Ontario

LAKE ONTARIO FISH COMMUNITIES AND FISHERIES:

2002 ANNUAL REPORT OF THE LAKE ONTARIO MANAGEMENT UNIT

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Lake Ontario Committee
Great Lakes Fishery Commission

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Lake Ontario Fish Communities and Fisheries: 2002 Annual Report of the Lake Ontario Management Unit

Introduction

The Lake Ontario Management Unit (LOMU) is part of the Fish and Wildlife Branch, Natural Resource Management Division of the Ontario Ministry of Natural Resources (OMNR). The LOMU is OMNR's lead administrative unit for fisheries management on Lake Ontario and the St. Lawrence River.

The 2002 Annual Report documents results of LOMU programs, completed in 2002, to assess the fish communities and fisheries of Lake Ontario.

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Acknowledgements

The contributions of all Lake Ontario Management Unit staff are gratefully acknowledged. Also, we would like to acknowledge the help and information provided by our many partners and volunteers.

Species Highlights

Chinook salmon
- Decline in angler catch and harvest, perhaps due to unusual weather (Chapter 9)
- Analysis of stocking and population shows current stocking levels near the effective limit (Chapter 2)
- Continuing natural reproduction likely contributes to lake population (Chapter 2)
- Growth in length moderately high compared to long-term trend (Chapter 2)
- Condition remained low, consistent with the condition of alewife (Chapter 2)
- Increased age-at-maturity may increase prey fish consumption (Chapter 2)

Rainbow trout
- Distribution and catch by anglers dependent on spring temperatures (Chapter 2)
- Angler catch and harvest moderate (Chapter 9)
- Year-class strength of juvenile rainbow trout slightly lower than average (Chapter 2)

Coho salmon
- Stocked fish do not contribute to sport fishery (Chapter 2)

Atlantic salmon
- Survival of stocked fry to fall fingerling stage exceeded the established benchmark of 5 fish/100^2 at over half the sites surveyed during a 5-year research study (Chapter 12)
- High quality habitat, with good cover and low amounts of fine materials in the substrate, supported high densities of both Atlantic salmon and rainbow trout juveniles (Chapter 12)
- One of the greatest challenges to restoring Atlantic salmon may be a thiamine deficiency, linked to a diet rich in alewife or smelt, that affects reproductive success (Chapter 12)

Pelagic prey fish
- Adult alewife population maintained at moderate levels (Chapter 1)
- Adult smelt population remains low for fourth consecutive year (Chapter 1)

Lake trout
- Decline in numbers of adult fish continued (Chapter 3)
- Survival of juvenile stocked fish is low but steady (Chapter 3)
- Natural reproduction detected in U.S. waters (Chapter 3)

Lake whitefish
- Body condition improving and growth stabilized at a lower level (Chapter 3)
- Delayed mean age-at-first-maturity (Chapter 3)
- Virtually no recruitment since 1998 (Chapter 3)
- Distribution of adult fish contracting (Chapter 3)
- Continued decline in commercial harvest (Chapter 6)

Eel
- Eel counts at the Moses Saunders dam eel ladder have been at very low level since 1998 (Chapter 5)
- Continued declines in Lake Ontario and St. Lawrence River commercial harvest (Chapter 6 and 7)

Walleye
- Lower recruitment since 1996 (Chapter 4)
- Adult population stabilizing at lower level (Chapter 4)
- Population of age-3 and older about 400,000 fish (Chapter 4)
- 2001 year-class strong; 2002 year-class very weak (Chapter 4)
- Total annual adult walleye mortality steady at about 35% (Chapter 4)
- Higher success rates in angling fishery (Chapter 8)

Species Highlights (continued)

- Genetic study confirm eastern Lake Ontario and Bay of Quinte walleye comprise a single stock (Chapter 11)

Yellow perch

- Populations are relatively high in the Bay of Quinte (Chapter 4)
- Populations appear stable in eastern Lake Ontario (Chapter 4) but declining in Lake St. Francis (Chapter 5)
- Commercial harvest declined (Chapters 6 and 7)

Round goby

- Exotic invader spreading throughout the Bay of Quinte and eastern Lake Ontario (Chapter 4)

Smallmouth bass

- Year-class strength improved in recent years (Chapter 4)
- Adult abundance very low in eastern Lake Ontario (Chapters 4)

Largemouth bass

- High angling catch rates in the Bay of Quinte (Chapter 8)

Panfish

- Black crappie, bluegill and pumpkinseed sunfish abundant in the Bay of Quinte (Chapter 4)

1

Lake Ontario Pelagic Fish 1: Prey Fish

T. Schaner and S. R. LaPan[1]

Introduction

Alewife (*Alosa pseudoharengus*) and rainbow smelt (*Osmerus mordax*) are the most abundant pelagic planktivores in Lake Ontario, and the most important prey for large salmonines. Alewife are also important prey for many warm water predators, notably, walleye. The total amount of Lake Ontario's pelagic planktivore biomass has declined over the past decade, probably due to reduced nutrient loading, proliferation of exotic *Dreissena* mussels, and predation by salmon and trout. Coincident with this decline, threespine sticklebacks (*Gasterosteus aculeatus*) have become more common in survey catches, and in 1995-1997 there was also a temporary increase in catches of emerald shiners (*Notropis atherinoides*). These recent observations may signal a change in the pelagic fish community.

Concerns for declining numbers of prey fish were addressed by the Canadian and U.S. management agencies in 1993, by reducing the number of stocked salmonines to a level that would cut the prey demand by approximately half. In 1997, however, stocking levels were moderately increased following public consultation on both sides of the border. Also, since 1997, increased rates of natural reproduction by chinook salmon have been observed. Thus the alewife and smelt populations continue to be under intense predatory pressure. Adjustments of management plans must be informed by estimates of prey quantities, and therefore since 1991 the New York State Department of Environmental Conservation (NYSDEC) and the Ontario Ministry of Natural Resources (OMNR) have conducted joint surveys of prey fish abundance. Lake-wide data from these surveys complements information from bottom trawling surveys conducted annually by NYSDEC and the U.S. Geological Survey (USGS) on the U.S. side of the lake (O'Gorman et al. 2003).

1 New York State Department of Environmental Conservation, P.O. Box 292, Cape Vincent, NY, 13618, U.S.A.

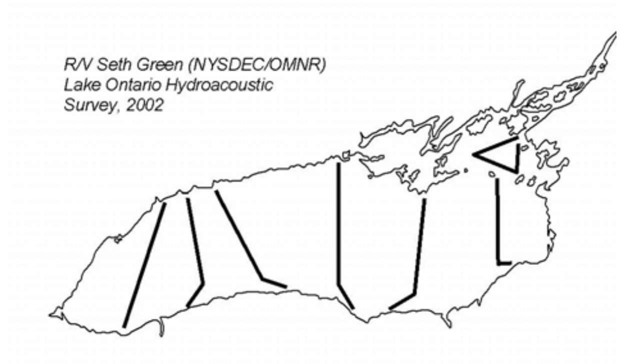

FIG. 1. Map of Lake Ontario showing transects sampled during the 2002 hydroacoustic survey.

Methods

The hydroacoustic surveys consist of six cross-lake transects and an Eastern Basin transect (Fig. 1). The transects in the main lake follow a north-south line across the lake, but in the 10-100m zone in U.S. waters the shore is approached at an angle to increase sampling opportunity in the otherwise narrow nearshore zone. Each night, sampling begins approximately one hour after sunset at the 10 m depth contour at one shore, and proceeds across the lake at approximately 6 knots to the 10 m depth contour at the other shore. Sampling is usually completed one hour before sunrise to minimize avoidance of fish to the trawls, and to maximize dispersion of fish to be recorded by the echosounder. Acoustic data are collected along the full length of the transects using Simrad EY500 120 kHz dual beam echosounder. No midwater trawls were made in 2002 due to staff shortages, but in all previous years a mid-water trawl with a 57 m^2 opening was used to ground-truth the acoustic data. The captured fish were processed to establish species and size composition.

In 2002 we used a new procedure to estimate the alewife and smelt population abundances, and the same procedure was also used to revise population estimates from the 1997-2001 summer surveys. The revisions were prompted by new information on target strength characteristics of both alewife (Warner et al.2002) and smelt (Rudstam et al. 1999, Rudstam et al. *in press*), showing that alewife presented larger backscattering cross-section than previously assumed, while smelt presented one that is smaller than previously assumed. Our previous assumptions about target strength were based on commonly used general models (Love 1971, Love 1977).

Initial target abundance estimates by region, thermal layer and target strength category (3 dB bins) were obtained using Simrad analytical software (EP500). The regional estimates were summed to obtain whole-lake estimates by thermal layer and target strength category. The resulting target strength-frequency distributions were then processed to identify targets due to yearling-and-older (YAO) alewife and smelt based on target strength and position in the water column.

Experience from several years of midwater trawling indicates that at night during the summer, yearling and older (YAO) alewife occupy the epi- and metalimnion, while YAO smelt occupy the meta- and hypolimnion. The typical acoustic target strength distribution from the epi- and metalimnion is multimodal (Fig. 2), with a prominent peak in the –55dB to –45dB region (smaller fish targets), and a weaker overlapping peak in the –40dB to –35dB region (larger fish targets). New target strength information suggests that the latter peak represents YAO alewife, and also that some of the targets in the former peak (–55dB to –45dB region) are due to YAO smelt. In the hypolimnion only a single peak in the –53dB to –43dB region is generally present (Fig. 3), and we assume that it represents YAO smelt.

Overlap between peaks in the target strength distributions in the upper layers required that the individual modes be resolved. This was accomplished by assuming that the individual contributing distributions were normal, and then using Microsoft Excel solver function to fit the component modes by minimizing sums-of-squares. The targets belonging to the right-most mode (generally in the –40 dB to –35 dB region) were assumed to be YAO alewife. Hypolimnetic targets, on the other hand, generally formed a single mode with most targets larger than –55 dB. Based on trawls, and on the new information on target strength, these targets were all assumed to be YAO smelt. The abundance of hypolimnetic YAO smelt was thus estimated as the number of targets stronger than -58 dB.

