	05	91	Ringwood	Lake Ontario	06	5.3	none	46,622
TOTAL FINGERLING CHINOOK								**604,755**
				RAINBOW TROUT YEARLINGS				
Bronte Cr.	03	91	Ringwood	Ganaraska/ Normandale	12	35.6	RP	25,349
Credit R.	03	91	Ringwood	Ganaraska/ Normandale	12	35.4	RP	25,367
Rouge R.	03	91	Ringwood	Ganaraska/ Normandale	12	37.0	RP	13,162
Wilmot Cr.	04	91	Ringwood	Ganaraska/ Normandale	13	39.2	RP	500
TOTAL YEARLING RAINBOW								**64,378**
				RAINBOW TROUT FINGERLINGS				
Bronte Cr. Normandale	10	92	Ringwood	Ganaraska/	08	13.6	Ad	24,961

*Sir Sanford Fleming College, Lindsay, Ontario

APPENDIX A
Salmon, trout and walleye stocked in Province of Ontario waters of Lake Ontario in 1992.

Location	Month Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age Months	Ave. Weight	Mark	Number Stocked
Credit R.	10	92	Ringwood	Ganaraska/ Normandale	08	11.6	Ad	50,063
Humber R.	10	92	Ringwood	Ganaraska/ Normandale	08	9.5	Ad	50,506
Jordan Hr.	11	92	Normandale	Ganaraska/ Normandale	07	18.1	Ad	31,127
Port Dalhousie	11	92	Normandale	Ganaraska/ Normandale	07	17.9	Ad	44,373
Rouge R.	10	92	Ringwood	Ganaraska/ Normandale	08	9.0	Ad	25,256
TOTAL FALL FINGERLING RAINBOW TROUT								**226,286**
TOTAL YEARLING RAINBOW TROUT								**64,378**
TOTAL RAINBOW TROUT								**290,664**
			ATLANTIC SALMON YEARLINGS					
Credit R.	03	90	Normandale	Anadromous LeHave, N.S.	14	35.4	AdLV	22,358
	08	90	Guelph University	Anadromous LeHave, N.S.	18	60.9	none	2,400
CREDIT RIVER TOTAL								22,358
Wilmot Cr.	03	90	Normandale	Anadromous LeHave, N.S.	14	35.2	AdLV	10,000
TOTAL YEARLING ATLANTIC SALMON								34,758
			BROWN TROUT YEARLINGS					
Ashbridges Bay	05	90	Harwood	Ganaraska/ Codrington	17	62.3	RV	6,084
	05	90	Harwood	Ganaraska/ Codrington	16	43.3	RV	3,592
ASHBRIDGES BAY TOTAL								9,676
Bluffers Park	05	90	Harwood	Ganaraska/ Codrington	17	67.8	RV	6,104
	05	90	Harwood	Ganaraska/ Codrington	16	39.4	RV	3,536
BLUFFERS PARK TOTAL								9,640

APPENDIX A
Salmon, trout and walleye stocked in Province of Ontario waters of Lake Ontario in 1992.

Location	Month Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age Months	Ave. Weight	Mark	Number Stocked
Bronte Cr.	03	90	Ringwood	Ganaraska/ Codrington	13	37.2	AdRV	15,126
Burlington Canal	03	90	Ringwood	Ganaraska/ Codrington	13	37.9	AdRV	15,128
Duffins Cr.	04	90	Harwood	Ganaraska/ Codrington	15	34.0	RV	3,572
	04	90	Harwood	Ganaraska/ Codrington	16	38.3	RV	6,068
DUFFINS CR. TOTAL								9,640
Fifty Point	03	90	Ringwood	Ganaraska/ Codrington	13	36.9	AdRV	22,690
Ganaraska R.	05	90	Harwood	Ganaraska/ Codrington	16	43.4	RV	3,453
	05	90	Harwood	Ganaraska Codrington	17	69.7	RV	5,964
GANARASKA R. TOTAL								9,417
Grimsby	03	90	Ringwood	Ganaraska/ Codrington	13	40.5	AdRV	7,562
Humber R.	05	90	Harwood	Ganaraska/ Codrington	16	39.4	RV	3,541
	05	90	Harwood	Ganaraska/ Codrington	17	79.9	RV	6,151
HUMBER R. TOTAL								9,692
Jordan Harbour	03	90	Codrington	Ganaraska/ Codrington	13	23.6	AdRV	23,142
	04	90	Codrington	Ganaraska/ Codrington	14	24.4	AdRV	25,820
JORDAN HARBOUR TOTAL 48,962								
Millhaven Wharf	03	90	Harwood	Ganaraska/ Codrington	15	43.8	RV	27,583
	05	90	Harwood	Ganaraska/ Codrington	16	47.9	RV	23,422
	05	90	Harwood	Ganaraska/ Codrington	17	75.6	RV	14,606
MILLHAVEN WHARF TOTAL								65,611

APPENDIX A
Salmon, trout and walleye stocked in Province of Ontario waters of Lake Ontario in 1992.

Location	Month Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age Months	Ave. Weight	Mark	Number Stocked
Oakville Harbour	03	90	Ringwood	Ganaraska/ Codrington	13	36.6	AdRV	15,127
Oshawa Harbour	05	90	Harwood	Ganaraska/ Codrington	16	44.4	RV	3,474
	05	90	Harwood	Ganaraska/ Codrington	17	72.0	RV	5,967
OSHAWA HARBOUR TOTAL								9,441
Rouge R.	05	90	Harwood	Ganaraska/ Codrington	16	39.4	RV	3,544
	05	90	Harwood	Ganaraska/ Codrington	17	75.7	RV	6,110
ROUGE RIVER TOTAL								9,654
TOTAL YEARLING BROWN TROUT								257,366

APPENDIX A
Salmon, trout and walleye stocked in Province of Ontario waters of Lake Ontario in 1992.

Location	Month Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age Months	Ave Weight	Mark	Number Stocked
				LAKE TROUT YEARLINGS				
Burlington Canal Normandale	04	90	Normandale	Seneca Lake/	15	59.1	Ad	
	05	90	Normandale	Seneca Lake/ Normandale	16	60.0	Ad	8,912
BURLINGTON CANAL TOTAL								41,882
Cobourg Harbour	02	90	Harwood	Slate Island/ Dorion	15	32.7	Ad	122,482
	04	90	Harwood	Slate Island/ Dorion	17	47.6	Ad	85,893
	05	90	Harwood	Slate Island Dorion	18	56.7	Ad	56,220
COBOURG HARBOUR TOTAL								264,595
Fifty Point	02	90	Harwood	Slate Island/ Dorion	15	33.1	Ad	125,628
	04	90	Harwood	Slate Island/ Dorion	17	48.0	Ad	57,784
	05	90	Harwood	Slate Island/ Dorion	18	54.4	Ad	62,479
FIFTY POINT TOTAL								245,891
Central Basin	04	90	White Lake	Slate Island/ Dorion	17	24.4	Ad	20,430
	04	90	Pembrook	Slate Island/ Dorion	16	17.1	Ad	178,578
CENTRAL BASIN TOTAL								199,008
Kingston Basin	04	90	White Lake Dorion	Slate Island/	17	23.7	Ad	90,437
	04	90	Pembrook	Slate Island/ Dorion	16	16.4	Ad	89,433
KINGSTON BASIN TOTAL								179,870
TOTAL YEARLING LAKE TROUT								**931,226**

APPENDIX A
Salmon, trout and walleye stocked in Province of Ontario waters of Lake Ontario in 1992.

Location	Month Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age Months	Ave. Weight	Mark	Number Stocked
			LAKE TROUT FINGERLINGS					
Bluffers Park	11	91	Harwood	Slate Island/ Dorion	12	17.7	Ad	62,349
Cobourg Harbour	11	91	Harwood	Slate Island/ Dorion	12	18.4	Ad	70,811
Fifty Point	11	91	Harwood	Slate Island/	12	15.9	Ad	61,914
TOTAL FINGERLING LAKE TROUT								**195,074**
TOTAL YEARLING LAKE TROUT								**931,226**
TOTAL LAKE TROUT								**1,126,300**
TOTAL SALMONIDS								**2,313,843**
			WALLEYE FALL FINGERLINGS					
Frenchman's Bay	9	92	OSFH[a]	Bay of Quinte	4	2.5	none	3,154
TOTAL FINGERLING WALLEYE								**3,154**
GRAND TOTAL ALL SPECIES								**2,316,997**

[a] - Ontario Sport Fish Hatchery (Private Hatchery)

APPENDIX B
Salmon, trout and walleye stocked in New York Lake Ontario waters in 1992.

Area Stocked	Location	Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age Months	#Fish/ Pound	Mark	Number Stocked
				LAKE TROUT YEARLINGS					
Lake Ont.	Olcott	5/21	91	Allegheny	Ontario Seneca	17	12.7	60-46-55	39,600
Lake Ont.	Hamlin	5/20	91	Allegheny	Lewis Lake	17	8.7	60-46-47	40,610
		5/20	91	Allegheny	Lewis Lake	17	8.1	60-46-46	40,340
		5/22	91	Allegheny	Superior	17	14.9	60-46-53	14,660
		5/22	91	Allegheny	Superior	17	11.8	60-46-52	40,470
		6/11	91	Caledonia	Finger Lakes	18	6.9	LV	4,300
		3/2	91	Allegheny/ Caledonia	Seneca and Ontario[1]	15	24.4	60-46-35, 36,37,44,58	12,300
HAMLIN TOTAL									153,180
Lake Ont.	Sodus	5/19	91	Allegheny	Ontario	17	10.3	60-46-61	40,000
		5/19	91	Allegheny	Ontairo	17	10.7	60-46-62	39,300
		5/27	91	Allegheny	Ontairo	17	10.5	60-46-56	38,350
SODUS TOTAL									118,650
Lake Ont.	Selkirk	5/15	91	Allegheny	Ontairo	17	11.0	60-46-60	40,700
		5/15	91	Allegheny	Ontario	17	11.2	60-46-59	33,380
		5/27	91	Allegheny	Lewis Lake	17	8.0	60-46-43	41,380
SELKIRK TOTAL									115,960
Lake Ont.	Stony	5/14	91	Allegheny	Ontario	17	10.7	60-46-50	39,340
		5/14	91	Allegheny	Ontario	17	10.5	60-46-57	40,350
STONY TOTAL									80,190
TOTAL YEARLING LAKE TROUT									**507,580**
				ATLANTIC SALMON YEARLINGS					
Lake Ont.	Irondequoit	4/30	91	Adirondack	Little Clear	15	10.3	none	16,660
Lake Ont.	Hamlin Beach	4/30	91	Adirondack	Little Clear	15	10.3	none	16,500
Lake Ont.	Sodus Point	5/1	91	Adirondack	Little Clear	15	10.0	none	16,600
Black R.	Dexter	4/1	91	Salmon R.	Little Clear	15	13.0	none	62,250
		6/15	91	Adirondack	Little Clear	17	8.4	none	7,070
DEXTER TOTAL									69,320
Lower Niagara R.	Lewiston Sand Docks	4/7	91	Salmon R.	Little Clear	15	14.8	none	24,900
Lake Ont.	Oswego	4/8	91	Salmon R.	Little Clear	15	14.0	none	25,225
TOTAL ATLANTIC SALMON YEARLINGS									**169,305**

[1] - 5 CWT lots of fish were transferred from Allegheny National Hatchery to Caledonia due to water flow problems at Allegheny. The marked fish were combined in 2 ponds prior to stocking.

APPENDIX B
Salmon, trout and walleye stocked in New York Lake Ontario waters in 1992.

Area Stocked	Location	Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age Months	#Fish/ Pound	Mark	Number Stocked
				BROWN TROUT YEARLINGS					
Lake Ont.	Ray Bay	5/4	91	Salmon R.	Rome Lab	17	4.5	none	16,435
Lake Ont.	Montario Pt.	5/7	91	Salmon R.	Rome Lab	17	4.6	none	16,435
		6/5	91	Salmon R.	Rome Lab	18	3.5	none	11,400
MONTARIO PT. TOTAL									27,835
Lake Ont.	Oswego	5/6	91	Caledonia	Seeforellen/ Caledonia	13	6.8	LV	20,000
		5/6	91	Salmon R.	Rome Lab	17	4.4	LV-Ad	16,500
OSWEGO TOTAL									36,500
Lake Ont.	Fair Haven	4/27	91	Salmon R.	Rome Lab	17	4.8	none	10,000
		5/1	91	Rome	Rome Lab	17	5.3	none	20,000
FIAR HAVEN TOTAL									30,000
Lake Ont.	Sodus Pt.	4/30	91	Salmon R.	Rome Lab	17	4.1	none	27,680
		6/12	91	Salmon R.	Rome Lab	18.5	3.4	none	5,700
SODUS PT. TOTAL									33,380
Lake Ont.	Pultneyville	4/28	91	Salmon R.	Rome Lab	17	4.4	none	20,760
Lake Ont.	Webster	4/29	91	Salmon R.	Rome Lab	17	4.6	none	19,900
Lake Ont.	Irondequoit	5/8	91	Caledonia	Rome Lab/ Randolph	16	4.5	none	19,900
Lake Ont.	Rochester	5/11	91	Caledonia	Rome Lab/ Randolph	16	4.3	none	25,950
Lake Ont.	Braddock's Bay	5/7	91	Caledonia	Rome Lab/ Randolph	15.5	5.2	none	19,900
Lake Ont.	Hamlin	5/4	91	Caledonia	Rome Lab/ Randolph	15.5	4.0	none	31,140
Lake Ont.	Point Breeze	5/12 & 5/14	91	Caledonia	Rome Lab/ Randolph	16	4.1	none	32,870
Lake Ont.	Olcott	5/18 & 5/19	91	Caledonia	Rome Lab/ Randolph	16	4.1	none	21,630
Lake Ont.	Wilson	6/11	91	Salmon R.	Rome Lab	18.5	3.4	none	4,150
		5/21 & 5/22	91	Caledonia	Rome Lab/ Randolph	16	3.8	none	21,630
WILSON TOTAL									25,780

APPENDIX B
Salmon, trout and walleye stocked in New York Lake Ontario waters in 1992.

Area Stocked	Location	Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age Months	#Fish/ Pound	Mark[a]	Number Stocked
Lake Ont.	Selkirk Shores	5/5	91	Caledonia	Seeforellen/ Caledonia	13	7.6	LV	20,000
		5/15	91	Caledonia	Seeforellen/ Caledonia	13.5	6.7	LV	5,290
		5/5	91	Salmon R.	Rome Lab	17	4.4	LV-Ad	16,500
		6/5	91	Salmon R.	Rome Lab	18	3.6	none	11,400
SELKIRK SHORES TOTAL									53,190
TOTAL YEARLING BROWN TROUT									415,170
				COHO SALMON YEARLINGS					
Beaverdam Brook	Hatchery smolt release pond	3/31[2] & 4/30	91	Salmon R.	Salmon R.	15.5	11.2	none	94,100
TOTAL YEARLING COHO SALMON									**94,100**
				COHO SALMON FINGERLINGS					
Sodus Bay	West Pier	9/25	92	Salmon R.	Salmon R.	10	16.2	none	26,000
Genesee River	Naval Militia Boat Ramp	9/28	92	Salmon R.	Salmon R.	10	17.8	none	22,000
		6/17	92	Salmon R.	Salmon R.	6.5	95.1	none	72,500
GENESEE RIVER TOTAL									94,500
Sandy Creek	Parkway Bridge	9/28	92	Salmon R.	Salmon R.	10	18.4	none	26,000
Oak Orchard Creek	Twin Bridges	9/28	92	Salmon R.	Salmon R.	10	24.0	none	26,000
		6/17	92	Salmon R.	Salmon R.	6.5	95.3	none	72,500
OAK ORCHARD CREEK TOTAL									98,500
Eighteen Mile Creek	Olcott Harbour	9/29	92	Salmon R.	Salmon R.	10	24.5	none	30,000
Niagara River	Lewiston Sand Docks	9/29	92	Salmon R.	Salmon R.	10	24.5	none	25,000
		6/17	92	Salmon R.	Salmon R.	6.5	103.0	none	145,000
NIAGARA RIVER TOTAL									170,000
TOTAL FINGERLING COHO SALMON									**445,000**
TOTAL YEARLING COHO SALMON									**94,100**
TOTAL COHO SALMON									**539,100**

[2] - Coho salmon were stocked in the hatchery smolt release pond on March 31 and were allowed to voluntarily migrate until April 30 when the pond was drained.

APPENDIX B
Salmon, trout and walleye stocked in New York Lake Ontario waters in 1992.