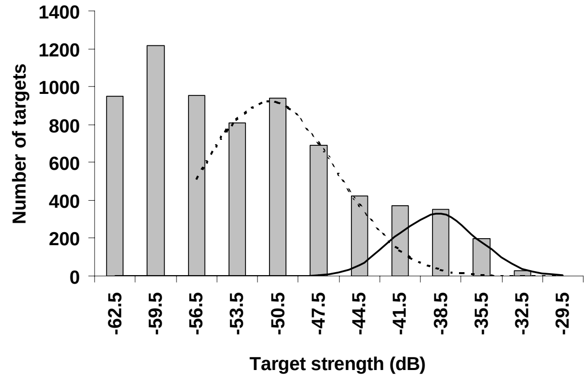

FIG. 2. *Acoustic target strength distribution from the epi- and metalimnion (data from summer 2000 shown here as a representative example). The bars show the acoustic target strength distribution, the lines show the separation into individual target strength modes. The smaller mode on the right represents YAO alewife.*

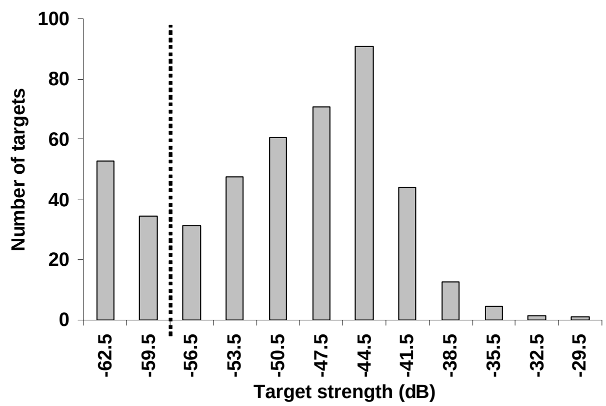

FIG. 3. *Acoustic target strength distribution from the hypolimnion (data from summer 2000 shown here as a representative example). Targets larger than -58dB*

The biomass of the YAO alewife and smelt was estimated by applying year-specific length-weight regressions to length composition measurements from trawls. The resulting mean weights of alewife or smelt were multiplied by numerical abundance estimates to obtain estimates of biomass.

Alewife

The lake-wide abundance estimates of YAO alewife in 1997-2002 varied between 0.4 and 1.0 billion fish (Fig. 4). After a low abundance in

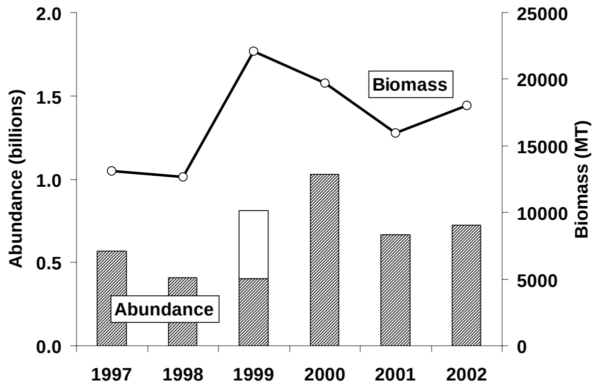

FIG. 4. *Abundance and biomass of yearling-and-older alewife. Abundance estimates were derived directly from hydroacoustic surveys, biomass estimates were obtained by applying average weights measured in midwater trawls to hydroacoustic abundance estimates. The abundance estimate for 1999 (dark plus light bars) was obtained by doubling the 1999 half-lake estimate (dark bar). Average weights used in biomass calculations in 1999 and 2002 were based on pooled data from other years.*

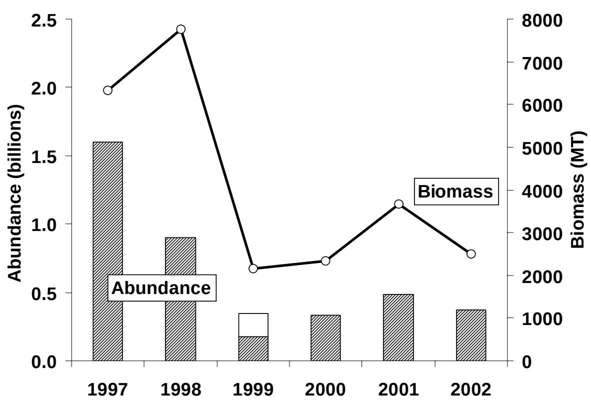

FIG. 5. Abundance and biomass of yearling-and-older smelt. Abundance estimates were derived directly from hydroacoustic surveys, biomass estimates were obtained by applying average weights measured in midwater trawls to hydroacoustic abundance estimates. The abundance estimate for 1999 (dark plus light bars) was obtained by doubling the 1999 half-lake estimate (dark bar). Average weights used in biomass calculations in 1999 and 2002 were based on pooled data from other years.

1997-1998, the exceptional 1998 year class boosted the population in 1999 and 2000. With the decline of the 1998 year class the population declined in 2001, but remained at a moderate level in 2002, likely through the contribution of the 2001 year class (O'Gorman et al. 2003).

The biomass of YAO alewife in 2002 was estimated to be 18,000 MT. The biomass generally tracked the numerical abundance, but while the highest numerical abundance occurred in 2000, the highest biomass was seen in 1999. This was because in 1999 there was a relatively high proportion of large fish (most likely the 1995 year class), while in 2000 the population was dominated by smaller age-2 fish from the 1998 year class.

Smelt

The lake-wide abundance estimates of YAO smelt decreased sharply in 1997-1998, from 1.6 billion in 1997 to less than 0.5 billion in 1999-2001 (Fig. 5). This pattern is similar to the one seen in spring bottom trawls conducted by USGS/ NYSDEC in the U.S. waters (O'Gorman et al. 2003). The latter data series, going back to 1978, suggests that the 1999-2002 observations represent unusually low abundances persisting for an unusually long period.

The biomass of YAO smelt dropped sharply in 1999 from around 8,000 MT, and remained at the 2,000 to 4,000 MT level since then. The average weights of YAO smelt in midwater trawls has remained fairly constant in 1999-2001 (no trawl data available for 2002), suggesting that the alternating year class pattern of recruitment (O'Gorman et al. 2003), with relatively small-bodied yearlings driving down the average weights in odd-numbered years, has recently been suppressed.

Threespine Stickleback

Threespine sticklebacks started showing up in midwater trawl catches in significant numbers in the early 1990's. Threespine sticklebacks are too small to be efficiently captured by our midwater

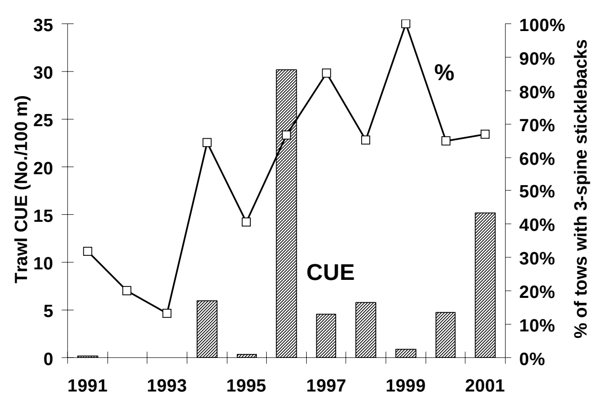

FIG. 6. Trawl catches of threespine sticklebacks in summer hydroacoustic surveys. Bars show the catch per unit effort, line shows the proportion of tows that contained sticklebacks. No trawls were done in 2002.

trawls, but the increased frequency of occurrence in the catches suggests that their abundance increased throughout the mid to late 1990s (Fig. 6). Trawls provide our only information on the threespine stickleback, because so far we are not able to identify them in the acoustic data. We did not trawl in 2002, and therefore we have no new information on the threespine sticklebacks.

Discussion

The abundance of alewife and smelt observed in the hydroacoustic surveys in years 1997-2001 should be interpreted against the longer term perspective of bottom trawl survey series in U.S. waters going back to late 1970s (O'Gorman et al. 2003). The latter series indicates that the overall 1997-2001 levels of YAO alewife abundance were below levels observed in the 1980s and early 1990s, and even the recent peak abundance in 2000 is only comparable to the average level of alewife abundance in the earlier period. The abundance of smelt declined after 1997, and in terms of YAO numbers, the four-year period of 1999-2002 is only comparable to occasional low years during the previous two decades. The smelt biomass in 1999-2002 was significantly lower than any biomass observed in the previous two decades.

It is doubtful that either alewife or smelt will return to their former abundance because their decline was probably related to decreased productivity of the lake. The relatively stable levels observed in both species in the last four years may represent a new equilibrium state for the foreseeable future. The absolute abundance of threespine sticklebacks, and their role as forage for large predators (and possibly even for adult alewife and smelt), should be elucidated.

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2

Lake Ontario Pelagic Fish 2: Salmon and Trout

J. N. Bowlby and M. E. Daniels

Introduction

The principal members of the offshore pelagic fish community in Lake Ontario are alewife and rainbow smelt, and their salmonine predators: chinook salmon, rainbow trout, coho salmon, brown trout, lake trout, and Atlantic salmon. Salmon and trout populations in Lake Ontario are sustained chiefly by stocking. As well, significant natural reproduction occurs in chinook salmon and rainbow trout. Chinook salmon are the principal stocked species, followed by rainbow trout and lake trout, and by lesser numbers of coho salmon, brown trout, and Atlantic salmon. In the late 1980s and early 1990s, Canadian and U.S. agencies stocked more than 8 million fish into Lake Ontario. In 1993, stocking levels for all species were reduced to levels that would lower prey consumption by approximately one-half in an attempt to reduce predator demand on alewife and smelt. Based on further public consultation stocking was modestly increased in 1997 (Stewart et al. 1999).

This chapter describes salmon and trout stocking, and our current information on the status of chinook salmon, rainbow trout, coho salmon, and brown trout. Lake trout, which play a significant role in the offshore pelagic community, but are also associated with the benthic community, are discussed in Chapter 3 of this report. Atlantic salmon are discussed in Chapter 12 of this report.

Information sources

Salmon and trout populations in Lake Ontario were assessed in a variety of ways. The catch and harvest rate from the boat angler fishery in western Lake Ontario (Bowlby 2003: Chapter 9 in this report) was used as an index of relative abundance of salmon and trout. The least-square mean harvest rate by year class (cohort) across ages 1 to 3 from the Ontario (Bowlby 2003) and New York (Eckert 2003) angling fisheries was used as an index of the year class strength of chinook salmon. This value is the average relative abundance of a cohort over most of its life, and is statistically adjusted for missing ages.

Wild juvenile salmon and trout populations were assessed by electrofishing 34 randomly selected sites in Lake Ontario tributaries (Bowlby et al. 1994). Year-class strength of wild rainbow trout in Ontario tributaries was calculated as the least-square mean density of juvenile rainbow by year-class.

Chinook salmon growth was monitored during summer in the boat angler fishery, and during fall in the spawning run at the Credit River at the Reid Milling dam in Streetsville. Chinook salmon were electrofished in the Credit River for spawn collection by the Ringwood Fish Culture Station. Growth and abundance of spawning rainbow trout were usually monitored during spring at the Ganaraska River fishway. However, in 2002 no data were collected.

Stocking Program

In 2002, OMNR stocked about 2 million salmon and trout into Lake Ontario (Table 1). In the spring of 2002, the number of fish stocked at each site differed somewhat from OMNR's established stocking schedule. However, all fish were stocked in a healthy condition at suitable stocking sites. About 575,000 chinook salmon spring fingerlings were stocked at various locations, mainly in the western end of the lake, to provide put-grow-and-take fishing opportunities. About 178,000 coho salmon fall fingerlings and spring yearlings were stocked into the Credit River. Because of a poor coho run in 2002, the 2003 production target will not be met. This

TABLE 1. Salmon and trout stocked into Province of Ontario waters of Lake Ontario, 2002, and target for 2003.

Species	Life Stage	Number stocked in 2002	Target for 2003
ATLANTIC SALMON	Green eggs	17,000	
	Eyed eggs	27,000	
	Delayed fry	5,511	
	Advanced fry	194,735	100,000
	Spring fingerlings	34,190	
	Fall fingerlings	14,613	100,000
	Yearlings	1,299	
	Adults	578	
		294,926	**200,000**
CHINOOK SALMON	Spring fingerlings	**575,226**	**540,000**
COHO SALMON	Fall fingerlings	92,354	75,000
	Spring yearlings	85,527	75,000
		177,881	**150,000**
LAKE TROUT	Spring yearlings	**444,580**	**440,000**
RAINBOW TROUT	Fry	249,100	
	Spring yearlings	143,827	140,000
		392,927	**140,000**
BROWN TROUT	Spring yearlings	**162,746**	**165,000**
SALMON & TROUT TOTAL		**2,046,987**	**1,635,000**

shortfall could not be corrected by importing eggs from the Salmon River in New York State in 2002. Over 290,000 Atlantic salmon (mainly advanced fry) were stocked in support of an ongoing program to determine the feasibility of restoring self-sustaining populations of this native species to the Lake Ontario watershed. About 445,000 lake trout yearlings were also stocked as part of an established, long-term rehabilitation program. Efforts are focused in eastern Lake Ontario where most of the historic spawning shoals are found. OMNR stocked approximately 144,000 rainbow trout yearlings, while local community groups reared another 250,000 fry. About 163,000 brown trout yearlings were stocked at various locations to provide shore and boat fishing opportunities.

Detailed information about OMNR's 2002 stocking activities is found in Appendix A. The New York State Department of Environmental Conservation (NYSDEC) also stocked 3.7 million salmon and trout into Lake Ontario in 2002 (Eckert 2003).

Chinook Salmon

Abundance

Catch rates of chinook salmon from the boat fishery in western Lake Ontario declined 22% from the previous 5-yr average (Fig. 1). This decline appears to be related to unusual weather affecting the distribution of chinook salmon in Lake Ontario during 2002, rather than a decline in abundance (Bowlby 2003). Chinook salmon abundance has been stable for the past six years.

Stocking largely determines the abundance of chinook salmon in Lake Ontario (Bowlby et al. 1996). As chinook salmon stocking increased in the early 1980s, the population increased (Fig. 2). The stocking reductions in 1993 and 1994 initially produced the desired decline in population (Fig. 2). However, since 1995 chinook salmon year class strength and hence, abundance, has been higher than expected. Increases in natural reproduction and density-dependent increases in survival may explain these results. Summer electrofishing surveys across 21 Ontario streams detected an abrupt increase in natural reproduction of chinook salmon between 1995 and 1997 which has continued to 2002 (Fig 3). Spring electrofishing surveys by OMNR suggest that natural reproduction increased abruptly in 1996 in Ontario. In New York, natural reproduction of chinook salmon increased in 1997 after increased regulated winter flows in the Salmon River. Accordingly, the higher than expected population of the 1995 year class was not a result of increased natural reproduction. Rather, higher survival of young chinook salmon would appear to be the best explanation for strength of this year class. Moreover, the 2-year lag between stocking cuts and the strong 1995 year class favors reduced predation over competition as the reason for higher survival. Regardless, in 1995 the fish community in the pelagic zone of Lake Ontario was in flux as a result of the stocking cuts to chinook salmon , and

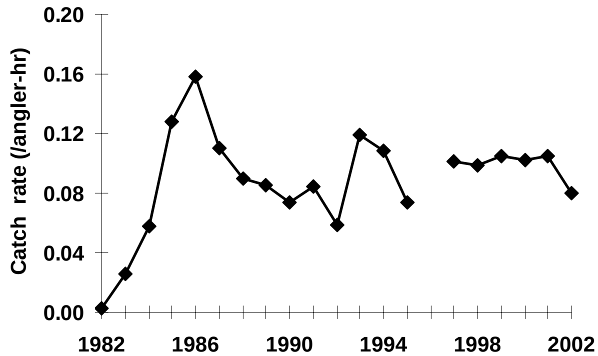

FIG. 1. The catch rate of chinook salmon in the western Lake Ontario launch daily salmonid boat fishery (Ontario portion) from 1982 to 2002.

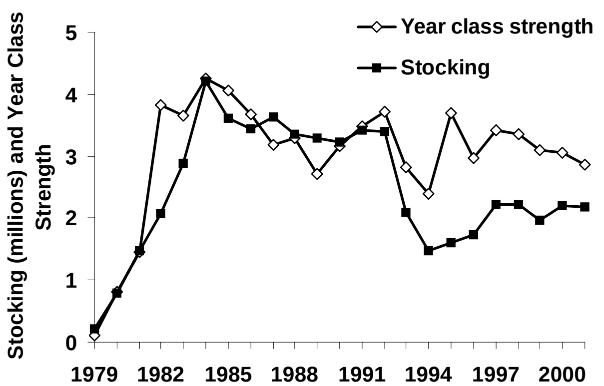

FIG. 2. Stocking Numbers and Year Class Strength of Chinook Salmon in Lake Ontario. Year class strength represents the mean of age-specific harvest rates (age 1 to 3) from OMNR and NYSDEC angling surveys. Means were adjusted (least square means) through a general linear model to account for missing data.

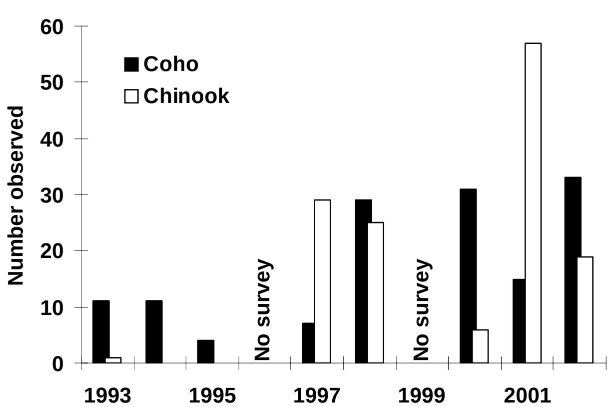

Fig. 3. Number of YOY coho and chinook salmon observed during summer surveys of Lake Ontario tributaries in Ontario. No surveys were conducted in 1996 and 1999.

lake trout, as well.

Stocking usually determines year class strength through a stock-recruitment relationship when stocking is the only source of recruitment for fish populations. This may be valid for chinook salmon in Lake Ontario (Fig. 4). A linear fit to this relationship would indicate the lower limb of a stock-recruitment curve where density dependence has little influence. A dome-shaped or asymptotic line would show a stock recruitment curve where density-dependence is strong. However, the presence of significant numbers of wild smolts since 1996 complicates this relationship, especially when the contribution of wild smolts to the Lake Ontario population is unknown. The predominantly stocked year classes from 1979 to 1994 (1995 was excluded as a statistical outlier) do not clearly favor a straight line or curved relationship, but both are valid descriptions of the data (Fig. 5, 6). Linear and quadratic approximations of a stock-recruitment curve were used to test for a difference in the year class strength between the pre-1995 and post-1995 year classes. Both curves suggest that post-1995 year classes were higher than predicted, consistent with a contribution of wild chinook salmon to the population in Lake Ontario (Table 2). Quadratic and linear equations estimate that the average wild smolt production from 1996 to 2001 was equivalent to 468,000 and 810,000 stocked smolts, respectively. These estimates of wild smolts are consistent with estimates of about 400,000 chinook salmon pre-smolt fingerlings in Ontario tributaries of Lake Ontario during spring 1997 (Bowlby et al. 1998).