Area Stocked	Location	Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age Months	#Fish/ Pound	Mark[2]	Number Stocked
				CHINOOK SALMON FINGERLINGS					
Henderson Bay	Association Island Cut	6/4	92	Salmon R.	Salmon R.	4	110	RV	40,000
		6/4	92	Salmon R.	Salmon R.	4	106	none	10,000
		6/8	92	Salmon R.	Salmon R.	5	116.5	Ad	46,260
		6/8	92	Salmon R.	Salmon R.	5	90	none	13,740
HENDERSON BAY TOTAL									110,000
Lake Ont.	Stony Creek Boat Launch	6/4	92	Salmon R.	Salmon R.	5	106	none	35,000
N. Sandy Creek	NY Rt. 3	5/29	92	Salmon R.	Salmon R.	4	103	none	90,000
S. Sandy Creek	NY Rt. 3	5/29	92	Salmon R.	Salmon R.	4	103	none	90,000
Beaverdam Brook	Salmon River Hatchery	6/12	92	Salmon R.	Salmon R.	5	80	none	450,000
Salmon R.	NY Rt. 3	6/12	92	Salmon R.	Salmon R.	5	81	none	120,000
Salmon R.	NY Rt. 3	6/12	92	Salmon R.	Salmon R.	5	80	none	97,000
SALMON RIVER TOTAL									667,100
Oswego R.	Oswego Harbour	5/26	92	Salmon R.	Salmon R.	4	110	none	225,000
Little Sodus Bay	State Park Boat Launch	5/27	92	Salmon R.	Salmon R.	4	125	none	180,000
Sodus Bay	Outlet Channel	5/27	92	Salmon R.	Salmon R.	4	125	none	180,000
Genesee R.	Naval Militia Boat Ramp	5/26	92	Salmon R.	Salmon R.	4	103	none	75,670
		5/26	92	Salmon R.	Salmon R.	4	112.3	none	194,330
GENESEE RIVER TOTAL									270,000
Sandy Creek	DEC Boat Ramp	6/1	92	Salmon R.	Salmon R.	4	93.6	none	180,000
Oak Orchard Creek	Twin Bridges	6/3	92	Salmon R.	Salmon R.	4	123	LV	91,320[3]
		6/3	92	Salmon R.	Salmon R.	4	101.2	none	178,680
		6/10	92	Salmon R.	Salmon R.	5	90	none	1,115[4]
OAK ORCHARD CREEK TOTAL									271,115

[3] - Surplus
[4] - Triploid

APPENDIX B

Salmon, trout and walleye stocked in New York Lake Ontario waters in 1992.

Area Stocked	Location	Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age Months	#Fish/ Pound	Mark[a]	Number Stocked
Eighteen Mile Creek	Olcott Harbour	6/1	92	Salmon R.	Salmon R.	4	93.8	none	120,000
		6/1	92	Salmon R.	Salmon R.	4	110	LP	30,000
		6/1	92	Salmon R.	Salmon R.	4	129.9	RP	30,000
EIGHTEEN MILE CREEK TOTAL									180,000
Twelve Mile Creek	Wilson Harbour	6/1	92	Salmon R.	Salmon R.	4	94.3	none	60,000
Niagara R.	Lewiston Sand Docks	6/2	92	Salmon R.	Salmon R.	4	98.4	none	260,000
TOTAL CHINOOK SALMON									**2,798,215**
				RAINBOW TROUT YEARLINGS					
Lake Ont.	Selkirk Shr. State Park	5/29	91	Caledonia	Utah	13	6.0	none	17,350
Lake Ont.	Sodus Point	5/20	91	Caledonia	Utah	13	6.0	none	18,000
Lake Ont.	Webster	5/6	91	Caledonia	Nashua	13	5.1	none	9,000
Lake Ont.	Hamlin Beach State Park	5/5	91	Caledonia	Nashua	13	4.6	none	18,000
Lake Ont.	Olcott Harbour	5/19	91	Caledonia	Utah	13	5.0	none	11,250
Lake Ont.	Wilson Harbour	5/22	91	Caledonia	Utah	13	5.8	none	11,250
TOTAL YEARLING RAINBOW TROUT									**84,850**
				STEELHEAD YEARLINGS					
Black R.	Dexter Boat Lauch	4/13	91	Salmon R.	Washington-Salmon R.	12	17.7	none	47,000
		5/25	91	Salmon R.	Washington-Salmon R.	12	12.5	none	5,000[5]
		4/2	91	Caledonia	Skamania	9	9.3	LP-Ad	18,780
		4/28	91	Salmon R.	Washington-Salmon R.	12	15.9	none	23,000
BLACK RIVER TOTAL									93,780

[5] - Surplus stocking

APPENDIX B
Salmon, trout and walleye stocked in New York Lake Ontario waters in 1992.

Area Stocked	Location	Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age Months	#Fish/ Pound	Mark	Number Stocked
—									
Stony Ck.	State Park Boat Lauch	4/9	91	Salmon R.	Washington-Salmon R.	12	12.0	none	18,000
South Sandy Ck.	NY Rt. 3	4/10	91	Salmon R.	Washington-Salmon R.	12	14.9	none	25,000
Beaverdam Brook	Salmon R. Hatchery	4/30	91	Caledonia	Skamania	9	9.5	LP-Ad	30,000
		4/30	91	Salmon R.	Washington-Salmon R.	12	12.7	LV	60,000
BEAVERDAM BROOK DAM TOTAL									90,000
Orwell Brook	Tubbs Road	3/24	91	Salmon R.	Washington-Salmon R.	12	13.0	LV	20,000
Trout Brook	Mattison Rd. and Co. Rt. 22	4/9	91	Salmon R.	Washington-Salmon R.	12	13.0	LV	20,000
		5/27	91	Salmon R.	Washington-Salmon R.	12	12.0	none	4,000[6]
TROUT BROOK TOTAL									24,000
Spring Bk.	Reservoir	3/25	91	Salmon R.	Washington-Salmon R.	12	13.0	LV	20,000
		4/28	91	Salmon R.	Washington-Salmon R.	12	15.9	none	23,000
SPRING BK. TOTAL									43,000
Oswego R.	Below Rt. 104	4/8	91	Salmon R.	Washington-Salmon R.	12	12.0	none	15,000
Maxwell Ck.	Mouth to Trib. 2.	3/31	91	Caledonia	Skamania	9	9.1	LP-Ad	18,000
Irondequoit Creek	Audubon Property	4/2	91	Salmon R.	Washington-Salmon R.	12	12.4	none	24,000
Genesee River	Naval Militia Boat Ramp	4/2	91	Salmon R.	Washington-Salmon R.	12	12.4	none	20,000
Salmon Ck.	Near Hilton High School	4/6	91	Salmon R.	Washington-Salmon R.	12	10.9	none	5,600
Sandy Ck.	DEC Boat Launch	4/6	91	Salmon R.	Washington-Salmon R.	12	10.9	none	10,000

- Surplus stocking

APPENDIX B
Salmon, trout and walleye stocked in New York Lake Ontario waters in 1992.

Area Stocked	Location	Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age Months	#Fish/ Pound	Mark	Number Stocked
Oak Orchard Creek	Twin Bridges	4/9	91	Salmon R.	Washington-Salmon R.	12	18.8	none	20,000
Johnson Ck.	Kirkville to Lyndonville	4/9	91	Salmon R.	Washington-Salmon R.	12	18.8	none	6,700
Keg Creek	Rt. 18	4/3	91	Salmon R.	Washington-	12	11.4	none	11,100
E. Branch 12 Mile Ck.	Near Mouth	4/13	91	Salmon R.	Washington-Salmon R.	12	17.7	none	13,300
12 Mile Cr.	Rt. 18 and Youngstown Rd.	4/13	91	Salmon R.	Washington-Salmon R.	12	17.7	none	13,300
Niagara R.	Lewiston Sand Docks	4/3	91	Salmon R.	Washington-Salmon R.	12	11.4	none	25,000
		4/1	91	Salmon R.	Skamania	9	9.4	LP-Ad	18,000

NIAGARA RIVER TOTAL	43,000
TOTAL SCHEDULED WASHINGTON STEELHEAD YEARLINGS	421,000
TOTAL SURPLUS WASHINGTON STEELHEAD YEARLINGS	9,000
TOTAL WASHINGTON STEELHEAD YEARLINGS	430,000
TOTAL SKAMANIA STEELHEAD YEARLINGS	84,780
TOTAL STEELHEAD YEARLINGS	**514,780**
TOTAL SALMONIDS	**5,029,000**

APPENDIX B
Salmon, trout and walleye stocked in New York Lake Ontario waters in 1992.

Area Stocked	Location	Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age Months	#Fish/ Pound	Mark	Number Stocked
				WALLEYE FINGERLINGS					
Niagara R.	Lewiston	2nd wk of July	92	NRAA[7] Ponds	Lake Erie	2.5	2"-2.5"	Oxytet-racycline	2,700
Lake Ontario	Fairhaven	2nd wk of July	92	Sanford[8] Bait farms	Lake Erie	2	1"-2"	Oxytet-racycline	10,000
		October	92	Sanford Bait farms	Lake Erie	4.5	4"-6"	Oxytet-racycline	500
Lake Ontario	Blind Sodus	2nd wk of July	92	Sanford Bait farms	Lake Erie	2	1"-2"	Oxytet-racycline	7,500
Lake Ontario	Sodus Bay	2nd wk of July	92	Sanford Bait farms	Lake Erie	2	1"-2"	Oxytet-racycline	25,000
		October		Sanford Bait farms	Lake Erie	4.5	4"-6"	Oxytet-racycline	6,000
TOTAL WALLEYE FINGERLINGS									**51,700**
GRAND TOTAL ALL SPECIES									**5,080,700**

[7] - Niagara River Anglers Association - 10 ponds, 1/2 acre each
[8] - Sanford Bait Farms - 11 ponds, 1/4 to one acre, total of 9 1/2 acres

APPENDIX C

Coho salmon stocked in Province of Ontario waters of Lake Ontario in 1992 not included in the 1991 report (LeTendre and Savoie 1992).

Location	Month Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age Months	Ave. Weight	Mark	Number Stocked
			COHO SALMON YEARLINGS					
Bronte Creek	02	89	Ringwood	Lake Ontario	13	18.1	RV	29,914
Credit River	02	89	Ringwood	Lake Ontario	13	19.8	Ad	93,449
Port Dalhousie	02	89	Ringwood	Lake Ontario	13	18.3	Rp	24,643
TOTAL YEARLING COHO								**148,006**

Commercial Harvest of Walleye in Lake Ontario during 1992

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Lake Ontario Fisheries Unit, 1992 Annual Report, Section 12

Commercial fishermen harvested 9,055 kg (19,921 pounds) of walleye (5,816 fish) during the 1992 entrapment gear fishery. All fish were harvested in quota zones 1, 2.1, and 2.2 which are located in eastern Lake Ontario The mean fork length of the harvested walleye was 50.3 cm (21 inches total length) and the mean weight was 1.56 kg (3.4 pounds). The majority of the sampled walleye were 4, 5, or 6 yr-old fish.

Recommendations

1. Monitor the commercial entrapment gear fishery every 3 years or whenever there are significant changes in the regulations controlling the fishery.
2. When sampling occurs, attempt to sample each commercial fisherman equally.

Introduction

Walleye (*Stizostedion vitreum vitreum*) have been harvested by commercial fishermen using entrapment gear in Lake Ontario since 1989. This fishery was established following a complete ban on commercial harvest of walleye during the period from 1984 and 1988 inclusive. The current commercial fishery is restricted to Quota Zones 1, 2.1 and 2.2 in eastern Lake Ontario (Fig. 1). The total weight of walleye which each of the ten commercial licenses is allowed to harvest is set by quota. The quota for 1992 was 13,591 kg (29,900 pounds). Harvest must occur between May 1 and June 30. A 'slot size' regulation restricts harvest to fish between 39 and 58 cm fork length (16 and 24 inches total length).

This program updates information on size and age distribution of the harvested walleye which was last surveyed in 1989 (Mathers and Bowlby 1991). These data are essential for the development and maintenance of a walleye management model (Bowlby and Mathers 1989).

Methods

Lake Ontario Fisheries Unit (LOFU) staff sampled harvested walleye at commercial fish processing plants. Data on the fishermen, location of capture, date of capture, and total weight of fish in the catch were recorded from the daily catch records. The fork length of all the individual fish in a catch were tallied to the nearest 10 mm. Also, a group of fish was selected at random for more complete sampling, which included measurement of total length, fork length, and round weight, and a scale sample was taken for age interpretation.

Results and Discussion

Commercial fishermen reported a total of 9,055 kg (19,921 pounds) of walleye harvested during the 1992 entrapment gear fishery which we estimate represents 5,816 fish. The harvest in the 1992 fishery was lower than reported for the last two years (Fig. 2). Commercial fishermen have attributed the decline in the walleye harvest in 1992 to the late spring which may have caused the walleye to be late moving out from their spawning grounds in the Bay of Quinte to Lake Ontario where they are vulnerable to the commercial fishery.

Of the total harvest 6,397 kg (14,073 pounds or 4,146 fish) were harvested on the seven licenses in quota zone 2.1 (Fig. 1). In quota zone 2.2, 2,022 kg of walleye (4,448 pounds or 1,296 fish) were reported on 2 licenses and 636 kg (1,400 pounds or 374 fish) were harvested by the single license in quota zone 1.

LOFU staff sampled 1,468 walleye, 25% of the commercial harvest. If the catches of the individual commercial fishermen involved in the fishery are examined separately we

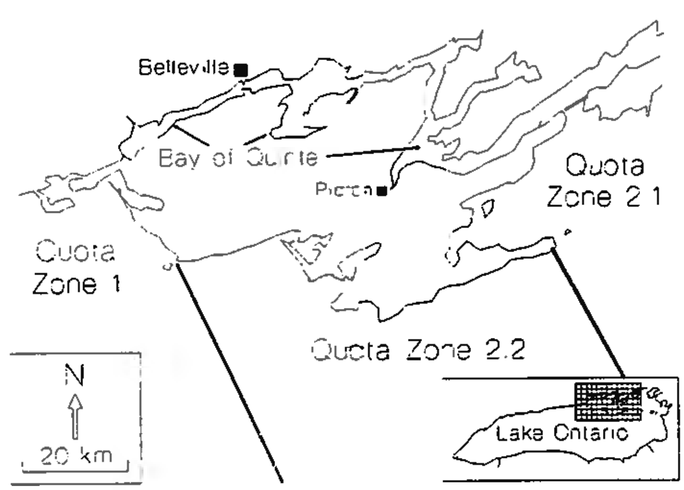

FIG. 1. Map of eastern Lake Ontario showing the quota zones used for commercial fish management.

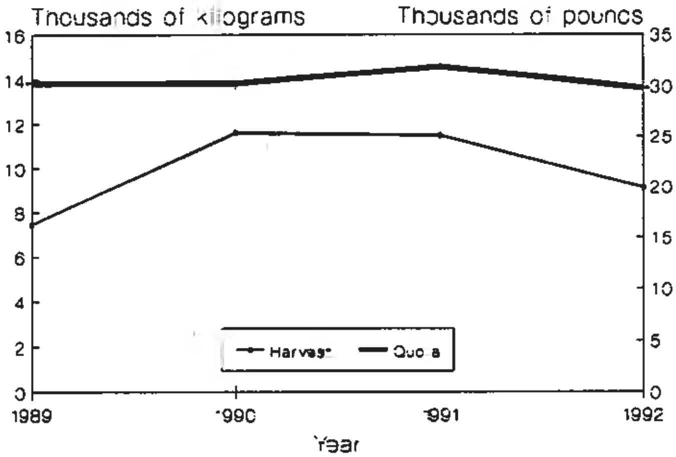

FIG. 2. Walleye quota allocated and harvested by the commercial fishery in eastern Lake Ontario during 1989 to 1992. Data are presented in both imperial and metric measure.

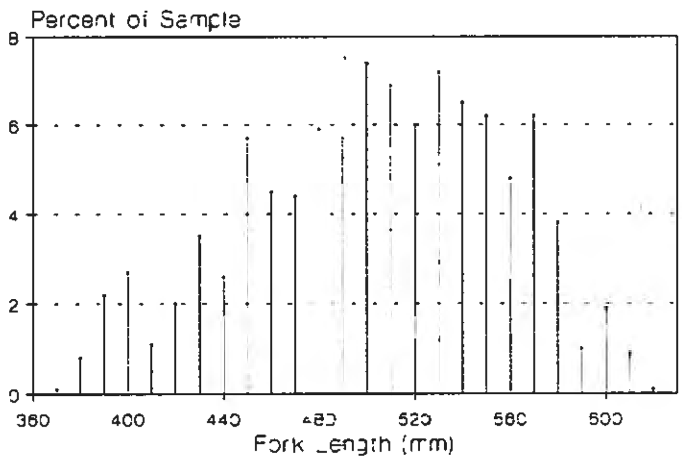

FIG. 3. Fork length distribution of walleye harvested during the 1992 commercial entrapment gear fishery. The distribution of the sampled walleye of each fisherman was weighted by the total reported harvest.

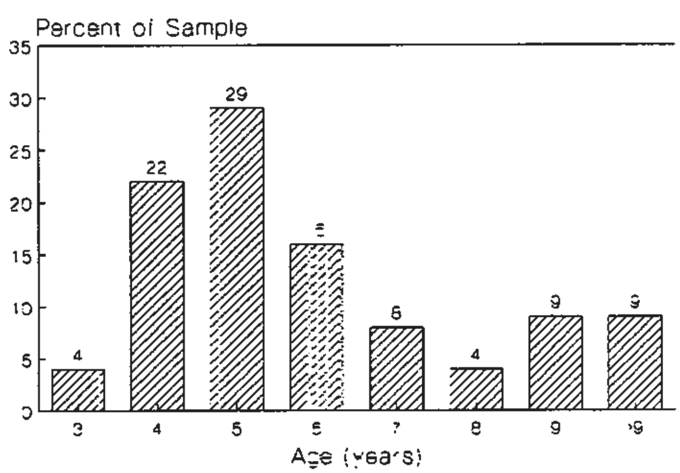

FIG. 4. Age distribution of walleye harvested during the 1992 commercial entrapment gear fishery. The distribution of the sampled walleye of each fisherman was weighted by the total reported harvest.

sampled between 3 and 52% of their catches. A more even distribution of our samples across the fishery would be desirable.