The quadratic equation provides a better fit to the data (Table 2) suggesting that stocking and density dependent interactions combine to determine the abundance of chinook salmon in Lake Ontario. Accordingly, increases in stocking are unlikely to provide significant increases in chinook salmon abundance. Above a stocking level of 2 million chinook salmon smolts per year we see no appreciable increase in chinook salmon abundance in Lake Ontario (Fig. 4). The relative abundance of chinook salmon appears to asymptote at higher levels of stocking. At current stocking levels, a portion of the wild production of chinook salmon in Lake Ontario tributaries appears to contribute to the Lake Ontario population. Increased stocking of chinook salmon may result in a shift to more stocked fish and fewer wild fish in the population with no overall increase in chinook salmon abundance. It is

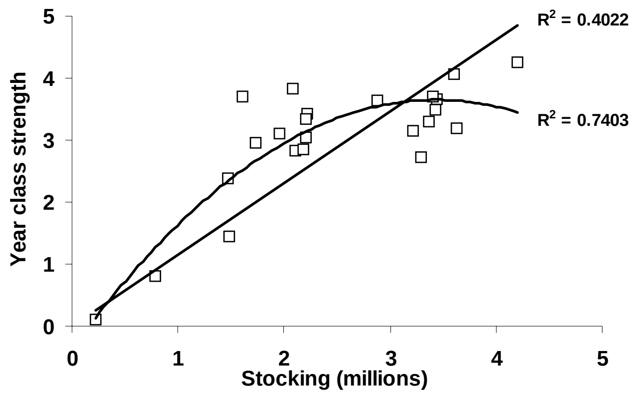

FIG. 4. The relationship between stocking and year-class strength of chinook salmon in Lake Ontario for 1979 to 2001. Linear and quadratic fits to the data are illustrated.

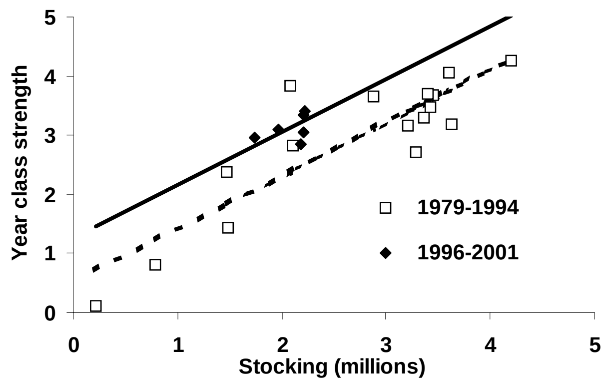

FIG. 5. The linear fit to the relationship between stocking and year class strength of chinook salmon in Lake Ontario for pre-1995 and post-1995 periods of low and high natural reproduction, respectively.

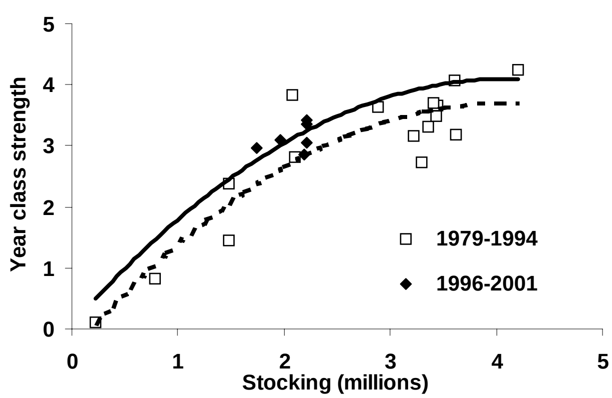

FIG. 6. The quadratic fit to the relationship between stocking and year class strength of chinook salmon in Lake Ontario for pre-1995 and post-1995 periods of low and high natural reproduction, respectively.

TABLE 2. Evaluation of linear and quadratic aproximations of a stock recruitment model and estimation of the mean number wild smolts each year from 1996 to 2001.

	Mean year class strength				
Model	1979-1994	1996-2001	p	Estimated wild smolts	Overall model R^2
Linear	2.77	3.50	0.005	810,068	0.77
Quadratic	2.86	3.25	0.079	472,806	0.83

unclear how wild production of chinook salmon might respond to a stocking reduction, but, it is entirely possible that survival of wild fish might increase.

Year-Class Strength of Wild Chinook

Wild chinook salmon were observed during summer in an electrofishing survey of juvenile salmon and trout in Lake Ontario tributaries. These were the 10% of wild chinook salmon that remain in Lake Ontario tributaries during their first summer and smolt out as yearlings (Bowlby et al. 1998). The abrupt increase in wild chinook salmon after 1996 was sustained in 2002 (Fig. 3). Juvenile chinook salmon were observed in Duffins Creek, Wilmot Creek, Shelter Valley Creek, and the Ganaraska River during summer surveys in 2002.

Growth and Maturity

Yearly variations in growth by length of chinook salmon during summer in Lake Ontario (Fig. 7) and during fall in the Credit River (Fig. 8) are similar. The length of male and female 3-yr-old chinook salmon in the Credit River during fall 2002 declined over the past several years (Fig. 7). Growth of chinook salmon in Lake Ontario still remains higher than the early 1990s and better than the upper Great Lakes. The pattern of body condition of chinook salmon (Fig. 9) differs from growth. Overall, condition of chinook salmon decreased slightly due to a decline in condition of the male fish (Fig. 9). This was consistent with that of their main diet item, alewife (Fig. 10).

The age of maturity of chinook salmon in Lake Ontario is quite variable and highly influenced by relatively small differences in growth. Higher growth results in greater maturation of younger fish (Fig. 11, 12). The length of 2-yr-old chinook salmon was much greater in the Credit River than Lake Ontario because only the larger,

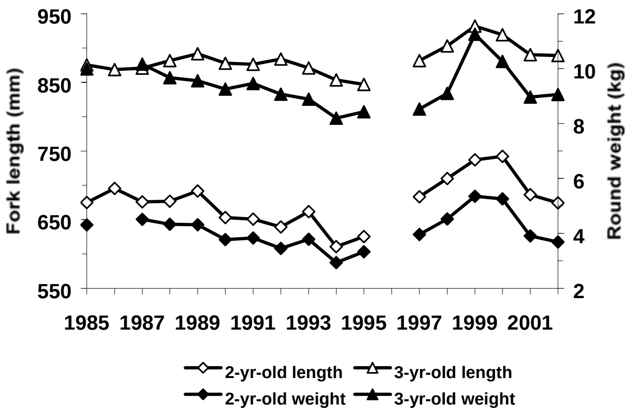

FIG. 7. Mean Fork length and round weight of chinook salmon in Lake Ontario during summer months, 1985-2002.

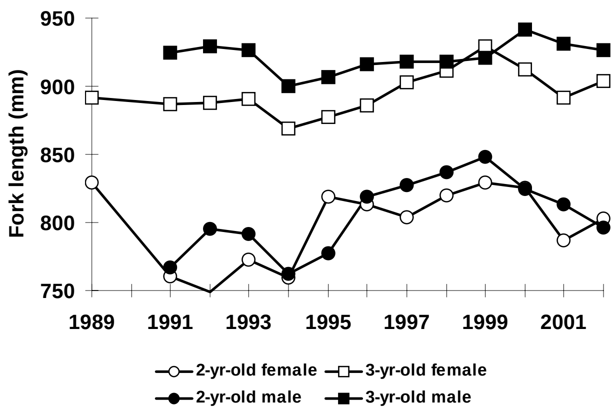

FIG.8. Mean fork length of chinook salmon in the Credit River during spawning run in September and October, 1989-2002.

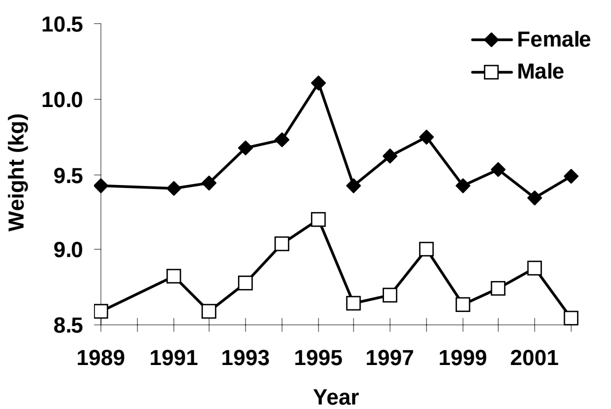

FIG. 9. Mean weight of a 900 mm chinook salmon in the Credit River during the spawning run about October 1, 1989-2002.

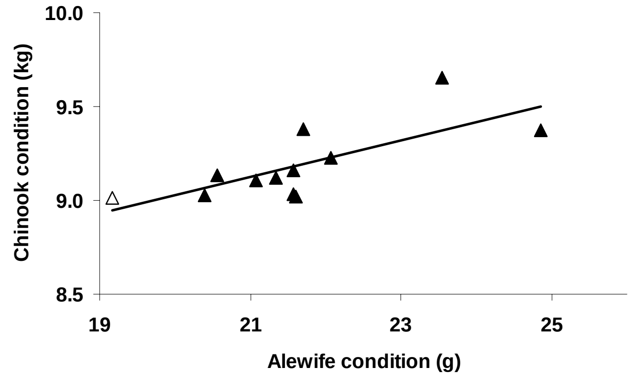

FIG. 10. A plot of condition of chinook salmon in the Credit River during the spawning run in September and October and condition of alewife (wt of 126 mm fish) in Lake Ontario during the same year from 1991 to 2002. The 2002 data point is indicated with an open triangle.

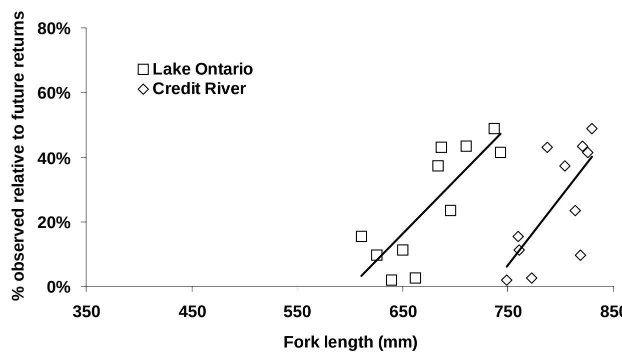

FIG. 11. The percent of female Chinook salmon observed returning to the Credit River as 2-yr-olds relative to total observed returns of the same cohort at age 2 and 3. These values are plotted against the fork length of 2-yr-old female Chinook salmon from the Credit River during fall and Lake Ontario (combined sex) during June to September.