The sampled walleye ranged in size between 37 and 62 cm fork length (15 and 27 inches total length) with the mean being 50.3 cm (21 inches total length - Fig. 3). In total four percent of all fish sampled were outside the slot limit and catches of individual fishermen ranged from 0 to 19% of the fish outside the slot limit. The mean weight of the fish sampled was 1.56 kg (3.4 pounds) and the mean age was 6.1 years. Sixty-seven percent of the sampled walleye were 4, 5, or 6 yr-old fish (Fig. 4). In the 1989 fishery 5 and 7 yr-old fish were the most abundant (Mathers and Bowlby 1991), however, the slot size regulations restricted harvest to between 43 and 58 cm fork length (18 and 24 inches total length) during that year.

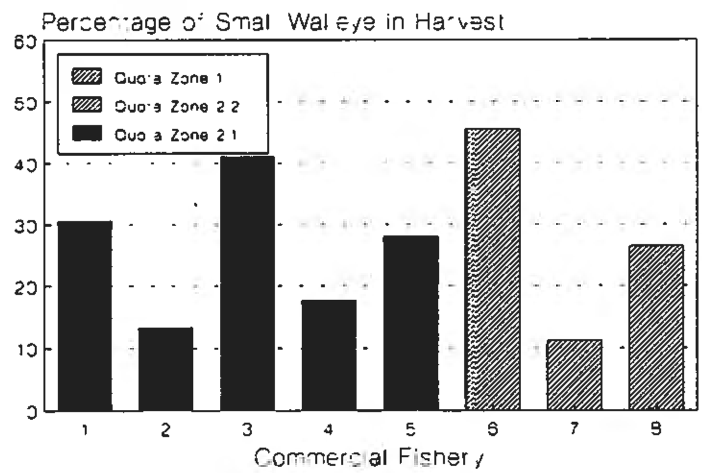

FIG. 5. Proportion of small walleye <49 cm fork length or 20 inches total length) in the barvest of each of the commercial licenses. The quota zone of each fishery is identified.

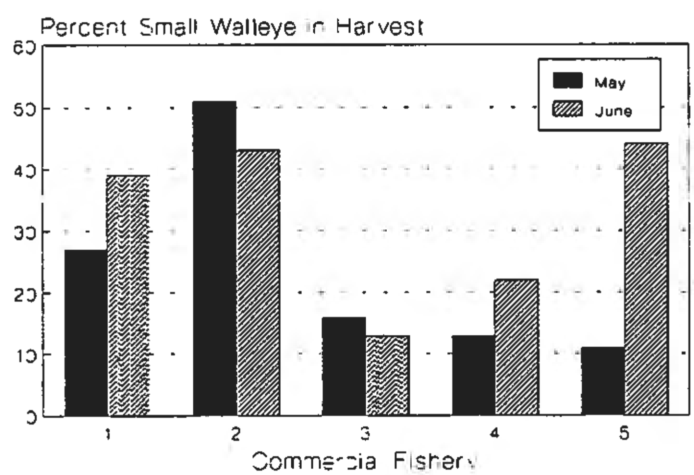

FIG. 6. Proportion of small walleye <49 cm fork length or 20 inches total length) in the harvest of each of the commercial license for each month. Adequate data for both months were available for only 5 commercial licenses.

The proportion of small walleye (less than 49 cm fork length or 20 inches total length) in the harvest varied between 11% and 46% for individual commercial fisheries during 1992 (Fig. 5). There was no pattern apparent between quota zones. The proportion of small walleye in the harvest during May was different from the proportion harvested during June for most of the fishermen (Fig. 6). However, there was no clear pattern which was apparent for all fisheries.

Acknowledgments

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Trends in Condition of Rainbow Trout, Coho Salmon, and Chinook Salmon in Lake Ontario.

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Length and weight data from rainbow trout, coho salmon and chinook salmon were collected to test for trends in body condition during 1974-1992. Rainbow trout were collected from spawning runs in the Ganaraska River. Coho salmon and chinook salmon were collected from spawning runs in the Credit River. As well chinook salmon were sampled from angler catches during surveys of the western Lake Ontario boat fishery. In general, body condition of rainbow trout has been significantly lower since 1987 than for most years prior to 1987. However, since 1987 there has been a consistent increasing trend in rainbow trout condition. Skagit strain coho salmon returned to the Credit River in 1992, three years since its last return. Since 1989, the body condition of Skagit coho salmon males and females increased significantly. In the same period their round weight did not change significantly. However, the fork length of Skagit males declined significantly, while the fork length of females did not differ significantly from 1989 to 1992. The general long term trends for coho salmon reflect declining growth rates, based primarily on the fork length trend. Angler-caught chinook salmon and spawning chinook salmon declined significantly in body condition between the early 1980s and the last five years.

Recommendations

1. Extend size at age analysis to more species.

Introduction

Dimond and Bowlby (1992) reported declining trends in growth and condition of coho salmon that spawned in the Credit River during 1977-1991. Since growth and condition are generally related to availability of food in lower trophic levels, these trends correspond to increased stocking of predators during 1979-1984 and to recent observations that suggest declines in productivity at all lower trophic levels (Anonymous 1992). If similar trends in body condition are found among several species, then that would support the view that the observed coho trends are related to a general decline in availability of prey. The purpose of this report is to extend the observations on Credit River coho salmon for one more year, and to test for trends in condition of chinook salmon and rainbow trout.

Methods

Body Condition

Length and weight data from rainbow trout, coho salmon and chinook salmon were collected from spawning runs in Lake Ontario tributaries and from the western Lake Ontario boat fishery to test for trends in body condition. Rainbow trout were collected from spawning runs in the Ganaraska

River at the fishway in Port Hope during April of 1974-1979, 1981, 1983-5, 1987, and 1990-1992 by the Ontario Ministry of Natural Resources (OMNR) Fork length, round weight, and sex were determined in the field. For 1983-1985, data for female rainbow trout were obtained from Normandale Fish Culture Station's egg collection operation. These data were used instead of the field data because the weight data were collected under laboratory conditions. As well, total length and round weight of rainbow trout from the Ganaraska River fishway were collected by the Ontario Ministry of the Environment (OMOE) as part of Ontario's fish contaminant monitoring program. The OMOE samples were included in this analysis for comparison with OMNR data for years which OMNR had not collected data at the fishway. OMOE samples were collected during April of 1976, 1980, 1981, 1983, 1984, 1986, and 1988-1992.

Coho salmon and chinook salmon were collected from spawning runs by electrofishing below the dam in Streetsville on the Credit River as part of Ringwood Fish Culture Station's egg collection operations Coho salmon were sampled during November of 1977-1992. In 1992 there was no egg collection for coho salmon, but Ringwood staff assisted with sample collection. Chinook salmon were sampled during September and October during 1983-1985, 1989, 1991, and 1992. Fork length, round weight, and sex were determined in the field, except during 1992 about one half of the coho salmon were sampled under laboratory conditions.

As well, chinook salmon were sampled from angler catches during surveys of the western Lake Ontario boat fishery (*e.g.* Bowlby and Savoie 1992) during September 1977-1979, 1981-1985, and 1988-1992. Fork length and round weight were determined in the field. Sex could not be determined externally from many of these fish because they were immature.

Body condition was determined as the mean weight after adjusting for length using analysis of covariance, as outlined by Dimond and Bowlby (1992). Tests for differences in body condition, fork length and round weight between years were conducted and results below are based on these tests. However, for purposes of presentation we have shown mean condition plus and minus two standard errors to show statistical differences. The reader is cautioned that two standard errors may be slightly more conservative in showing differences than the multiple comparison tests used in the analysis. We could not detect significant differences in body condition among different size classes (surrogate for age classes) in either chinook salmon or rainbow trout, and so all size classes were combined for analysis of body condition in these species.

Results and Discussion

Rainbow Trout

Male and female rainbow trout in the Ganaraska River had similar trends in body condition from 1974 to 1992 (Fig. 1). Females were about 800 g larger than males, as a result of later maturity of the females. Significant differences in body condition between years are shown in Fig. 1. The highest body condition for females was 2648 g in 1981 and for males was 1862 g in 1979. The lowest body condition for females was 2375 g in 1987 (10% lower than in 1981), and the lowest body condition for males was 1547 g, also in 1987 (17% lower than in 1979). In general, body condition of rainbow trout has been significantly lower since 1987 than most of the years prior to 1987. However, exceptions such as 1975, 1977, and 1983, when condition was lower should be noted. Moreover, since 1987 there has been a consistent increasing trend in rainbow trout condition (Fig. 1), and in 1992 condition was not significantly different than some of the earlier years. The body condition of rainbow trout in the OMOE samples did not differ significantly with respect to year for either males or females although small sample size was a limitation in this analysis. Body condition calculated from the OMOE data tended to be larger than OMNR data because the OMOE samples were collected in a length stratified manner whereas the OMNR samples were either a complete sample or a random subsample. Statistical comparisons between OMNR and OMOE data sets are not valid. However, the patterns of body condition are still comparable. The OMOE and OMNR data have similar patterns in that body condition tends to be lower in later years (Fig. 2).

There are several hypotheses for the trends in condition in rainbow trout. First, the size structure of the spawning population has increased (Table 1), perhaps as a result of delayed maturity. The fishway at Port Hope was opened in 1974, and this has likely resulted in a suite of new pressures on the selection of fish size For instance, angling intensity and distribution changed as a result of new habitat upstream of the fishway. As well, the physical requirements for jumping into and swimming through the fishway were new selective pressures on fish size. Second, declining productivity in Lake Ontario may be responsible for longer term declines in condition. Third, more recent increases in condition may have resulted from reductions in rainbow trout populations in Lake Ontario due, perhaps, to lower production of wild fish in the late-1980's, or to higher density-dependent mortality or angler mortality in Lake Ontario. Savoie and Bowlby (1993) have documented consistent declines in harvest rate of rainbow trout since 1988, suggesting declines in rainbow trout populations.

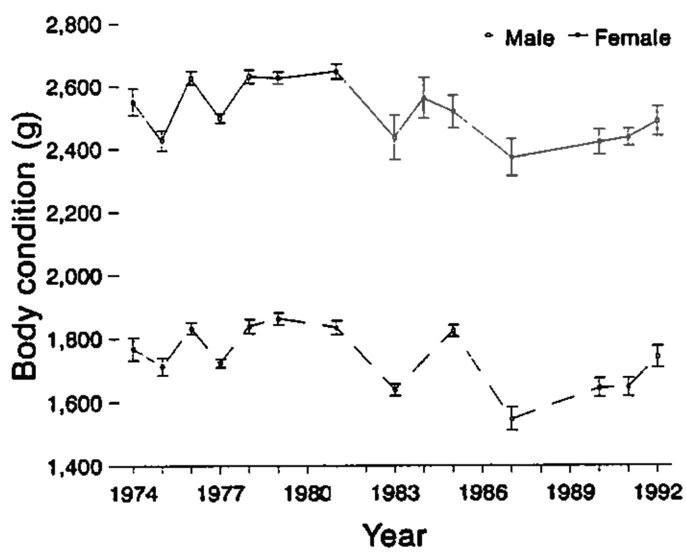

FIG. 1. Body condition (mean + or - 2 SE) of rainbow trout collected by OMNR in the Ganaraska River during 1974-1992. Body condition was determined as the mean weight after adjusting for differences in length.

TABLE 1. Mean size of male and female rainbow trout sampled at the Ganaraska River fishway by OMNR during April 1974-1992.

	Males			Females		
Year	N	Fork length (mm)	Round weight (g)	N	Fork length (mm)	Round weight (g)
1974	173	447.9	1207.7	231	513.8	1838.5
1975	183	474.5	1432.9	279	535.3	2005.4
1976	411	503.5	1817.4	588	561.7	2463.7
1977	635	498.4	1687.6	979	580.1	2587.2
1978	255	538.5	2183.9	512	588.9	2815.8
1979	344	556.4	2425.4	626	594.0	2900.2
1981	252	547.4	2369.7	468	614.4	3233.5
1983	308	580.4	2531.1	132	679.0	3774.4
1984	-	-	-	120	656.5	3587.3
1985	410	588.3	2796.7	154	640.9	3385.3
1987	66	521.9	1774.2	74	633.5	3182.4
1990	259	631.9	2997.6	197	640.7	3270.2
1991	126	591.0	2692.8	289	610.3	2888.9
1992	138	607.8	2867.4	165	648.4	3410.2

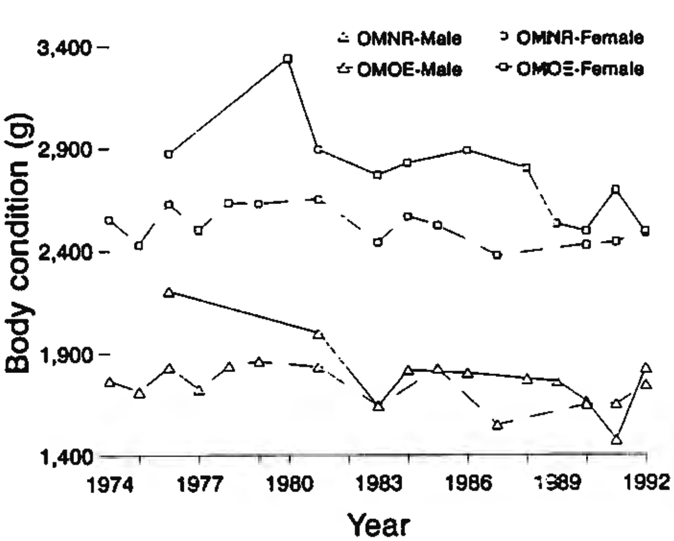

FIG. 2. Mean body condition of rainbow trout collected by OMOE and OMNR in the Ganaraska River during 1974-1992. Body condition was determined as the mean weight after adjusting for differences in length.

Coho Salmon

Trends in fork length, round weight and body condition of coho salmon returning to the Credit River prior to 1992 have been presented and discussed by Dimond and Bowlby (1992). The Skagit strain (one of three alternating strains) returned in 1992, three years since its last return. Since 1989, the body condition of Skagit coho salmon males and females increased significantly (Fig. 3). In the same period their round weight did not change significantly (Fig. 4). However, the fork length of Skagit males declined significantly while the fork length of females did not differ significantly from 1989 to 1992 (Fig. 5).

Our interpretation of this data does not differ from Dimond and Bowlby (1992). The general long term trends reflect declining growth rates, based primarily on the fork length trend. This is despite hatchery selection for increased

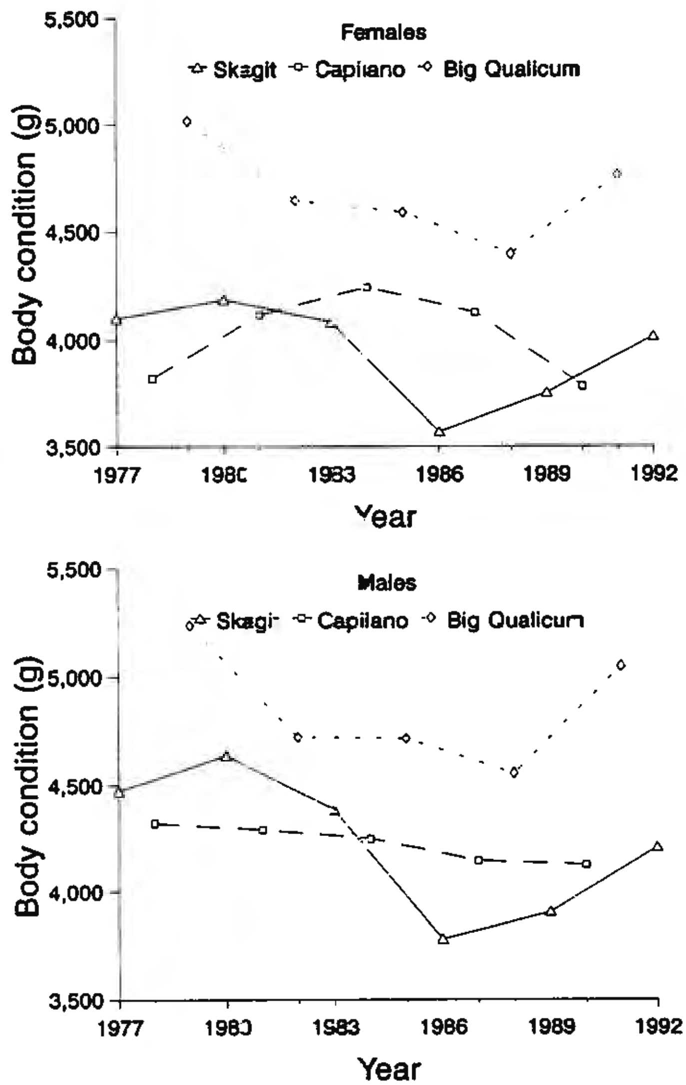

FIG. 3. Mean body condition of coho salmon in the Credit River during 1977-1992. Body condition was determined as the mean weight after adjusting for differences in length.

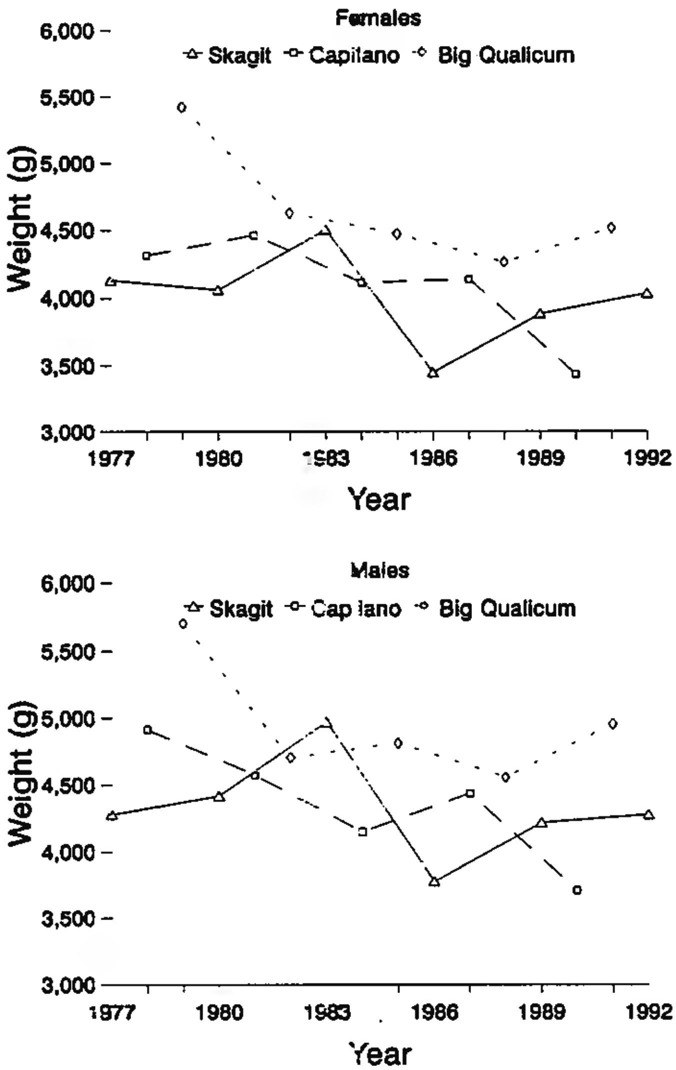

FIG. 4. Mean weight of coho salmon in the Credit River during 1977-1992.

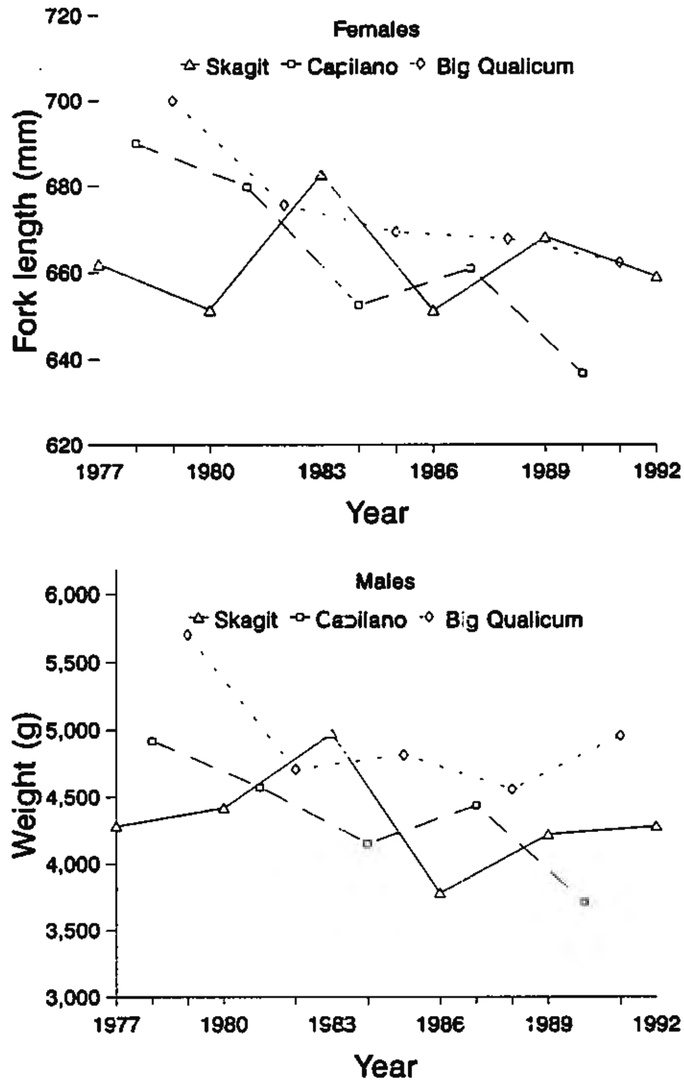

FIG. 5. Mean fork length of coho salmon in the Credit River during 1977-1992.

fish size (Dimond and Bowlby 1992). Declines in length with concurrent increases in condition might result from greater seasonal variability in prey. For instance, prey may be rare for most of the year resulting in low growth, but high for a period just before sampling resulting in high condition. Alternatively, reduced length might result from selection to optimize predator size with respect to prey size. Either of these hypothesized mechanisms would be expected under conditions of reduced prey population.

Chinook Salmon

Angler-caught chinook salmon and spawning chinook salmon declined significantly in body condition between the early 1980s and the last five years (Fig. 6, 7). The highest condition of angler-caught chinook was 4580 g in 1978, and the lowest condition of angler-caught chinook salmon was 3459 g in 1989. This was a 24% decline in condition and represented a more than 1 kg reduction in the weight of fish of average length. The highest condition of spawning chinook was 9863 g for males in 1983, and the lowest condition of spawning chinook salmon was 8089 g for males in 1989. Accordingly, males declined in condition more than females (Fig. 7). Sampling in 1983 was done 3 weeks later than in subsequent years and so those estimates of condition may be low.

Overview

Rainbow trout, coho salmon, and chinook salmon exhibited evidence of decline in growth or body condition from the late 1970s or early 1980s to the present. This decline in condition corresponded with tripling of stocking from 1979 to 1984. In all of these species the lowest condition occurred in the late 1980s and has since increased slightly or remained relatively constant. This increase may be indicative of increased mortality of these species due to anglers or predation by larger salmonids. This is consistent with declines in the size of the spawning population of rainbow trout in the Ganaraska River (Fig. 8), and with declines in catch and harvest rates of salmonids in the boat fishery in western Lake Ontario (Savoie and Bowlby 1992).

The coho salmon data were presented for a single age class, and so it represented length and weight at age. The length at age data appeared to be more sensitive to long-term changes in growth rate than measures of body condition.

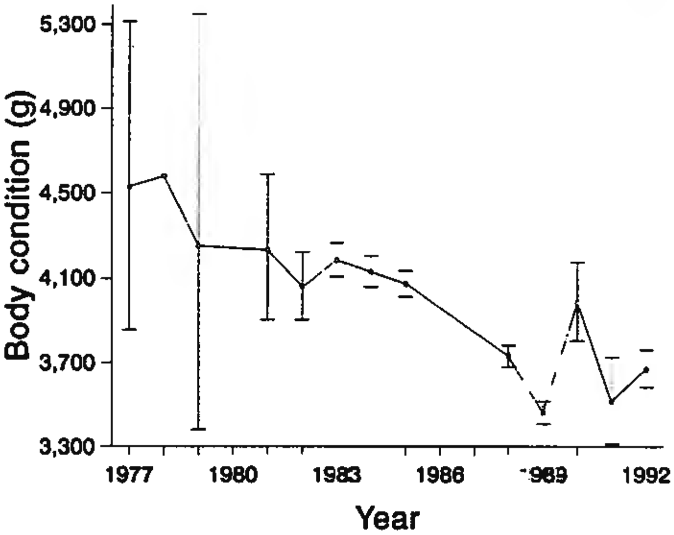

FIG. 6. Body condition (mean + or - 2 SE) of chinook salmon in the boat fishery in western Lake Ontario during 1977-1992. Body condition was determined as the mean weight after adjusting for differences in length. Standard error bars were not presented for the body condition of chinook salmon in 1978, but condition in 1978 was not significantly different from other years, likely as a result of small sample size (N=3).

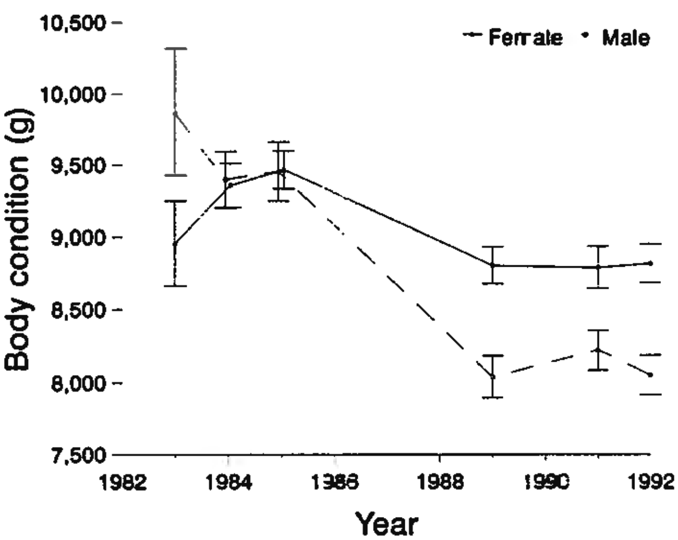

FIG. 7. Body condition (mean + or - 2 SE) of chinook salmon in the Credit River during 1983-1992. Body condition was determined as the mean weight after adjusting for differences in length. Sampling in 1983 was done 3 weeks later than in subsequent years and so those estimates of condition may be low.

Body condition may have reflected more recent availability of food. Thus, size at age analysis is recommended for all species. As well, seasonal measurements of body condition may be more enlightening.

Acknowledgments

This report benefited from comments by Tom Stewart. Thanks to field staff from Lindsay District, Lake Ontario Fisheries Unit, Normandale FCS, and Ringwood FCS for fish collections.

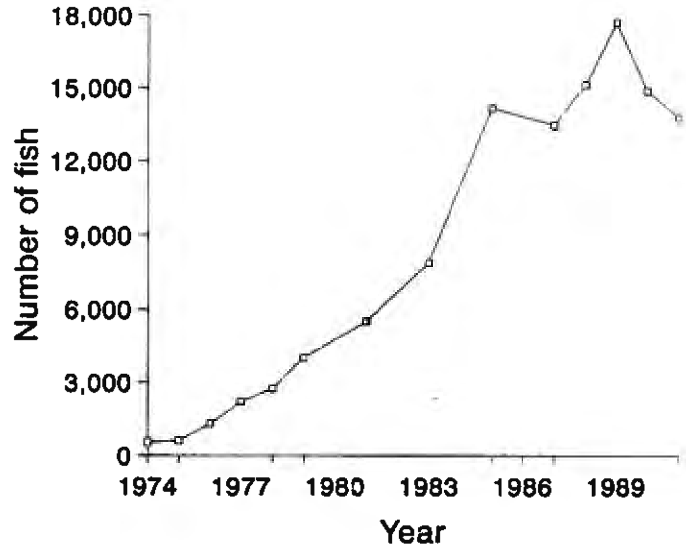

FIG. 8. Counts of rainbow trout passing through the fishway on the Ganaraska River at Port Hope during 1974-1991.

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Lake Ontario Lake Whitefish Stock Status, 1992

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Lake Ontario Fisheries Unit, 1992 Annual Report 1, Section 14

The population status of eastern Lake Ontario lake whitefish (*Coregonus clupeaformis*) was updated for 1992. Young-of-the-year (YOY) catches in bottom trawls indicated that strong year-classes were produced by the Bay of Quinte spawning population in each of the last two years; corresponding year-classes from the Lake Ontario spawning population were weak. Juvenile/adult lake whitefish abundance remained high at all outlet basin index gillnetting sites. Large numbers of small lake whitefish in index gillnets, corresponding to yearlings and 2-yr-olds, bode well for lake whitefish populations in the near future. Lake whitefish abundance in the Wellington and Brighton areas remained low. The commercial fish industry harvested over 138,000 kg of lake whitefish in 1992, about 77% of the allocated quota. Lake whitefish harvested from the Lake Ontario spawning population were larger (548 mm and 526 mm in Quota Zones 1 and 2 respectively) than those harvested from the Bay of Quinte (480 mm, Quota Zone 3) or the North Channel (448 mm, Quota Zone 4).

Recommendations

1. Implement lake whitefish stock discrimination techniques on a routine basis.
2. Determine age-specific estimates of the Bay of Quinte lake whitefish spawning population size from the fall mark/recapture trapnetting program (1991 and 1992), and correlate with the measure of year-class strength in bottom trawls.
3. Determine lake whitefish age distribution in index gillnets and for the commercial fishery.

Introduction

Lake Ontario lake whitefish (*Coregonus clupeaformis*) are concentrated in the eastern end of the lake where habitat is most suitable. Lake whitefish abundance has increased dramatically in the past decade, from extremely low levels of the 1960's and 1970's (Hoyle 1992a). Explanations for the increase in lake whitefish abundance include relaxation of overfishing and eutrophication (Christie 1977), the decline in abundance of large smelt (*Osmerus mordax*), which are thought to prey upon lake whitefish larvae (Casselman 1992), and the lamprey control.

The eastern Lake Ontario lake whitefish population is supported by two major spawning stocks, one which migrates into the Bay of Quinte to spawn; and the other which spawns in Lake Ontario, mostly along the south shore of Prince Edward County. Both spawning stocks are exploited by the local commercial fish industry. With the recovery of the lake whitefish population, the commercial harvest has also increased significantly; although it is now limited by quota management, first introduced in 1984 (Fig. 1). In addition to quotas on total lake whitefish harvest, there are minimum gillnet mesh size limitations (4 1/2 inches), and season restrictions designed to limit incidental catch, primarily of lake trout and walleye.

To manage the two lake whitefish stocks most effectively, indices of abundance are required for each. Unfortunately, this has not been possible to date. Mark-recapture population estimates from a fall trapnet program has been used to assess and manage the Bay of Quinte spawning stock in the past (Bowlby 1990) but this approach has not proven feasible for the Lake Ontario spawning stock.

The two lake whitefish stocks cohabit in the outlet basin of Lake Ontario (Christie 1967), and are caught and assessed in the eastern Lake Ontario fish community index netting program (Hoyle 1992b). The stocks are morphologically as well as behaviorally divergent (Ihssen et al. 1985), and ongoing research, aimed at quantifying the unique morphological features, may soon allow routine discrimination of the two stocks in our index nets (Casselman 1990, Brown and Casselman 1992).

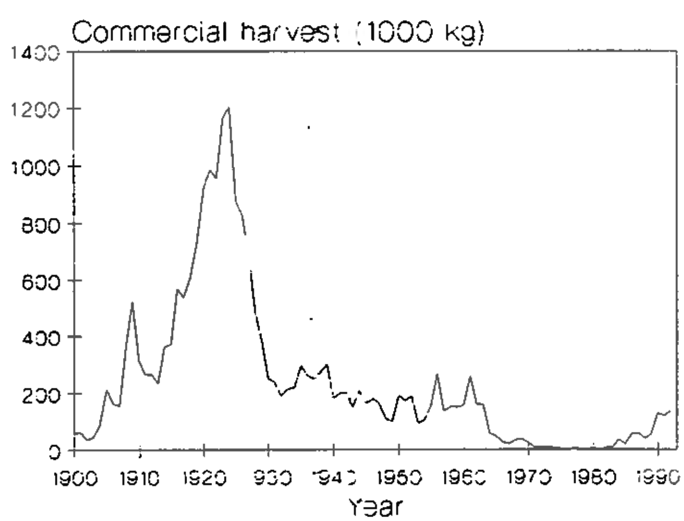

FIG. 1. Lake whitefish commercial harvest from the Canadian waters of Lake Ontario, 1900 to 1992.