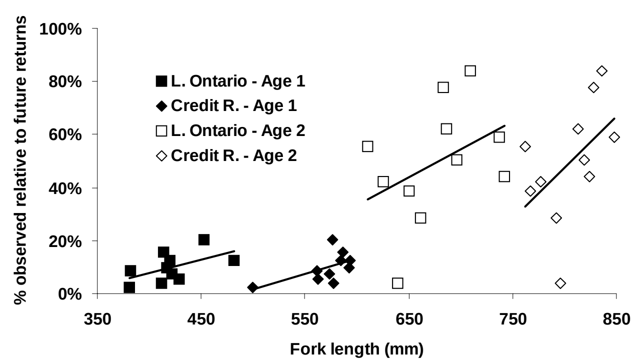

FIG. 12. The percent of male Chinook salmon observed returning to the Credit River as 1-yr-olds and 2-yr-olds relative to total observed returns of the same cohort at ages 1 to 3. These values are plotted against the fork length of the same aged male Chinook salmon from the Credit River during fall and Lake Ontario (combined sex) during June to September.

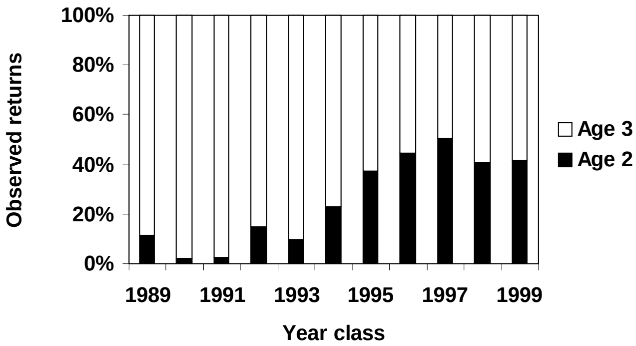

FIG. 13. The percentage by age and year class of female Chinook salmon returns to the Credit River.

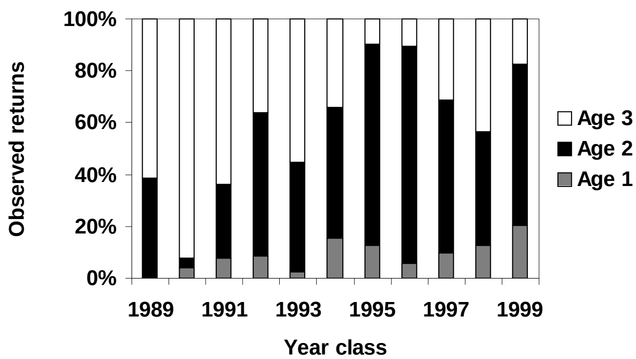

FIG. 14. The percentage by age and year class of female Chinook salmon returns to the Credit River. A value for age 1 males was unavailable for the 1989 year class.

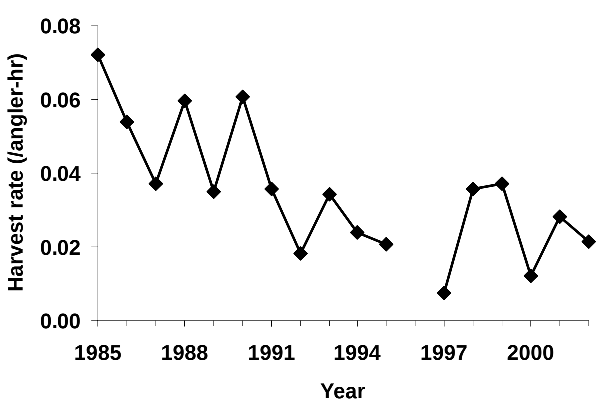

FIG. 15. Harvest rate of rainbow trout by Ontario boat anglers in Lake Ontario from April to September.

faster-growing 2-yr-olds mature and spawn (Fig. 11, 12). Most female 2 yr-olds remain in Lake Ontario and mature as 3-yr-olds. Although some male fish mature at age 1 (Fig. 12), most mature at either age 2 or 3 (Fig. 14). A small percent of chinook salmon in Lake Ontario and the Salmon River mature as 4 yr-olds (Eckert 2003, Bishop 2003). Moreover, they observed a greater proportion 4 yr-olds in years with lower growth. Accordingly, lower growth in Lake Ontario results in increased age of maturity and lifespan. In Ontario, our aging method could not discriminate 4 yr-olds from 3 yr-olds but 4 yr-olds are few.

Rainbow Trout

Abundance

Initial examination of harvest rates of rainbow trout in the Ontario boat fishery of western Lake Ontario might suggest a decline in abundance from the 1980s to the 1990s (Fig. 15). However, harvest rates in New York water showed the opposite trend (Eckert 2003). Accordingly, the harvest rate trend suggests that the rainbow trout population has been steady over this time period. Rainbow trout stocking in Lake Ontario has been relatively constant since 1985, averaging close to 900,000 per year. The catch rates of rainbow trout in Ontario are positively correlated with the mean April air temperature, whereas the catch rates in New York are negatively correlated with the same air temperatures (Fig. 16). Along the north shore of Lake Ontario the highest monthly catch rates of rainbow trout occur during the warmest springs, but the lowest catch rates are in the coldest springs (Schaner et al. 2002). Spring air temperatures affect the timing of spawning and out migration of rainbow trout from the tributaries. Moreover, the tributary temperatures affect the formation of thermal bars near stream mouths. The thermal bars have a great impact on the distribution of salmonines in Lake Ontario. The springtime formation of thermal bars differs radically between New York and Ontario, due to the strong effect of the Niagara River plume. Thus, rainbow trout distribution varies seasonally, and among years.

Year-Class Strength of Wild Rainbow Trout

The proportion of wild rainbow trout in Lake Ontario from 1989 to 1995 averaged 38% (Bowlby and Stanfield 2001). The relative contribution of wild rainbow trout from Ontario and New York streams is unknown, but most are

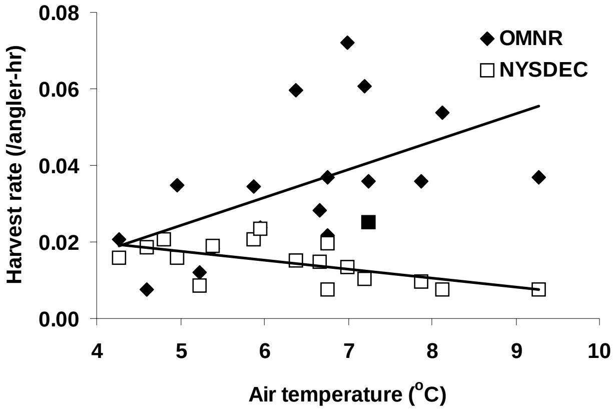

FIG. 16. Relationship between harvest rate of rainbow trout by New York and Ontario boat anglers in Lake Ontario and mean air temperature during April.

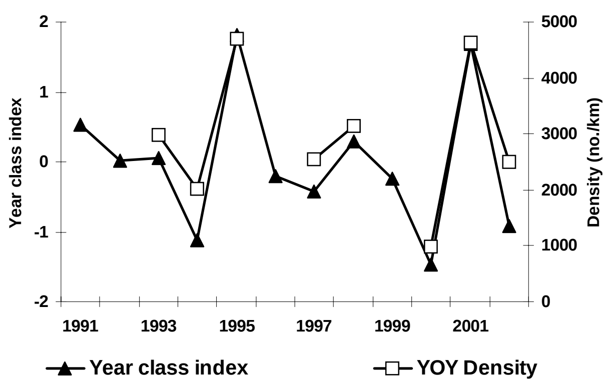

FIG. 17. Density of young-of-the-year (YOY) and year class strength of rainbow trout in Ontario tributaries of Lake Ontario, 1991-2002.

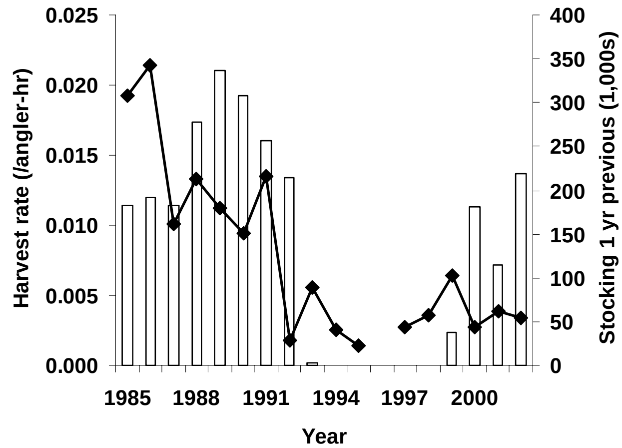

FIG. 18. Stocking of coho salmon by Ontario Ministry of Natural Resources and subsequent harvest rate of coho salmon by Ontario boat anglers in Lake Ontario from April to September.

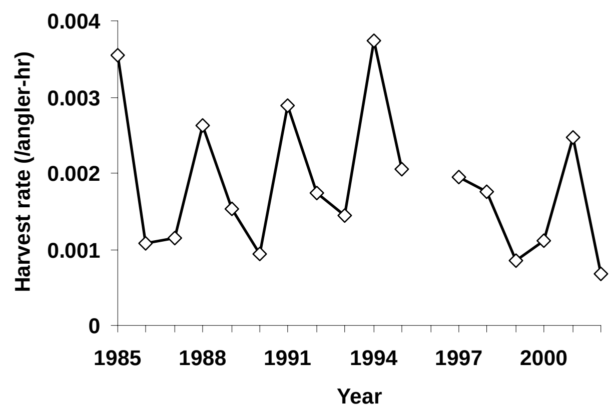

FIG. 19. Harvest rate of brown trout by Ontario boat anglers in Lake Ontario from April to September.

thought to originate from Ontario tributaries where suitable nursery habitat is more abundant. In 2002, year-class strength of juvenile rainbow trout was slightly lower than the long term average (Fig. 17). Year-class strength was calculated as the standardized least-square mean of age-specific density. The mean density of young-of-the-year rainbow trout in these tributaries continues to be a good predictor of year-class strength (Fig. 17).

Coho Salmon

Most coho salmon in Lake Ontario are stocked by Ontario and New York, since few are observed in Ontario tributaries during summer surveys (Fig. 3). OMNR stopped stocking coho salmon in 1991 and this was reflected by a sharp decline in the Ontario harvest rates through the mid 1990s (Fig. 18). After OMNR resumed stocking coho salmon in 1997, harvest rates did not differ significantly (t-test, p= 0.20) from the period of no stocking. Very few coho salmon with Ontario fin clips were observed in the boat fishery. Clearly, coho salmon stocked more recently by OMNR have not impacted the boat fishery. Moreover, in attempts to obtain eggs from returning adults since 1999, very few coho salmon have been detected in the Credit River. The reason for poor performance of stocked coho salmon is not clear. The good performance of other salmon and trout stocked by OMNR from the same hatchery would suggest that the problem is not with the hatchery, or with Lake Ontario. Moreover, Lake Ontario strain coho salmon eggs were obtained from the Salmon River Hatchery in New York. The strain used is suited to Lake Ontario. Stocking location within the Credit River may be a more likely explanation and merits further study. Likely, the first hypothesis worth testing relates to the expanded distribution of smallmouth bass at stocking locations. Smallmouth bass may be a significant predator of hatchery raised coho salmon.

Natural reproduction of coho salmon in Ontario tributaries has more than tripled in the years since 1998, similar to chinook salmon (Fig. 3). Juvenile coho salmon and chinook salmon occupy much different habitat in streams. The reason for the coincident increase in wild coho salmon and chinook salmon may be a similar response by these species to a common but yet to be determined factor. The contribution of 'wild' fish to the juvenile and adult population is unknown at present.

Brown Trout

Harvest rates of brown trout in the boat fishery have fluctuated significantly since 1985, but show no long-term trends (Fig. 19). Numbers of yearlings stocked by Ontario and New York have been relatively consistent since 1982 and fluctuations in harvest rates show no correlation with fluctuations in numbers stocked.

Summary and Conclusions

In 2002, OMNR stocked about 2 million salmon and trout into Lake Ontario. About 575,000 chinook salmon, 178,000 coho salmon, 163,000 brown trout, and 144,000 rainbow trout were stocked to sustain the boat and land-based fisheries in Lake Ontario and its tributaries. In addition, local community groups reared about rainbow trout 250,000 fry. Over 290,000 Atlantic salmon (mainly spring fingerlings) and 445,000 lake trout were stocked in support of restoring self-sustaining populations of these native species in Lake Ontario.

The abundance of most salmon and trout in Lake Ontario is dependent on stocking. However, there are limits to effective stocking. The best model relating chinook salmon stocking and abundance suggests that chinook salmon stocking is less effective above current stocking levels. The corollary is that chinook salmon populations in Lake Ontario may exhibit self-regulation contributing to stability in the predator community. Natural reproduction of chinook and coho salmon has suddenly increased in recent years. Lower stocking of chinook salmon might promote further increases in natural reproduction, but the extent is unclear.

The age of maturity, and consequently, life span of chinook salmon in Lake Ontario increases with lowered growth. To understand the impacts of chinook salmon on alewife populations it is clear that we must better understand the relationship between growth and maturation rates of chinook salmon. Chinook salmon spawn once and then die. By increasing the age of maturity and life span, they feed for more years before dying, and would have a greater impact on the alewife population than predicted by a static maturity schedule.

Rainbow trout and brown trout populations appear to be stable. Observed variations in abundance indices of rainbow trout in Lake Ontario are related to spring temperature and its influence on movement and distribution of rainbow trout in Lake Ontario and tributaries. Natural reproduction of rainbow trout in Ontario tributaries continues, similar to past levels, but density of juvenile rainbow trout remains well under the optimum for the available habitat.

Coho salmon stocked by OMNR make little contribution to the boat fishery, and returns of adults to the Credit River have been low. Although there are a number of hypotheses for the poor performance of stocked coho salmon, we believe that studies should start with the potential impact of changes in the Credit River, particularly smallmouth bass.

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3

Lake Ontario Offshore Benthic Fish

J.A. Hoyle and T. Schaner

Introduction

The most abundant members in the Lake Ontario offshore benthic fish community include one top predator, lake trout, and two benthivores, lake whitefish and slimy sculpin. Much less abundant benthic species include burbot, round whitefish, deepwater sculpin, and the parasitic sea lamprey. Other, primarily pelagic species, overlapping in distribution with the benthic community include alewife, smelt, lake herring and threespine stickleback (see Chapter 1 in this report).

The benthic fish community has undergone tremendous change. Stress brought about by over-exploitation, degraded water quality, the parasitic sea lamprey, and increases in larval fish predators (i.e., alewife and smelt) caused lake trout, four species of deepwater cisco and deepwater sculpin to be extirpated, or nearly so, and lake whitefish and burbot to decline to remnant population sizes by the 1960s and 1970s.

Regulated harvest, improvement to water quality, lamprey control, and large-scale stocking of salmon and trout (see Chapter 2 in this report), all initiated in the 1970s, led to improved stock status of some species. Lake trout are the subject of a multi-agency restoration program and currently maintained by stocking but detectable levels of natural reproduction have occurred since 1993. Lake whitefish recruitment increased during the late-1970s and populations of two major spawning stocks (i.e., Bay of Quinte and Lake Ontario) recovered over the mid-1980s to early-1990s time-period but declined thereafter. Slimy sculpin, which did not experience major negative impacts during the 1960s and 1970s, declined in abundance under intense predation pressure by lake trout through the 1980s and early 1990s—especially in the shallow regions of their distribution. Burbot abundance remained low. Changes in round whitefish abundance, a species confined largely to north central Lake Ontario waters, are not well documented and are not considered further in this report. Deepwater sculpin, thought to be extirpated from Lake Ontario since the early 1970s, re-appeared in small numbers beginning in 1996. Deepwater cisco remained absent.

In the early-1990s critically important changes occurred in the benthic zone of Lake Ontario. *Dreissenia sp*. (zebra and quagga mussels) invaded and proliferated throughout Lake Ontario. Concurrently, the macroinvertebrate *Diporeia sp*. disappeared (Dermott 2001). *Diporeia* was an important and energy rich diet item for benthic fish that had previously accounted for 86% of the total benthic production in Lake Ontario (Dermott 2001). Subsequent changes in the benthic fish community were severe. For example, lake whitefish have shown changes in bathymetric and geographic distribution, a reduction in body condition and growth, delayed age-at-maturity, and very poor reproductive success (Hoyle and Schaner 2002, Hoyle et al. In Press).

This chapter updates the status of lake trout, lake whitefish, slimy sculpin, burbot and deepwater sculpin for 2002.

Information Sources

Information on the benthic fish community was summarized from the eastern Lake Ontario fish community index gillnetting and trawling program (Fig. 1, Hoyle 2002a), and also, in the case of lake whitefish, from commercial catch sampling during lake whitefish spawning (Hoyle 2002b). For a complete list of species-specific catches in this program, see Appendix B.

Lake Trout

Abundance

The catch per unit effort (CUE) for mature lake trout in the index gillnet continued to decrease in 2002 (Fig. 2). Previously we have

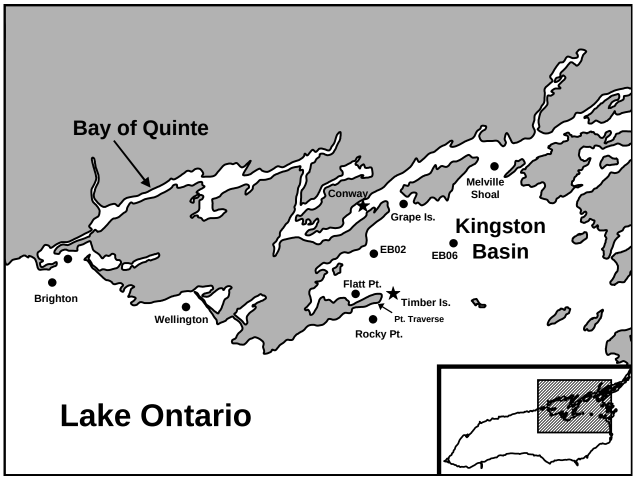

FIG. 1. Map of northeastern Lake Ontario showing fish community index gillnetting (circles) and trawling (stars, Conway and Timber Island) locations.

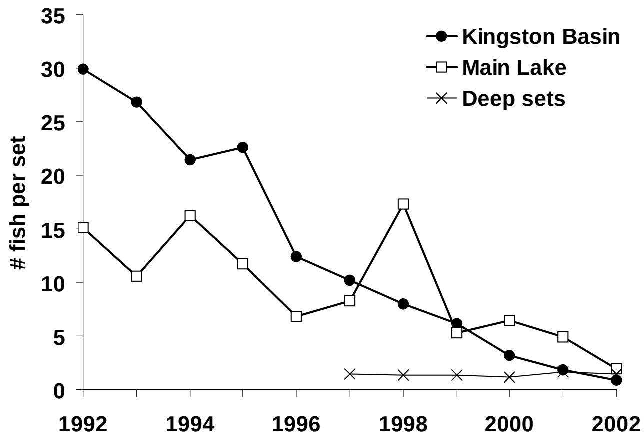

FIG. 2. Catches of mature lake trout (number of fish per standard gillnet set) in the community index gillnetting program. Only catches from July through September made at bottom temperatures less than 12oC were used. 'Deep sets' shows catches from Rocky Point, south of Point Traverse, at depths greater than 60 meters.