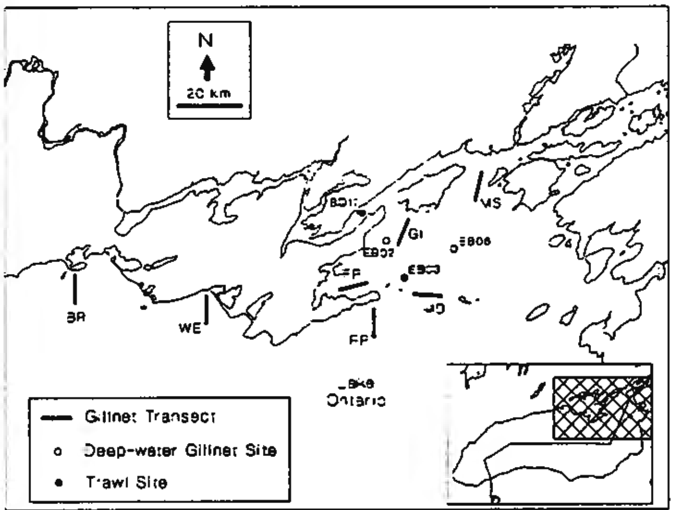

FIG. 2. Location of gillnet and trapnet sites, from the eastern Lake Ontario fish community index netting program, used to calculate lake whitefish indices of abundance. Depth-stratified index gillnetting sites included: Brighton (BR), Wellington (WE), Rocky Point (RP), Main Duck Sill (MD), Flatt Point (FP), Grape Island (GI), and Melville Shoal (MS). Deep-water index gillnetting sites in the outlet basin included EB02 and EB06, while index bottom trawling locations included Timber Island (EB03) and Conway (BQ17).

Until stock discrimination techniques are implemented, abundance indices in the eastern Lake Ontario fish community index netting program can not be reported separately for the two stocks.

This report serves to update trend-through-time indices of lake whitefish abundance and 1992 commercial harvest statistics.

Methods

Indices of Abundance

Three lake whitefish indices of abundance, as described by Hoyle (1992a), were calculated using data from the eastern Lake Ontario fish community index netting program. The 1992 index netting program represents an amalgamation of former Lake Ontario Fisheries Unit research and assessment index gillnetting and trawling programs on Lake Ontario and the Bay of Quinte (Casselman 1992, Hoyle 1992a, 1992b).

Monofilament gillnets replaced multifilament gillnets in the amalgamated program. Fishing effectiveness was compared for the two gear types by Casselman (1992) to ensure continuity of trend-though-time indices of abundance. Casselman (1992) found that the new monofilament gillnets caught 14% more lake whitefish than the traditional multifilament gillnets but this result was not statistically significant. Therefore, no adjustment was made to the 1992 lake whitefish indices reported here.

Young-of-the-year

Lake whitefish year-class strength was estimated from bottom trawl data at Timber Island and Conway (EB03 and BQ17, Fig. 2). These sites were considered to represent Lake Ontario and Bay of Quinte lake whitefish nursery areas respectively. Young-of-the-year lake whitefish mean catches were presented graphically as the number of fish per 12 min trawl as in previous years.

Juvenile/adult

Two indices of juvenile/adult lake whitefish abundance were calculated from gillnet data.

One index was calculated using the two deep-water sites in the outlet basin (EB02 and EB06, Fig. 2). The index was traditionally based on six sites and therefore, the 1992 data were adjusted proportionately to allow comparison to the historic data series.

The second index was calculated using seven depth-stratified sites (Brighton, Wellington, Rocky Point, Main Duck Sill, Flatt Point, Grape Island, and Melville Shoal). Only the 22.5 m and 27.5 m depths and 1 1/2 inch to 5 inch mesh sizes (1/2 inch intervals) were included in the index. Mean catches were grouped for the Brighton and Wellington sites (here after referred to as central basin), and for the Grape Island and Melville Shoal sites (hereafter referred to as outlet basin depth-stratified sites) following Hoyle (1992a). Note that 1992 was the first year in which netting was conducted at the Main Duck Sill location.

Size-specific indices of abundance were calculated for the two deep-water outlet basin sites, and the seven depth-stratified sites. These size-specific indices were calculated in the same fashion as the second juvenile/adult abundance index except on a size-specific basis (10 mm fork length intervals), and in this case all mesh sizes, 1 1/2 to 6 inches, were included.

Commercial Harvest

A lake whitefish harvest sampling program was conducted for the first time since 1988. Sampling focused on four areas, each with its own unique lake whitefish fishery: Brighton, south shore of Prince Edward County, Bay of Quinte, and the North Channel. These four geographic areas represent commercial harvest quota zones 1, 2, 3, and 4 respectively (Table 1, Fig. 3). The commercial harvest sampling protocol was described by Hoyle (1992c).

Sampling included length-tally information on a large number of lake whitefish, and more complete biological sampling on a random sample of fish. Length distribution data was collected from commercial fishermen and commercial fish processors for Quota Zones 1, 2, and 4, while that for

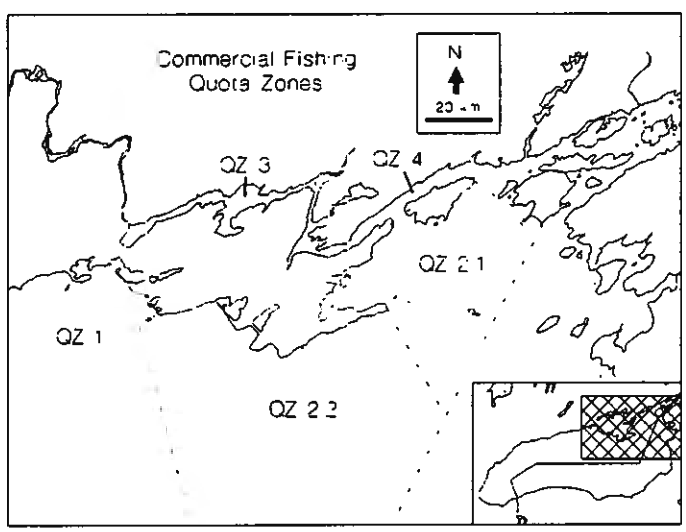

FIG. 3. Ontario Ministry of Natural Resources, former Napanee District, commercial fishing quota zones.

TABLE 1. Lake Ontario lake whitefish commercial quota allocation and fishing seasons by quota zone (Ontario Ministry of Natural Resources, former Napanee District quota zones).

Fishery	Quota Zone	Number of Licenses[1]	1992 Quota (kg)	Season (1992/93)	Gear
Brighton	1	4	13835	Nov. 1 to Nov. 30	4 1/2" gillnet[2]
South Shore	2	15	115963	Nov. 1 to Dec. 10	4 1/2" gillnet[3]
Bay of Quinte	3	20	21410	All year	Hoop and Trapnets
North Channel	4	15	28305	Dec. 1 to mid-Mar	4 1/2" gillnet

1. Some fishermen control more than one license.
2. There is also a single trapnet license which can be fished in any season (5443 kg).
3. There is some additional quota assigned to hoop and trapnet licenses which can be fished in any season.

TABLE 2. Fork length (mm) vs. weight (g) regression (natural logarithms: ln(weight) = a * (ln(length)) + b) parameters for Lake Ontario and Bay of Quinte stocks of lake whitefish. The Lake Ontario stock sample was obtained from the November commercial fishery on the south shore of Prince Edward County (Quota Zone 2). The Bay of Quinte stock sample was obtained from the assessment trapnet program during the fall lake whitefish spawning run in the Bay of Quinte (Quota Zone 3). These data were used to estimate the weight of lake whitefish which were length-tallied during commercial harvest sampling. The lake stock regression was applied to fish from Quota Zones 1 and 2, while the bay stock regression was applied to fish from Quota Zones 3 and 4.

Stock		a	b	r^2	n
Lake Ontario	Males	3.192	-12.474	0.84	50
	Females	2.450	-8.167	0.71	50
	All fish	2.900	-10.638	0.79	100
Bay of Quinte	Males	3.155	-12.263	0.93	48
	Females	3.266	-12.894	0.77	8
	All fish	3.333	-13.330	0.88	96

the Bay of Quinte (Quota Zone 3) came from an assessment mark/recapture trapnet program (Mathers 1992).

Lake whitefish harvested along the south shore of Prince Edward County (Quota Zone 2) were considered to represent the Lake Ontario spawning population. Those sampled in Bay of Quinte trapnets were considered to represent the Bay of Quinte spawning population and the commercial harvest, because the commercial fishery also uses entrapment gear, and fishes over the same time period. Length distributions of lake whitefish from the commercial harvest and index nets were compared.

Weights of all lake whitefish sampled were estimated based on length-weight regressions determined for samples of fish from Lake Ontario (Quota Zone 2, south shore Prince Edward County gillnet commercial fishery) and Bay of Quinte (Quota Zone 3, assessment trapnets) spawning stocks (about 100 fish, 50 males and 50 females, from each stock (Table 2).

Total lake whitefish commercial quota allocation and harvest results were also summarized.

Results and Discussion

Indices of Abundance

Young-of-the-year

Trawl catches of young-of-the-year (YOY) lake whitefish were relatively high at the Bay of Quinte site (Conway), and low at the Lake Ontario site (Fig. 4). Thus, year-class strength has been good for the last two years for the Bay of Quinte stock but poor for the Lake Ontario stock.

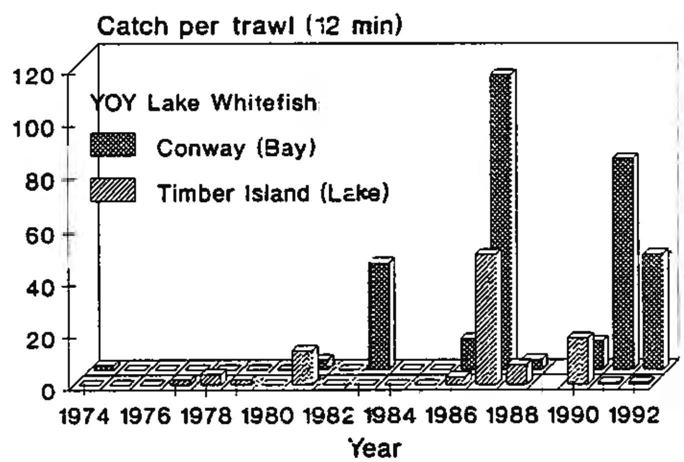

FIG. 4. Year-class strength of Lake Ontario and Bay of Quinte lake whitefish stocks, as represented by young-of-the-year (YOY) catches in 12 min bottom trawls, at Timber Island and Conway, respectively, 1974 to 1992. No trawling was conducted in 1989.

Juvenile/adult

Mean lake whitefish catches for the two deep-water gillnet sites in the outlet basin have been relatively stable over the past five years following the dramatic increase observed during the mid-1980's (Fig. 5). Catches at depth-stratified gillnet locations were similar to 1991 for Rocky Point and central basin sites but much higher for Flatt Point and the outlet basin sites (Fig. 6). The size distribution of lake whitefish shows relatively large numbers of small fish at those index gillnetting locations with high total catches in 1992 (Flatt Point, outlet basin deep sites, outlet basin depth-strati-

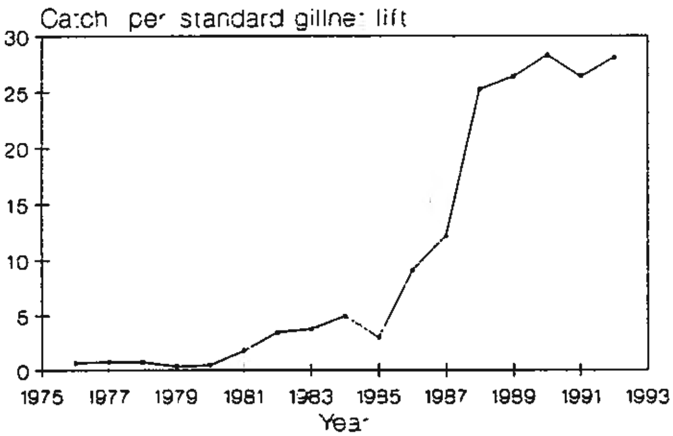

FIG. 5. Lake whitefish mean catch per standard gillnet lift at two deep-water index sites in the outlet basin of Lake Ontario (EB02 and EB06). Prior to 1991, six sites were used in the index, while in 1991 and 1992 there were three sites (EB02, EB04, and EB06) and two sites (EB02 and EB06) used, respectively. Thus, 1991 and 1992 catches were adjusted proportionately, to allow comparison to former years. The 1992 index was based on monofilament gillnets. Multifilament gillnets were used in all other years (see Casselman 1992 for a complete description of the gear used).

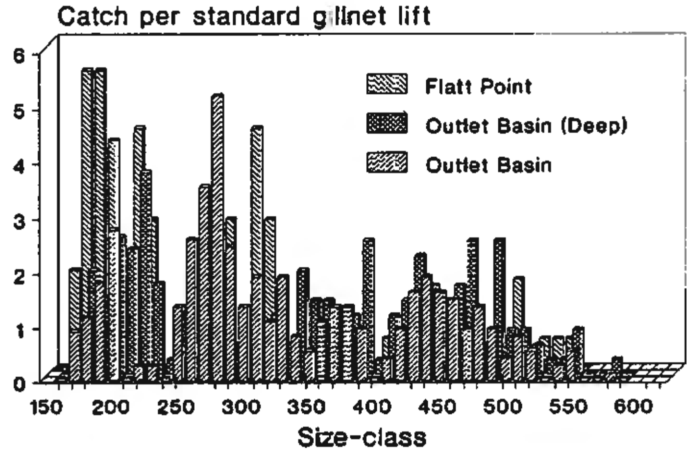

FIG. 7. Mean catch per standard gillnet lift (including 5 1/2 inch and 6 inch mesh sizes) for lake whitefish size-classes at Flatt Point, outlet basin deep-water sites (EB02 and EB06), and outlet basin depth-stratified sites (Melville Shoal and Grape Island)

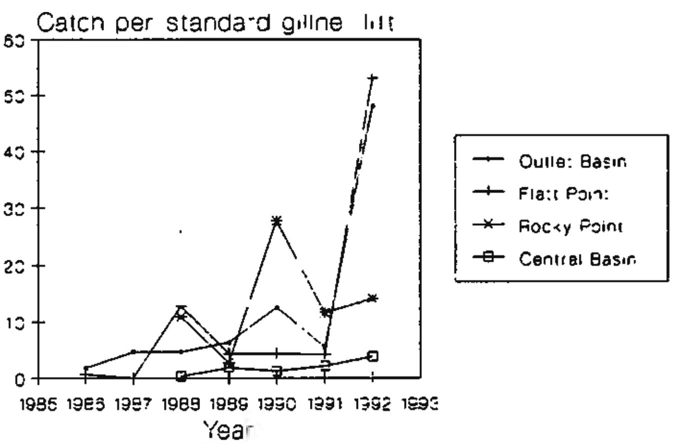

FIG. 6. Mean lake whitefish catch per standard gillnet lift (adjusted to 100 m for each of ten mesh sizes, 1 1/2 inches to 5 inches) at depth-stratified index netting sites (22.5 m and 27.5 m depths only). 'Outlet basin' is the mean of Melville Shoal and Grape Island; 'central basin' is the mean of Wellington and Brighton.

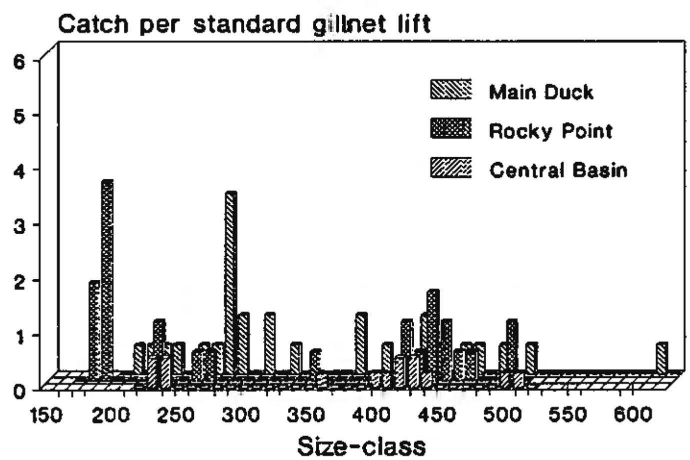

FIG. 8. Mean catch per standard gillnet lift (including 5 1/2 inch and 6 inch mesh sizes) for lake whitefish size-classes at Main Duck Sill, Rocky Point, and the central basin sites (Wellington and Brighton).

fied sites, Fig. 7). The lake whitefish size-classes around a mode of about 190 to 200 mm correspond to yearlings, while those around the mode of about 280 to 300 mm correspond to 2-yr-old fish. In contrast, sites to the west of the outlet basin show relatively few small fish, as well as fewer numbers of fish overall (Fig. 8).

The large numbers of yearling lake whitefish in the outlet basin (Fig. 7) are likely comprised mainly of Bay of Quinte stock from the 1991 year-class (Fig. 4). The 2-yr-old fish may be comprised of the 1990 year-classes from both Bay of Quinte and Lake Ontario stocks (Fig. 4).

Commercial Harvest

Lake whitefish commercial quota, harvest, and harvest sampling statistics are summarized in Table 3. About 77% of the nearly 180,000 kg of lake whitefish, allocated to the Lake Ontario commercial fishery in 1992, was harvested. This figure varied from 40% to 108% among quota zones, and may be influenced more by season length and weather conditions, which differ among quota zones, than by real deferences in lake whitefish abundance.

An estimated 4% of the fish harvested from Quota Zones 1, 2, and 4 was length-tallied during the commercial harvest sampling program. Future surveys should attempt to sample about 10% of the harvest. This will be most difficult for Quota Zone 4 where the harvest is sporadic, and occurs over a relatively long fishing season.

Bay of Quinte samples were obtained from assessment trapnets rather than the commercial fishery per se. If the trapnetting program is not conducted in future years, efforts will have to be made to obtain samples from fishermen or fish processors.

Commercial fisheries in Quota Zones 1 (Brighton) and 2 (south shore Prince Edward County), which are supported

TABLE 3. Summary of lake whitefish commercial quota, harvest, and harvest sampling statistics for 1992. Note that Quota Zone 3 samples were obtained from assessment trapnets, not from the commercial fishery. Harvest exceeded quota in Quota Zone 4 because of some experimental test netting in September.

Quota Zone	Quota (kg)	Harvest (kg)	Number Sampled	Mean Fork Length (mm)	Mean Weight (kg)	Total Weight Sampled (kg)	Percent Sampled
1	13835	5542	240	548	2.1	500	9.0
2	115963	67385	2091	526	1.8	3842	5.7
3	21410	15802	6113	480	1.4		
4	28305	30650	566	448	1.2	652	2.3
Total	179513	119379	9010			4994	5.0

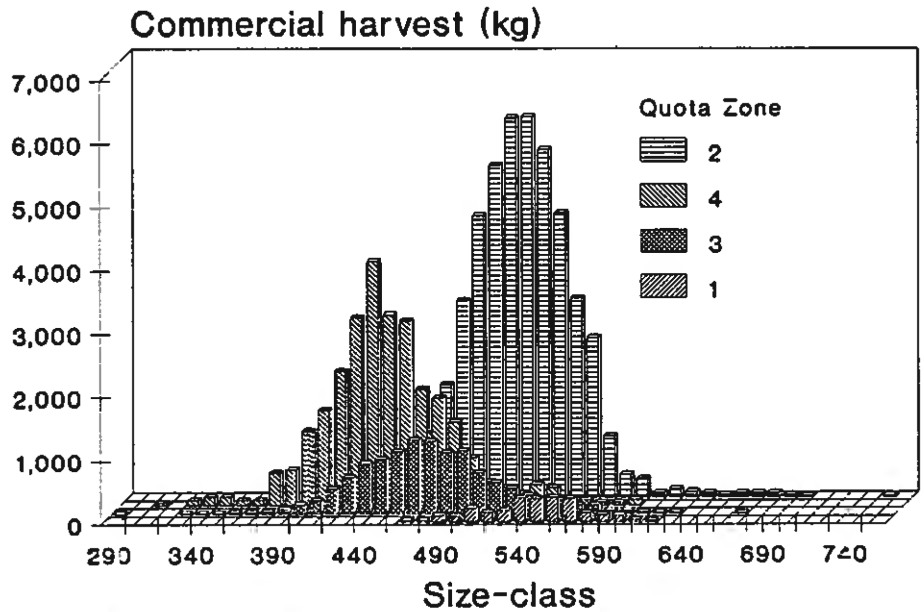

FIG. 9. Size distribution of lake whitefish harvested during the 1992 commercial fishery in Quota Zones 1, 2, 3, and 4.

TABLE 4. Summary of lake whitefish harvest sampling statistics by sex.

Quota Zone	Males	Females	Unknown	Total	Males	Females	Unknown	Total
1	161	70	9	240	548	550	521	548
2	1064	871	156	2091	521	533	520	526
3	2600	2291	1222	6113	471	489	480	480
4			566	566			448	448

by the Lake Ontario spawning stock, had the largest fish (Fig. 9, Table 3). The Quota Zone 4 (North Channel) commercial fishery had the smallest fish. Lake whitefish harvested from Quota Zone 4 are thought to be composed mainly of Bay of Quinte stock fish which are migrating back to the outlet basin of Lake Ontario after spawning. This fishery may be exploiting juvenile fish as well because the Bay of Quinte spawning stockfish (Quota Zone 3) were somewhat larger. Note, however, that only a very small proportion of the Quota Zone 4 commercial harvest was sampled (Table 3).

Mean lengths and weights of lake whitefish varied from 448 mm and 1.2 kg respectively for Quota Zone 4, to 548 mm and 2.1 kg respectively for Quota Zone 1 (Table 3). Females were somewhat larger than male lake whitefish (Table 4).

Size distributions of lake whitefish in assessment index gillnets (data from Melville Shoals, Grape Island, Flatt Point and the outlet basin deep sites averaged), and for Lake Ontario and Bay of Quinte spawning stocks are contrasted in Fig. 10. The distribution of sizes for the largest lake whitefish caught in assessment index nets matched that for the Bay of Quinte spawning stock quite closely. However, few fish as large as those in the Lake Ontario spawning stock were caught in assessment index gillnets. Differences in gear types cannot account for observed differences in size distributions because assessment gillnets use a variety of mesh sizes, including larger sizes (up to 6 inches) than those used

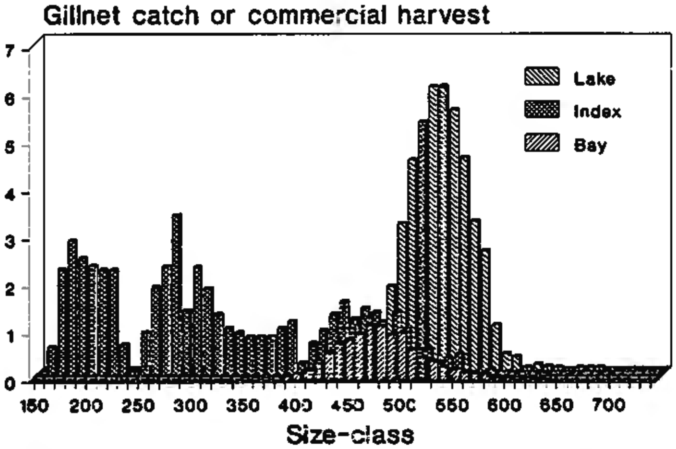

FIG. 10. Size distribution of lake whitefish in assessment index gillnets (mean catch per standard lift for three sites described in Fig. 7), and in the commercial harvest (1000 kg) in Quota Zones 2 (Lake Ontario spawning population) and 4 (Bay of Quinte spawning population).

in the commercial fishery (4 1/2 inches). Either the large fish of the Lake Ontario spawning population were of low abundance or they did not reside in those areas sampled by assessment index gillnets, as has been previously presumed. These possibilities should be investigated further.

Lake Whitefish Stock Assessment

Index gillnetting and trawling in eastern Lake Ontario have been used annually to index the abundance of lake whitefish. But until stock discrimination techniques are developed for routine use, the relative abundance of the two spawning stocks will remain unknown. Mean while, mark-recapture population estimates from the fall trapnet program should continue to be used to assess and manage the Bay of Quinte spawning stock. These population estimates indicate that the Bay of Quinte spawning stock increased tremendously during the mid-1980's (e.g. 3.2 times higher in 1988 than 1987, Bowlby 1990), but population estimates have not been calculated since 1988. I recommend that high priority be placed on this analysis.

The current status of the Lake Ontario spawning stock is not known (Stewart 1991). Commercial harvest reports suggest that the Lake Ontario spawning stock has also increased in abundance recently (P. Smith, Ontario Ministry of Natural Resources, R. R. # 4 Picton, Ontario, pers. comm.) but large lake whitefish observed in the commercial harvest are noticeably absent in assessment index gillnets. It is essential that stock discrimination techniques be implemented on a routine basis because it will allow the abundance of individual stocks to be monitored.

Acknowledgments

Thanks to Lake Ontario Fisheries Unit staff responsible for implementation of the 1992 eastern Lake Ontario fish community index netting program including Dale Dewey, Steve Lawrence, Wayne Miller, Tim Shannon, Dawn Walsh, and Chuck Wood. Thanks also to Randy Gurnsey, Vaughan Jamieson, and Dawn Walsh for conducting commercial harvest sampling.

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Walleye Populations in Eastern Lake Ontario and the Bay of Quinte, 1992

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Lake Ontario Fisheries Unit, 1992 Annual Report, Section 15

The 'fishable' walleye population size (age 2 and older) in eastern Lake Ontario and the Bay of Quinte was estimated at 1,753,287 fish in the spring of 1992. The population size has been relatively stable over recent years. Strong year-classes produced since 1985 suggest that fisheries which harvest walleye spawned in the Bay of Quinte will continue to prosper, at least over the short-term. Simulation of the walleye population with a model suggests that there is room for small increases in the total harvest.

Recommendations

1. Document the number of fish harvested and age composition of the harvest for unquantified walleye fisheries such as those conducted by the Mohawks of the Bay of Quinte.
2. Monitor for walleye reproduction outside the Bay of Quinte.

Introduction

There are a wide variety of user groups with a direct interest in the walleye (*Stizostedion vitreum vitreum*) population in the Bay of Quinte and eastern Lake Ontario. The primary responsibility of the Ontario Ministry of Natural Resources is to ensure the long-term conservation of this valuable resource. As walleye fisheries change over time is important to make certain that the total harvest does not exceed the population's ability to replenish itself.

This report updates the status of walleye in the Canadian portion of eastern Lake Ontario and the Bay of Quinte (Fig. 1). Commercial fishery harvest statistics (Mathers 1993b), sport fishery harvest statistics (Mathers 1993a), harvest by the Mohawks of the Bay of Quinte, and harvest from other fisheries during 1992 were all incorporated with population estimates from the 1991 mark-recapture project into an age-structured model which was used to predict future walleye populations and fisheries under varying levels of exploitation.

Methods

Population Estimates

A single mark-recapture session, conducted September 7 to November 8, 1991, collected data which complements the information from the spring and fall 1985 to 1987, and fall 1988 to 1989 sessions (Mathers 1991). There were 63 trapnet lifts (163 trapnet nights) at eight sites in the Bay of Quinte and 21 trapnet lifts (74 trapnet nights) at 3 sites in eastern Lake Ontario (Fig. 1). A total of 8,946 walleye were caught. Captured walleye were examined for marks from previous sessions. Dorsal fin ray punches were applied to unmarked fish.

These data were combined with previous estimates to update fall 1989 walleye population size for fish age 2 and older. Age-specific walleye population estimates were made for previous sessions using the Jolly-Seber method (Ricker 1975). The size of the 1988 and 1989 year-classes were estimated using the adjusted Peterson method (Ricker 1975) since these year-classes had less than 3 recapture sessions - a requirement of the Jolly-Seber method. Fish from year classes earlier than 1982 were lumped together and a single population estimate was made for this group.

The population size in spring 1992 was determined by using the 1989 estimate of fish age 2 and older and accounting for mortality of older fish and recruitment of younger fish. Mortality of older fish was determined from estimates of harvest (Mathers 1993a, Mathers 1993b) and natural mortality. Recruitment of younger fish was determined from an index of year-class strength as measured by catches of YOY in bottom trawls.

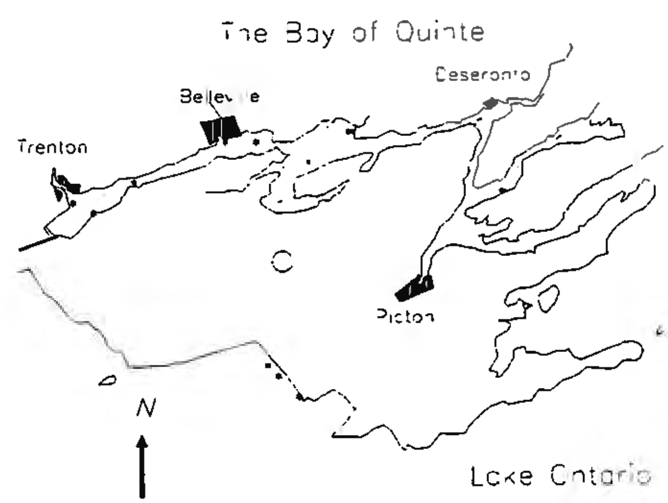

FIG 1. Bay of Quinte and eastern Lake Ontario showing trapnet locations for the fall 1991 mark-recapture project.

Spring 1992 population estimates are compared to known levels of harvest to examine the exploitation rate and age selectivity by fishery component. A simulation model (Bowlby and Mathers 1989) was used to predict future walleye populations subject to increased harvest.

Results and Discussion

Population Size

Inclusion of the fall 1991 mark-recapture data resulted in an estimate of the 'fishable' walleye population (age 2 and older) in eastern Lake Ontario of 1,012,453 fish during the fall of 1989 (Table 1). Natural mortality rates were determined by subtracting harvest measured during 1989 from the total mortality estimates calculated for 1989 by the Jolly-Seber model. This method assumes that natural mortality includes mortality due to illegal harvest, unreported incidental catch from commercial fisheries, unmeasured fisheries, predation, and spawning mortality. The average total mortality rate calculated by the Jolly-Seber model for the 3, 4, and 5 yr-old fish was 32% and natural mortality rate was 14%. For fish older than 5 years total mortality was calculated to be 31% and natural mortality 22%. No data are available to calculate natural mortality rates for younger fish so it was assumed to be: 20% for 1-yr-olds, and 10% for 2-yr-olds. These mortality rates are similar to previous estimates for this population (Mathers 1991).

The population of 'fishable' walleye (age 2 and older) in eastern Lake Ontario during the fall of 1992 was estimated at 1,753,287 (Fig. 2). Assuming that male fish mature at 3-yr-old and female fish mature a 4-yr-old (Bowlby et al. 1989), the abundance of adult fish was estimated at 893,884 fish. The population appears to have reached a state of some stability with the current harvest levels and environmental conditions. The recent population estimates do not differ greatly from the estimate of 1,000,000 walleye (age 3 and older) for 1958 which was prior to the population's decline in the 1960's and 1970's (Hurley and Christie 1977).

Generally, the population has varied between 1.0 and 3.5 million fish during the period from 1980 to 1992 (Fig. 2). The large population in the early 1980's was due to the unusually strong 1977 and 1978 year-classes. These two year classes have been reduced in numbers in recent years because

TABLE 1. Age-specific population estimates for the walleye population in eastern Lake Ontario and the Bay of Quinte. Estimates are based on data from the spring 1985 to fall 1991 mark-recapture sessions.

Session	Year-class 1987	1986	1985	1984	1983	1982	>1982	Population Age 2 and older
Fall 85					73,810	343,018	323,729	740,557
Spring 86					61,838	225,136	410,522	697,496
Fall 86				101,967	74,238	170,713	186,677	533,595
Spring 87				71,125	99,910	192,173	252,388	615,596
Fall 87			293,996	106,561	81,555	111,314	190,650	784,076
Fall 88		330,969	221,073	165,430	125,778	109,071	109,593	1,061,914
Fall 89	165,863	418,470	131,456	92,653	55,032	63,940	85,039	1,012,453

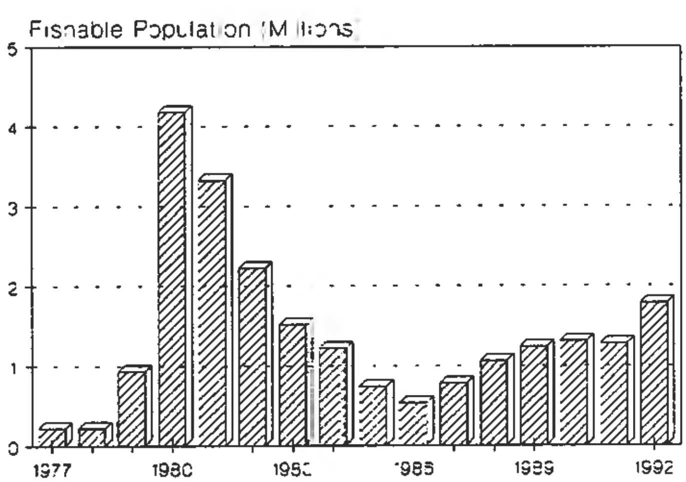

FIG 2. Population estimates of age 2 and older Bay of Quinte walleye, during the fall 1975 to 1992.

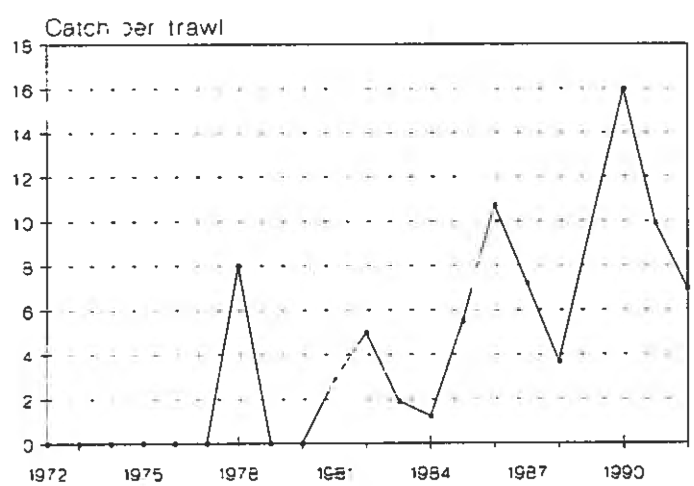

FIG 3. Mean catch of young-of-year walleye in trawls in the Bay of Quinte during late summer, for the years 1972 to 1992. Note that no data were collected during 1989.

of natural mortality and fishing harvest. These year-classes were produced under unusual conditions (low competition and predation) and high levels of recruitment should not be expected to occur again in the near future (Bowlby et al. 1991).