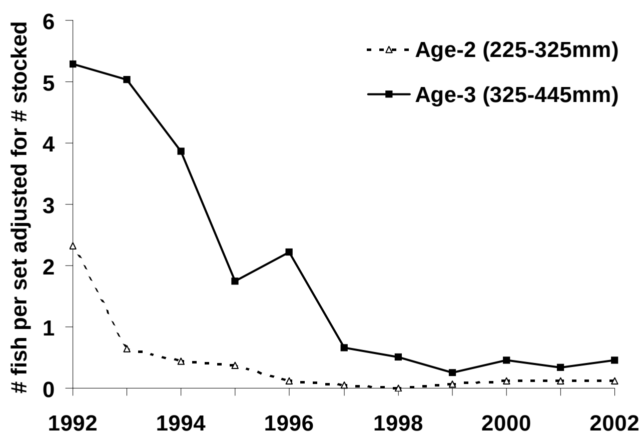

FIG. 3. Survival of stocked fish to ages 2 and 3. Fish in the ranges of 230-329 and 220-449 mm were assumed to be age-2 and age-3 old respectively, based on information from the recently discontinued coded wire tags, and from length frequency distributions. The graph shows the catches per standard set in the community index gillnetting program divided by the number of yearlings (in millions) of the corresponding year-class stocked in the Canadian waters east of Brighton.

reported population trends based on pooled observations from all areas surveyed in the eastern Lake Ontario (Hoyle and Schaner 2002), and suggested a strong decrease in numbers of adults starting in the mid-1990s. A more detailed examination of CUE data shows that there are regional differences. The decrease in the Kingston Basin has been fairly steady, and more than 20-fold since the early 1990s. In the main lake there was only slight, if any, decrease in the CUE through most of the 1990s, followed by a pronounced decrease since 1998. The pattern in the main lake is similar to the observations from the U.S. waters (Lantry et al. 2003). Finally, observations from deep gillnet sets (>60 m) at Rocky Point in the main lake show no discernable decrease in the CUE of adult fish over the 1997-2002 period.

These patterns can be interpreted as a result of a combination of factors. The two principal causes for the overall decline are the reduced survival of stocked fish (Fig. 3), and the reduction in stocking levels implemented in 1993 in response to decreasing abundance of forage fish. The regional differences in abundance patterns are consistent with changes in stocking patterns that accompanied the stocking reduction in 1993– there was a disproportionate reduction of numbers stocked in the Kingston Basin, and initiation of stocking in the adjacent waters in the main lake. This explains the much sharper decline in abundance of mature fish in the Kingston Basin than in the eastern waters of the main lake. Finally, starting in 1993, Seneca strain lake trout were stocked in Canadian waters. These fish are known for their deep water habits, and their introduction may account for the low but steady CUEs observed in the deep waters off Point Traverse since 1997.

These patterns and confounding factors make it difficult to determine what the recent overall trend in adult abundance has been. There appears little doubt that a decrease in numbers occurred over the last decade, similar to that observed in the U.S. waters. However, the preference of the Seneca strain for deep waters may have contributed to the low CUEs in the Kingston Basin and in the shallow waters of the main lake. Furthermore, the low but steady CUEs measured in deep waters may suggest low density, but not necessarily a low population abundance, if the fish are distributed over a wider range of depths, and therefore larger area.

The survival during the first and second years after stocking is low compared to levels seen a decade ago, but holding steady (Fig. 3). The index of early survival is calculated as the CUE of juveniles corrected for the numbers originally stocked. After a precipitous drop in the early 1990s, the index appears to have stabilized after 1999, and no further decline occurred in the previous four years. Similar to the index of abundance of adult fish, the interpretation of the index of early survival is complicated by changes in stocking patterns and distribution of the stocked fish.

Body Condition

The body condition of mature lake trout has decreased for four years in a row, and in 2002 it was the lowest since the beginning of the data series in 1992 (Fig. 4, 680 mm). This is in direct contradiction to the observations in the U.S. waters which suggest a relatively high body condition in 2002. Although the two data series represent slightly different seasons (Canada - summer, U.S. - early-fall), this diametrical difference is curious and can only be explained by regional differences in food availability. There is some evidence of unusual trophic conditions in 2002, when alewife suffered a loss of condition over the course of the summer (O'Gorman et al. 2003), and some observations suggested unusually low levels of possum shrimp *Mysis relicta* (T.Schaner, unpublished observations; R. O'Gorman, pers. comm.). A large difference between summer and fall condition may also occur if a good year class of alewife becomes available to the lake trout in the late-summer, and this may have been the case in 2002 (R.O'Gorman, pers. comm.).

There was no significant change in the body condition of juvenile lake trout (Fig. 4, 430 mm), but our ability to detect trends in the condition of the juvenile fish has suffered in the recent years due to low numbers of fish caught and available for measurements.

Lamprey wounding

The frequency of fresh lamprey wounds in lake trout has been demonstrated to be a direct indicator of mortality due to lamprey (Schneider et al. 1996). Due to successful lamprey control program, the lamprey wounding levels remain well below the rates observed during 1970s and early 1980s. Recent data suggest that there was a slight rebound of lamprey wounding in 1995 after very low levels in the early-1990s (Fig. 5), and since then the lamprey wounding rates have fluctuated without trend, suggesting lake trout mortality due to sea lamprey has remained constant since 1995.

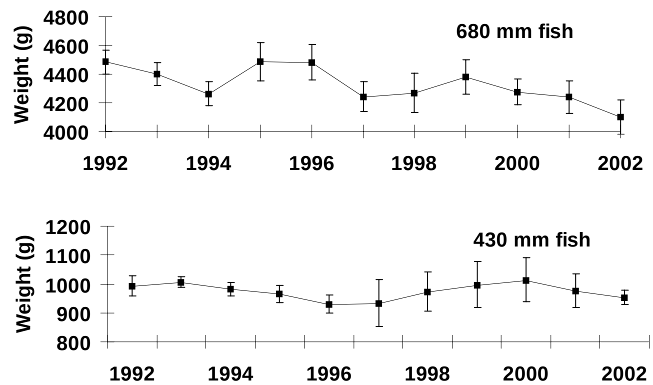

FIG. 4. Weights of 430 and 680 mm fish. The weights were calculated from regression of log transformed round weight on log transformed fork length, and only data from 50 mm brackets around the shown values of fork length were used in the regressions (405-455 mm and 655-705 mm). The error bars represent 95% confidence intervals on the estimated weight.

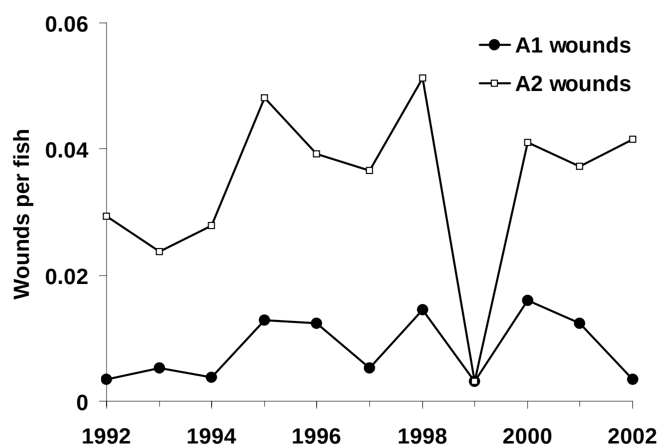

FIG. 5. Number of A1 and A2 (International Joint Commission classification) lamprey wounds per lake trout observed in the index gillnetting program.

Natural reproduction

Naturally produced lake trout were first observed in Lake Ontario in 1994, and fish of every year-class starting with 1993 have been captured since then. The numbers are low, and most naturally produced fish are observed in the U.S. waters in various bottom trawling programs. This technique is not used in Canadian waters outside of the Bay of Quinte and the Kingston Basin, and therefore opportunities for capture are few. No naturally produced lake trout were captured in Canadian waters in 2002, while 8 were captured in the U.S. waters (Lantry et al. 2003).

Lake Whitefish

Abundance and distribution

The abundance of lake whitefish age-1 year and older was monitored during summer at several gillnetting locations in eastern Lake Ontario (see Fig. 1). Abundance was very low prior to 1980, increased rapidly to a peak in 1993, and declined equally rapidly through the late-1990s. Abundance remained low in 2000 and 2001 and in 2002 fell to its lowest level since 1986 (Fig. 6). The recent declining trends in lake whitefish abundance were age-specific. The age distribution of fish in the 2002 gillnet catches indicated that fish less than age-7 were virtually absent (Fig. 7).

Changes in the spatial distribution of lake whitefish in eastern Lake Ontario summer index gillnet catches are illustrated in Table 1. In the early 1990s, at peak lake whitefish abundance, the majority of the catch occurred in the deep waters (approximately 30 m water depth) of the Kingston Basin (EB02 and EB06 sampling areas). At present, most lake whitefish are caught in a single sampling area (Flatt Point, approximately 20 to 30 m) in Prince Edward Bay.

Year class Strength

Lake whitefish year class strength was measured as young-of-the-year (age-0) catches in summer bottom trawls at Timber Island and Conway for 'lake' and 'bay' spawning stocks respectively (Fig. 1). Trawl catches of age-0 were low since 1996 (Fig. 8). No age-0 fish were observed at Timber Island during the past five years, and only small numbers were at Conway during this same time-period. In 2002, only a single age-0 lake whitefish was captured in the bottom trawls. The bottom trawl results were

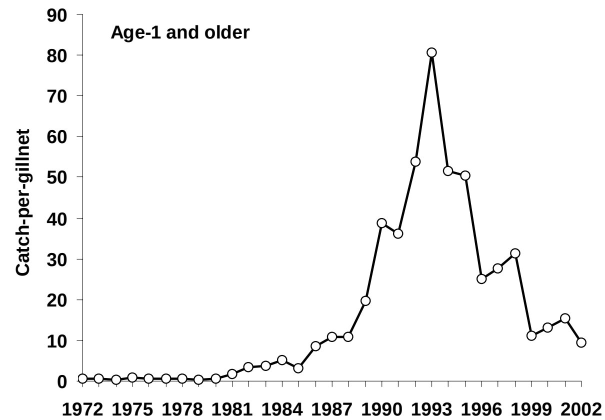

FIG. 6. Lake whitefish abundance (age-1 and older catch-per-gillnet adjusted to 100 m of each mesh size, 1 1/2 to 6 in), during summer in the Kingston Basin of Lake Ontario, 1972 to 2002.