Index gillnet catches in both the Ontario waters and New York state waters of the eastern outlet basin of Lake Ontario suggest that the numbers of walleye are increasing (Hoyle 1992, Eckert 1992). These observations could be due to increasing reproduction in this area, or a movement of walleye from the Bay of Quinte out into Lake Ontario (Mathers 1991). An assessment program designed to catch young-of-year (YOY) walleye in Lake Ontario or a program to identify walleye spawning locations would help to resolve this question.

Year-Class Strength

Catches of YOY walleye in the bottom trawling program (Fig. 3) conducted in the Bay of Quinte are correlated with population estimates of the same year class as 3-yr-olds (Fig. 4). The trawling data suggests that the 1978, 1982, 1986, and 1990 year-classes are all particularly strong. The age-structure of the walleye population present during 1992 (Fig. 5) shows evidence of a strong 1986 (age 6) and 1990 (age 2) year-classes. The 1978 (age 14) and 1982 (age 10) year-classes were also known to be strong but were lumped together with other ages in Figure 5.

Harvest Relative to Population Abundance

During 1992 we were able to document harvest of walleyes, on an age-specific basis, from a variety of sources. Angling harvest was estimated at 128,449 and 43,343 walleye for the open-water boat and ice angling fisheries respectively (Mathers 1993a). Bowlby and Mathers (1993) estimated that boat anglers harvested 273 walleye in the Canadian waters of the eastern basin of Lake Ontario. Shoreline angling surveys in the Bay of Quinte and eastern Lake Ontario have estimated that 750 walleye were harvested in the fall (Savoie and Bowlby 1992). Commercial fishermen harvested 5,816 walleye during the entrapment gear fishery in eastern Lake Ontario (Mathers 1993b).

There were other fisheries for which we were not able to accurately document harvest of walleye on an age-specific basis. Commercial fishermen reported a harvest of 1,935 kg of walleye which were caught incidentally in gillnets during the fall and winter whitefish fishery. No information on the age composition of the harvest is available for this specific fishery, however, assuming these fish have an age composition similar to those harvested during the spring entrapment gear fishery, it was estimated that this would represent 1,240 fish. Fishermen from the Bay of Quinte Mohawk Band harvested 813 walleye in the Trent, Moira and Napanee Rivers during the spring of 1992 (unpublished data). No age composition of the harvested walleye is available for this or any similar fishery. Also, this estimate of harvest by Mohawks is undoubtedly low since the survey, on which this estimate is based, did not cover all locations and times which fishing occurred. For example, the Salmon River was not surveyed during 1992 although 2,790 walleye were harvested there during 1982 (unpublished data). The age-specific harvest from the fishery conducted by Mohawk band members and the commercial gillnet fisheries should be quantified to provide a better basis for making wise management decisions for this fishery.

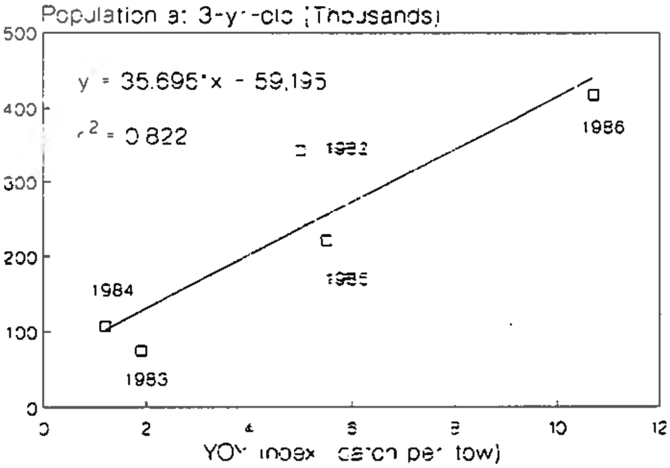

FIG 4. Fall walleye population of 3-yr-old fish based on Jolly-Seber estimates for the 1982 to 1986 year-classes plotted against the catch of young-of-year walleye in trawls for the same year-classes.

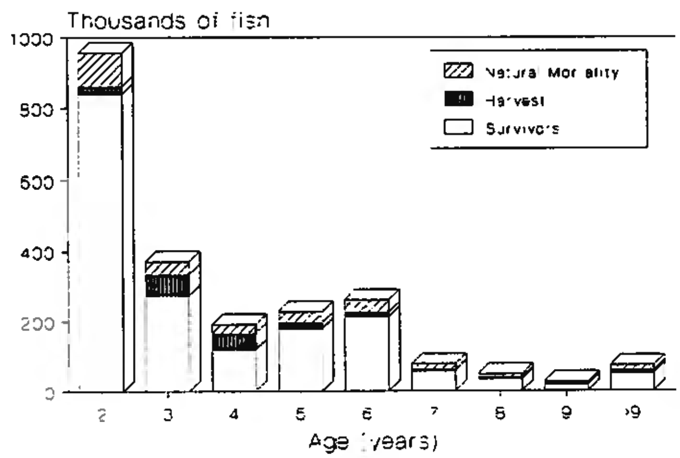

FIG 5. Eastern Lake Ontario walleye population structure for 1992.

Of all the mortalities documented for 1992 the angling fisheries accounted for a total of 35.5% (Fig. 6). The commercial fishery accounted for 1.5% of the documented mortalities. Documented harvest by native people accounted for 0.2%. Natural mortality (305,599 fish) is estimated to represent 62.8% of all mortalities. The age-specific harvest selectivity curves calculated for the major fisheries (Figs 5 and 7) were similar to those observed for previous years (Mathers 1991). Fish 3 and 4-yr-old were selected for most strongly by the open-water boat angling fishery with 19 and 30% of the population being harvested respectively. Selectivities for the other age groups were much lower. Ice angling selectivities were relatively low and remained consistent across all age-groups. The commercial entrapment gear fishery did not harvest many 2 or 3-yr-old fish but selectivity was relatively equal in the remainder of the age groups.

Future Walleye Populations

Harvest of walleye by anglers in the open-water boat and ice fisheries in the Bay of Quinte has never been higher than the levels observed in the two past years. In addition, there are many other smaller fisheries which are a source of mortality for this population including: the commercial entrapment gear fishery, walleye caught incidentally in the gillnets set for whitefish, shoreline angling fisheries, angling outside the Bay of Quinte, and harvest by members of the Bay of Quinte Mohawk Band.

The walleye model was updated with new angling and commercial fishing selectivity curves (Fig. 7) and the new population estimates described earlier and was used to predict walleye populations to the year 2002. The heart of all such models is the stock-recruitment relationship. Since the number of young fish produced annually is highly variable, future populations cannot be forecasted with certainty. Variation in the stock-recruitment relationship was simulated assuming that the variability in year class size would be the same as has been observed in the recent years (coefficient of variation = 62%). A single prediction of future populations would be unrealistic because of the inherent variability of the stock-recruitment relationship therefore the variety of possible outcomes was simulated by running the model 100 times with a single set of parameters. The range of outcomes was quantified by comparing the adult population after 10 years to a benchmark population of 500,000 adult fish.

The model predicted that if the total harvest of walleye remains at the levels documented for 1992 the adult population will continue to be similar to the current level of 900,000 fish (95% confidence interval of 600,000 to 1,200,000 fish) and it is very unlikely that adult population will fall below 500,000 fish (Fig. 8). If the total harvest of walleye is increased and maintained at levels which are more than 15,000 fish higher than the harvest levels documented for 1992 (190,000 fish) there will be a greatly increased chance that the population will not being able to sustain itself. This reinforces the need to quantify all major fisheries. Future changes to the environment such as those which may result from zebra mussel invasion into the Bay of Quinte (Mathers 1991) could greatly reduce our ability to predict future walleye populations.

Acknowledgements

Tom Stewart and Phil Smith both reviewed an earlier draft.

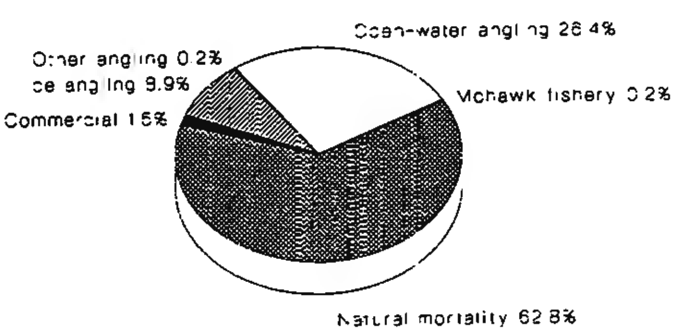

FIG 6. Relative size of the sources of mortality in the walleye population in eastern Lake Ontario during 1992. Note that natural mortality is assumed to include mortality due to illegal harvest, unreported incidental catch from commercial fisheries, unmeasured fisheries, predation, and spawning mortality.

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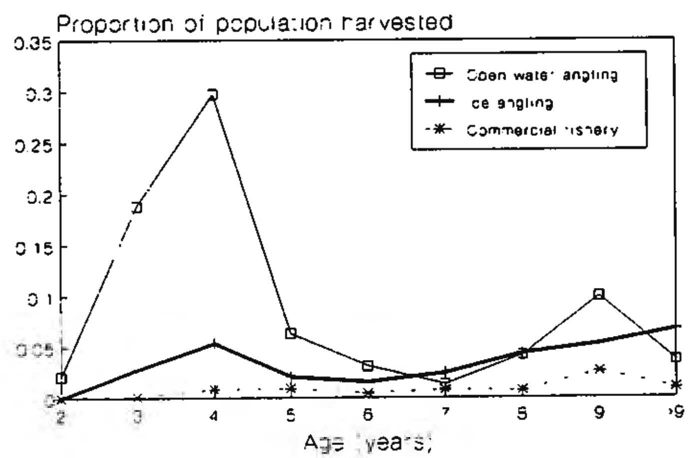

FIG 7. Selectivity curves of the 1992 open-water boat angling fishery, 1992 ice angling fishery, and the 1992 commercial entrapment gear fishery for walleye in the eastern Lake Ontario and the Bay of Quinte.

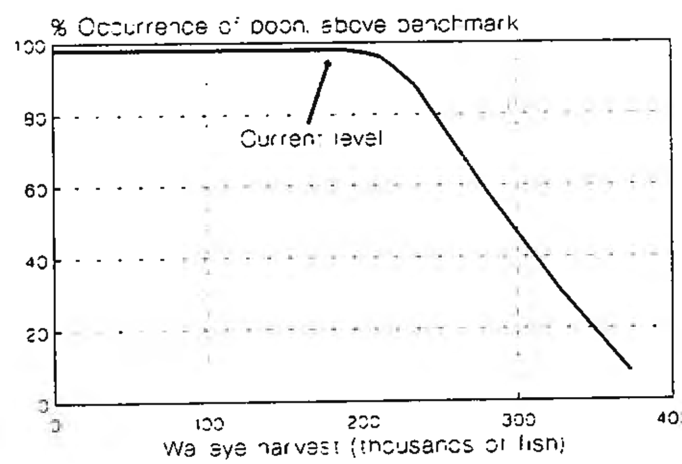

FIG 8. Simulated effect of varying the total harvest of walleye (from all fisheries) on the adult walleye population in the year 2002. Shown is the proportion of the model runs (100 runs for each observation) which had a walleye population above 500,000 adult fish for a range of total harvest levels.

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Pelagic Prey Stocks in Lake Ontario, 1991-1992

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Lake Ontario Fisheries Unit, 1992 Annual Report, Section 16

Hydroacoustic and midwater trawling surveys were conducted in May, July and October in 1991 and 1992. Abundances of pelagic fish decreased from 1991 to 1992 by more than 50%. Midwater trawls indicated a poor 1992 year-class of alewife, and poor 1991 and 1992 year-classes of smelt. The geographic distribution of the pelagic fish varied between seasons and years. Seasonal bathymetric distribution patterns are described.

Introduction

In 1991, the New York State Department of Environmental Conservation (NYSDEC) and the Ontario Ministry of Natural Resources (OMNR) initiated a hydroacoustic and midwater trawl survey to monitor the status of pelagic prey fish in Lake Ontario. Alewife (*Alosa pseudoharengus*) and smelt (*Osmerus mordax*) have been assessed yearly since the late 1970s with bottom trawls (O'Gorman et al. 1992, Mathers 1992), however, large areas on the Canadian side cannot be surveyed with this gear because the bottom is too rough. Hydroacoustic techniques combined with midwater trawling are not restricted by bottom features, and thus permit lake-wide assessment.

Six surveys have been completed to date. Because the sampling and analytical methods evolved through the surveys, some re-analysis of data is required, and remains to be done. Some questions, particularly apportionment of the total estimates by species and body size, are still being examined, and therefore much of the information contained in this report represents work in progress.

Methods

Sampling Schedule and Transect Locations

Three separate night surveys were conducted in May, July and October in both 1991 and 1992. In each survey we attempted six cross-lake transects (Fig. 1), but due to equipment failures, only half the survey was completed in July 1992, and portions of transects were also missed in the 1991 surveys. The transects were established to provide even geographic coverage, and to allow easy access to ports. In 1991 we sampled straight-line transects across the lake. In 1992 we started to sample along oblique paths in the 0-100 m zone in the U.S. waters, so that sampling effort in the 0-100 zone would be equivalent on two sides of the lake (the 0-100 m zone is much narrower on the U.S. side).

Each night, sampling began approximately one hour after dusk at the 10 m depth contour on one side, and continued across the lake to the 10 m depth contour on the other side. Sampling was usually completed one hour before sunrise the following morning. Surveys were schedule around new moon nights to minimize avoidance of fish to the trawls, and to maximize dispersion of fish for the hydroacoustic gear. A vessel contracted by MNR (JOHN D'EAU for all surveys except May 1991) was fitted with the hydroacoustic gear, and sampled the full length of the transect at approximately 11 km.h^{-1} (6 knots). Research vessel SETH GREEN (NYSDEC) conducted midwater trawling at locations and depths selected on the basis of acoustic scatterings. Temperature measurements were taken from JOHN D'EAU during spring and summer, and from the R/V SETH GREEN in the fall.

Midwater Trawling

A midwater trawl with a 57 m^2 opening was used for ground-truthing (establishing species and size composition). Tows were normally of 30 minutes duration, but varied sometimes depending on conditions. The depth of the net was monitored during the tows with a headrope transducer acoustically linked to the boat. Tow speed was generally 6.5 km.h^{-1} (3.5 knots), but varied somewhat when the captain tried to maintain a stable depth. Midwater trawl catches were

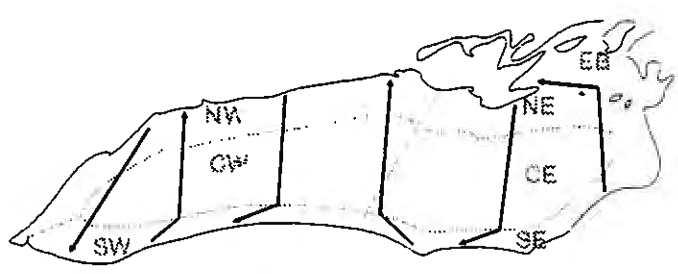

FIG. 1. Map of Lake Ontario showing survey transect, and geographical zone stratification. The survey transects shown are those followed in 1992 (for 1991 transects see Schaner and Schneider 1992). The boundaries between nearshore zones (NW, NE, SW, SE) and the central zones (CW, CE) follow the 100 m depth contour. The boundaries between western and eastern zones run along the Scotch Bonnet sill. The Outlet Basin (EB) zone is delimited by the Main Duck sill.

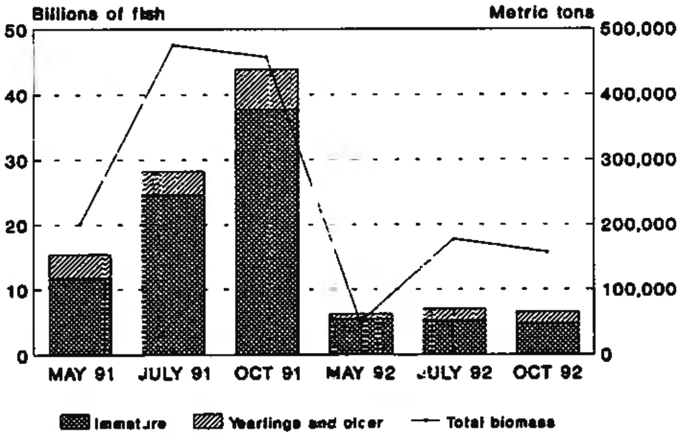

FIG. 2. Hydroacoustic estimates of pelagic fish abundance. Immature fish were defined as targets less than -47 dB, corresponding to fish smaller than 80 mm. Because of the large variance in the relationship between target strength and size of individual fish, the proportion of YOY to older fish may be biased, and should be regarded only as an index of trends. Biomass was calculated by applying the relationship between mean size in trawl catch and mean hydroacoustic target strength (Argyle et al. 1992) to the total hydroacoustic target abundance estimates.

weighed and counted by species, and individual fish were measured for fork length. Catches exceeding approximately 10 kg were subsampled.

Hydroacoustic systems

In 1991, and in May and July 1992, we used Biosonics Model 101 dual-beam echo sounders operating at 420 kHz ($6^o/15^o$ beam widths). In October 1992, after both units failed during the previous survey, we used a leased Biosonics Model 105 dual-beam echo sounder (420 kHz, $6^o/15^o$). The transducers were mounted on a 0.8 m (2 ft.) Endeco fin in all surveys, except October 1992, when we used a Biosonics Biofin. The fins were towed aft of mid-ship on the starboard side of the vessel, approximately 2 m off the side and 1-2 m below the surface, depending on sea state.

In May and July 1991, the signals were recorded on Beta videotape via Biosonics Model 171 Tape Interface, and the signals were processed using Biosonics Model 221 Echo Integrator and Biosonics Model 181 Dual Beam Processor. In October 1991, and in all 1992 surveys, analog signals were recorded on Sony DAT recorder via Biosonics Model 171 Tape Interface, and the signals were processed using a Biosonics ESP processor board installed in a 386/25 MHz computer.

Data processing and analysis

The recorded signal from the May and October 1991 surveys was processed in the lab after the cruise. During all other surveys, echo integration was performed during signal collection, and the accompanying dual beam analysis was completed the following day in port, using the recorded signal. During May and July 1991 surveys, both 20logR and 40logR signals were collected and processed, but from October 1991, malfunctioning equipment forced us to collect only 40logR signal, and to reconstruct the 20logR signal from it. This method proved to be simpler and more efficient, and the practice was continued in all subsequent surveys.

The continuously collected acoustic signal was processed by 20 minute segments during echo integration and dual beam analysis. For each transect there were normally between 15 and 23 such segments. The 20 minute segments were assigned to geographical strata (Fig. 1), and summarized to obtain stratum and lake-wide abundance estimates. Biomass estimates were made by applying the relationship between mean weight of trawl-caught fish and mean target strength from dual beam analysis (Argyle et al. 1992), to total target estimates.

Results

Abundance estimates from hydroacoustic data

The total abundance of pelagic fish decreased from 1991 to 1992 (Fig. 2). Estimates from the three surveys conducted in 1991 varied between 15.3 billion in May and 43.8 billion in October. The 1992 estimates varied between 6.2 and 6.5 billion, and were consistently lower than in 1991, suggesting

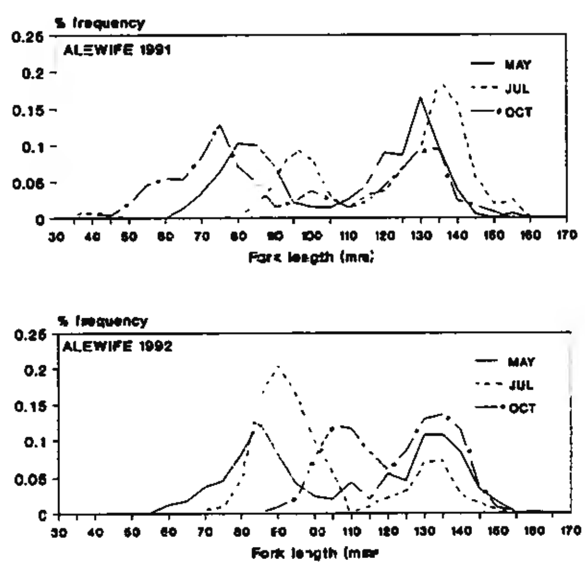

FIG. 3. Length frequency distributions of alewife caught by midwater trawl in 1991 and 1992.

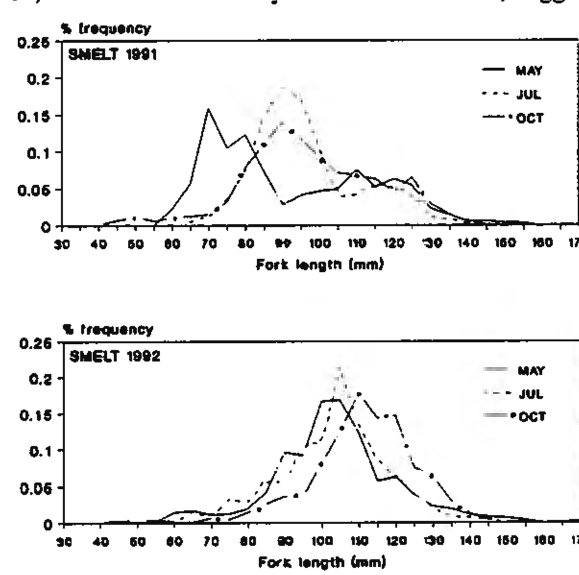

FIG. 4. Length frequency distributions of smelt caught by midwater trawl in 1991 and 1992.

a sharp decrease in pelagic fish abundance. Since targets corresponding to alewife and smelt sizes constituted more than 97% of detected targets, this trend largely represents a change in prey fish abundance. Furthermore, most of the decline in numbers between 1991 and 1992 was attributable to reductions in small young-of-the-year (YOY) sized targets.

Estimates of pelagic fish biomass in 1991 ranged between 200,000 MT (May) and 475,000 MT (July). In 1992 the biomass estimates fell to 50,000 and 157,000 MT (May and October). Preliminary partitioning of the 1992 October biomass estimate, based on trawl samples, and on recognition of individual acoustic scattering layers, suggests that 82% (128,000 MT) of the biomass were alewives, and the remainder were mostly smelt.

Species and size composition in midwater trawls

Trawl catches of alewife were markedly different in the two years (Fig 3). In the May and July surveys in 1991, yearling alewife (<110 mm) were a relatively important component of the catch, but they were caught in much lower numbers in the October survey. In 1992, yearling alewife made up a large proportion of the catch in all three surveys. In 1991 YOY alewife (mode at 75 mm in October) were first detected in low numbers in July, and they accounted for 33% of the catch in October. In October 1992 YOY alewife were nearly absent.

The catches of smelt also differed in the two years (Fig. 4). Yearling smelt (<105 mm) were the predominant group in all three 1991 surveys. Only few YOY smelt (mode at 50 mm) were collected in October 1991. In 1992, yearling smelt were nearly absent from the catches in all three surveys, and the majority of smelt were 2 yr old or older. In October 1992, YOY smelt were even more scarce than the previous year.

Geographic distribution

Pelagic prey fish distribution varied between seasons and years. In May of both years, most pelagic fish were found in nearshore zones (Fig. 5, NW, SW, NE and SE). The abundances in the offshore zones (CE and CW) in May of both years were uniformly low. In the eastern part of the lake abundances were high along the north shore (NE), and low along the south shore (SE) in May 1991, while the opposite was true in May 1992.

In October 1991 most pelagic fish were found in the Outlet Basin and in the southeast zone (EB and SE, Fig. 6). In 1992, pelagic prey were most abundant in the northeast (NE) and central (CE, CW) zones. Forty-nine percent of the pelagic fish were in the offshore central zones (CE, CW) in October 1992, compared to 10% in October 1991.

The proportion of fish found in the central zones (CE, CW) increased sharply from May to October in 1992 (Fig. 5, 6). In 1991, preference for the two central zones also increased from May to October, relative to most nearshore zones (NW, NE and SW), but the shift was overshadowed by high October abundances in southeast zone (SE) and in the Outlet Basin (EB).

Bathymetric distribution

The bathymetric distribution varied with season (Fig. 7). The May distributions were characterized by a wide dispersion of fish through the water column to depths of 50-60m, and dense unstratified aggregations of fish associated with

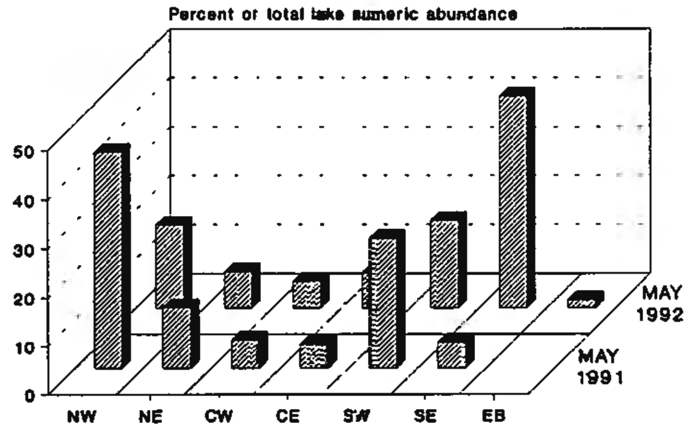

FIG. 5. Geographical distribution of abundance estimates from the May surveys in 1991 and 1992.

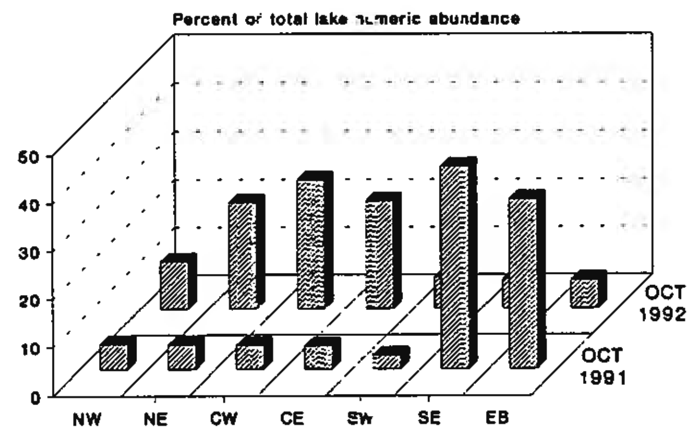

FIG. 6. Geographical distribution of abundance estimates from the October surveys in 1991 and 1992.

the bottom near the shore. In July, two distinct scattering layers were often formed, with the deeper layer forming denser aggregations near the shore. Two distinct scattering layers could still be seen in October, but they were more diffuse, the lower layer generally occurred at a greater depth, and the layers tended to break down near the shore.

A high degree of correspondence was noted between bathymetric distribution patterns, temperature patterns, and catches in midwater trawls. The undifferentiated wide distribution in May coincided with uniform low temperatures (<5°C) throughout the water column, typical of that time of the year. Both smelt and alewife were found in near-surface catches, though generally only smelt were found at greater depths. The two distinct scattering layers observed in July were closely associated with temperature profiles. It was found that the deeper layer occurred at the thermocline in temperatures below approximately 18°C, and the upper layer was associated with warm water. In areas where the thermocline was deep the two layers were distinct, while in areas of shallow thermocline (10-15 m) the two layers became adjacent or merged. The trawls indicated that alewife formed the surface layer while smelt formed the deep layer. In October of both years, the deeper scattering layer was still associated with the thermocline. The trawl catches in October showed that alewife still tended to form the upper layer, and smelt the lower layer, but in some cases smelt could be found throughout the water column.

Discussion

Abundance estimates from the three 1991 surveys varied between 15.3 billion in May and 43.8 billion in October. Several factors may have contributed to this nearly three-fold difference. The bathymetric and geographical distribution of the prey fish in the three sampling seasons was quite different, and coupled with suspected poor representation of near-surface fish, this would lead to systematic seasonal biases in the estimates. The large shifts in abundances between areas of the lake also suggest a heterogeneous geographical distribution of fish, resulting in large sampling variance, and large variability in estimates. However, an increase in abundance from spring to fall is expected, since during this period YOY alewife and smelt are born and recruited to the population of acoustic targets. We saw an increase in 1991, when midwater trawling confirmed the presence of YOY alewife in the fall, and we did not see it in 1992, when fall trawling data indicated that YOY alewife were scarce.

Preliminary biomass estimates, based on the relationship between mean weight in trawl and mean target strength (Argyle et al. 1992), ranged between 50,000 and 475,000 MT (May 1992 and July 1991). The October 1992 estimate of 157,000 MT translates into a density of 8.5 $g.m^{-2}$, which is comparable to biomass estimates of 7.2 $g.m^{-2}$ from Lake Michigan (Argyle et al. 1992). It should be noted, however, that the prey community in Lake Michigan contains a significant fraction of bloaters, and only 45% alewife. Estimation of prey biomass in Lake Ontario will require further attention, and alternative analytical methods will be sought to refine the estimates.

Midwater trawls were used to determine the species composition of target aggregations identified in the acoustic signal, and the trawling locations and depths were therefore not random. Nevertheless, the trawl catches provide insight into the dynamics of YOY and yearling alewife and smelt:

In 1991, yearling alewife (<110 mm) were a relatively important component of the catches in both May and July, but few were seen in October. The loss of yearlings between July and October suggests that predation may have been a factor, since predatory pressure is greatest in mid-summer and early fall (D. Stewart. SUNY, Oswego, pers. comm.). Furthermore, alewife have been in poor condition in recent years (O'Gorman et al. 1993), and secondary production has

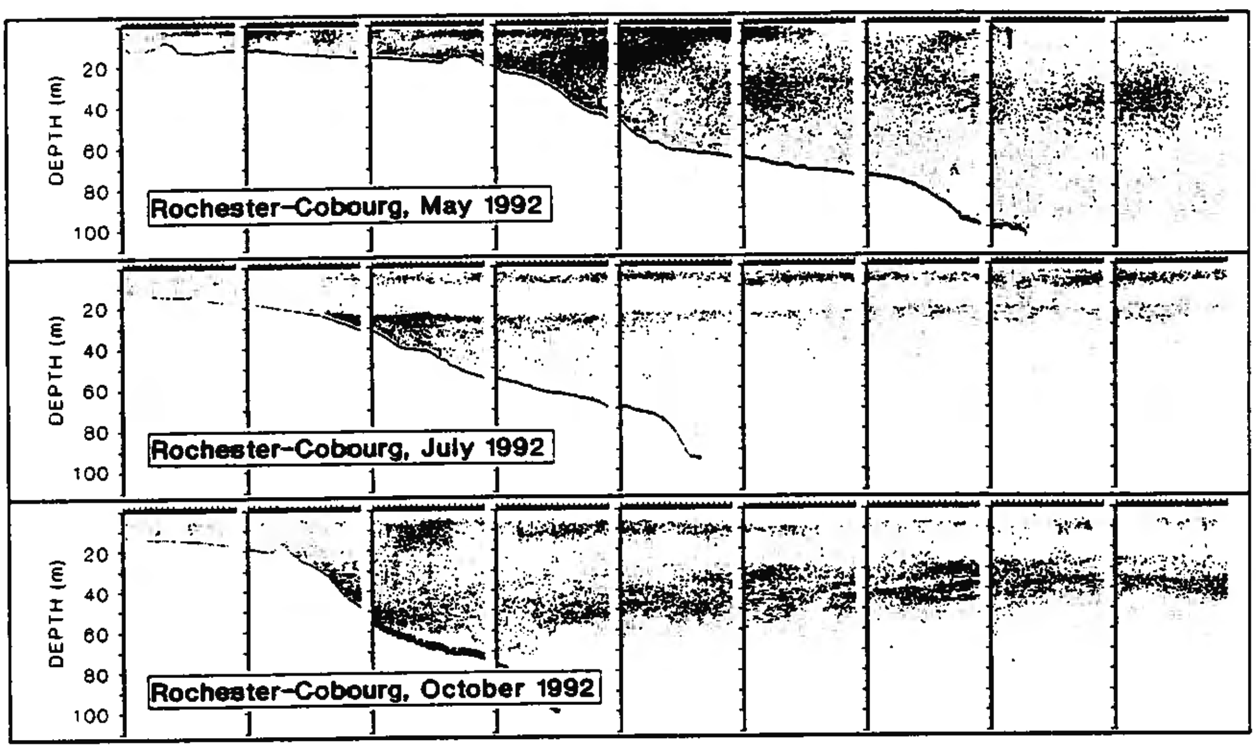

FIG. 7. Examples of typical target distributions encountered in May, July and October. All three diagrams show data collected on the Rochester-Cobourg transect in 1992. The dots represent single detected targets, but since the sampled volume increases with depth, there is a progressive bias in density representation, where near-surface densities are underrepresented relative to deeper densities.

declined (Anon. 1992). Therefore competition for limited food with adult alewife may also have been a factor responsible for the mortality.

The absence of YOY alewife in trawl catches in October 1992 suggests another setback to the alewife population. Applying the alewife length frequency distributions to the total hydroacoustic estimates in both years indicates that YOY abundance in 1992 declined by 99% from the previous year, while size breakdown of acoustic targets themselves suggests that YOY-sized targets declined by 88%. Both approaches connote a weak 1992 year-class of alewife.

Very few yearling smelt were caught in our midwater trawls in 1992, and similarly low catches were seen in bottom trawling programs in May and June (O'Gorman et al. 1993, A. Mathers, OMNR, unpubl.) Our midwater trawl catches of YOY smelt in October were very poor in both years. Having little experience with fall midwater trawling, it is difficult to confidently assess YOY smelt abundance. Nonetheless, the fact that poor YOY catches in October 1991 were followed by poor yearling catches in 1992, lead us to believe that the even smaller catches of YOY smelt in October 1992 will lead to another poor crop of yearlings in 1993.

The prospects for recovery of pelagic prey stocks in 1993 are not good. Prey abundance is low, YOY production was poor in both species, and condition of adult alewife in fall of 1992 was very poor. The decline in prey fish abundances may continue even further.

Acknowledgments

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