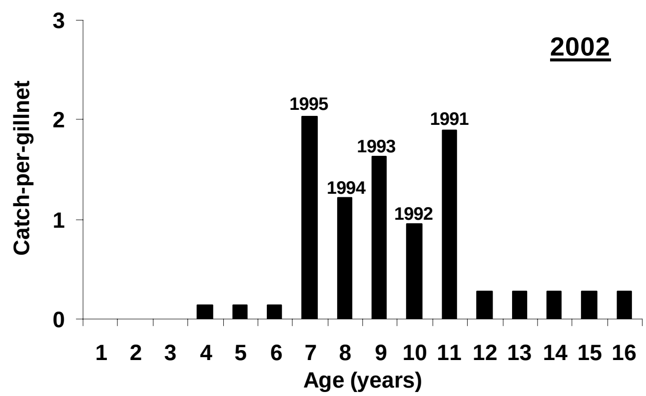

FIG. 7. Lake whitefish age distribution in the 2002 gillnet catch shown in Fig. 6. Strong year classes (1991-1995) are indicated.

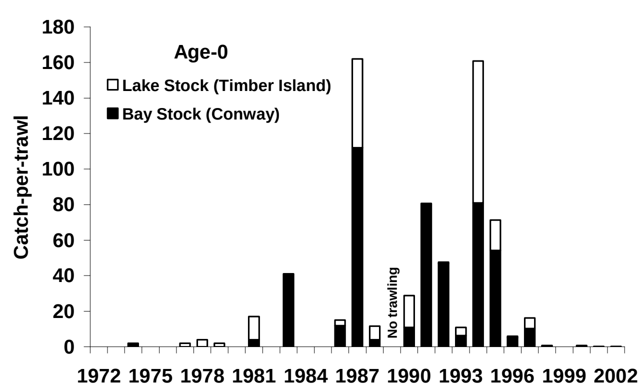

FIG. 8. . Relative abundance of age-0 lake whitefish caught in trawls for lake (Timber Island, open bars) and bay (Conway, closed bars) stocks, 1972-2002 (no trawling in 1989). See Fig. 1 for locations of Timber Island and Conway.

TABLE 1. Distribution of lake whitefish catch in index gillnets during summer in eastern Lake Ontario for early 1990s and early 2000s time-periods. See Fig. 1 for locations of sampling areas.

	Percent of Lake Whitefish Catch	
Area	Early 1990s	2001/02
Brighton	4%	0%
Wellington	1%	1%
Rocky Point	8%	2%
Flatt Point	8%	75%
EB02/EB06	60%	13%
Grape Island	10%	6%
Melville Shoal	9%	3%
	100%	100%

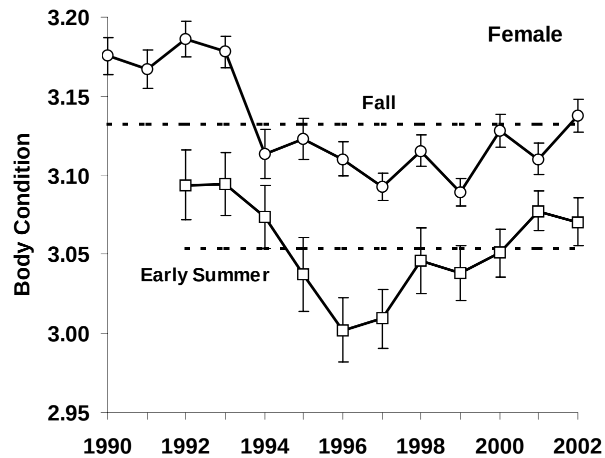

FIG. 9. Body condition (log10 round weight adjusted for differences in mean fork length among years, ANCOVA), for female lake whitefish sampled in the fall commercial fishery (1990-2002) and in summer index gillnets (1992-2002). Error bars are 95% CI.

consistent with the gillnet trends, and suggest that virtually no production of young fish has occurred since 1997.

Body condition and growth

Body condition of spawning lake whitefish declined from 1993 to 1994. The body condition of spawning lake whitefish (both 'lake' and 'bay' spawning stocks combined) declined precipitously from 1993 to 1994. Body condition appeared to remain relatively stable through 2001 with some indication of improvement in 2000 (Fig. 9). Body condition in 2002 was the highest since the decline in 1994.

Body condition of 'mixed' stocks of lake whitefish (age-5 and older) caught in summer index gillnets declined significantly from 1993 to 1996 then increased through 2001. Body condition in 2001 and 2002 approached the high values observed prior to 1995 (Fig. 9).

Lake whitefish growth is illustrated for the average age-6 fish in Fig. 10. Length and weight were high in the early 1990s, declined until 1997, and remained low in subsequent years. Growth rate appears to have stabilised at a new lower level.

Age at first maturity

Lake whitefish mean age at first sexual maturity (female) was 4 to 5-yrs-old in the early 1990s but gradually increased after 1995 to over age-7 by 2002 (Fig. 11).

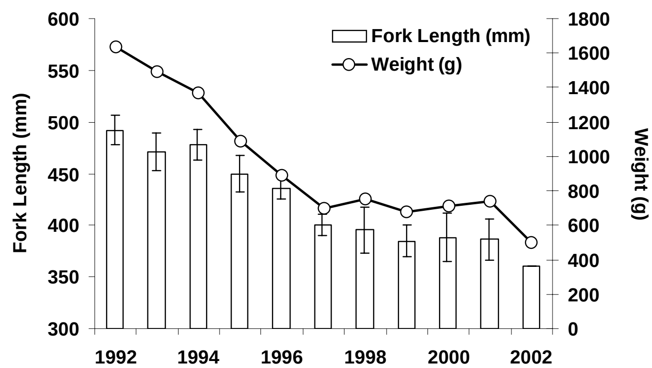

FIG. 10. Mean fork length (bars; error bars are 95% CI) and weight (line) for age-6 lake whitefish caught in summer index gillnetting in the Kingston Basin of Lake Ontario, 1992-2002. Note that only a single age-6 fish was caught in 2002.

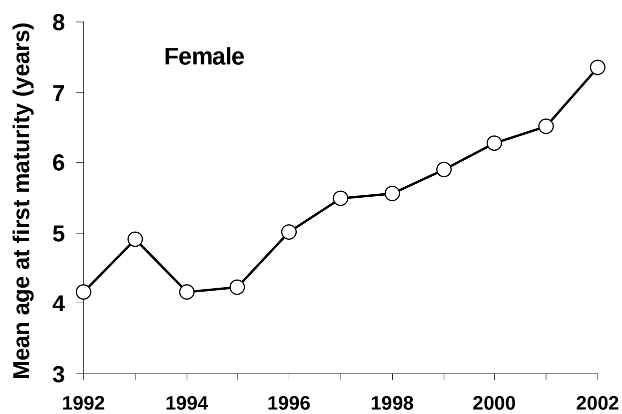

FIG. 11. Mean age at first maturity (Lysak 1980) based on gonad weight relative to body weight of female lake whitefish caught in summer index gillnets, 1992-2002.

Food-web disruption and lake whitefish biological responses

Peak lake whitefish abundance corresponded with the arrival of the exotic dreissenid mussels to eastern Lake Ontario. The high density of dreissenid mussels and their associated feeding ecology likely initiated or contributed to large changes to the eastern Lake Ontario ecosystem. Coincident with the establishment of dreissenid mussels and associated changes in water quality, the burrowing amphipod *Diporeia* suddenly disappeared from eastern Lake Ontario between 1993 and 1995 (Dermott 2001). The synchronized spread of dreissenid mussels and loss of *Diporeia* across the Great Lakes suggest that these events are closely linked. Hypotheses related to potential interactions have been proposed but the precise mechanism of the negative impact of dreissenid mussels on *Diporeia* has not been determined (Dermott 2001, Dermott and Kerec 1997, Dermott and Munawar 1993, Landrum et al. 2000, Nalepa et al. 1998).

Diporeia previously accounted for 86% of total benthic production in Lake Ontario (Dermott 2001) and were an important prey in the diet of lake whitefish (Christie et al. 1987). *Diporeia* densities declined throughout Lake Ontario at depths <100 m, remaining abundant only in very deep waters (Dermott 2001, Lozano et al. 2001).

Consistent with the disappearance of *Diporeia* and its importance in the lake whitefish diet, lake whitefish body condition, which had been high and stable, deteriorated markedly in 1994. Declines in lake whitefish growth rate lagged approximately one year behind the decline in body condition finally manifesting in an increase in mean age at first maturity beginning in 1996. The synchrony of these events suggests that, although lake whitefish abundance may have been approaching carrying capacity in eastern Lake Ontario, it was the sudden disappearance of *Diporeia* that precipitated changes in lake whitefish body condition and growth attributes. These typically density dependent attributes actually declined or remained low while lake whitefish density declined.

Changes in lake whitefish body condition were, to some degree, dependent on the time of year that the samples were taken. The body condition of spawning fish sampled in the fall remained poor following the large decline observed in 1994; improving only very recently. Fish sampled during summer showed body condition declines from 1993 to 1996 but condition improved steadily after 1997. One hypothesis that could account for the contradictory results is that lake whitefish modified their seasonal distribution and feeding patterns. During summer months lake whitefish must feed below the thermocline where food resources appear to be limiting since the disappearance of *Diporeia*, thus leading to losses in body condition throughout the summer and into early fall. At other times of the year (i.e., fall, winter, spring) lake whitefish are not constrained to depths below the thermocline and can feed in shallower water where prey alternative to *Diporeia* may be more abundant.

There is anecdotal evidence that in recent years lake whitefish have moved to shallow water areas near spawning grounds earlier and remained in shallow water areas later to feed.. Such adaptive behaviour could facilitate an increased capacity to improve body condition during fall, winter, and spring. Even during summer, it appears that lake whitefish distribution has changed. Most lake whitefish in eastern Lake Ontario gillnet sampling are now taken from index nets in a single area (Prince Edward Bay). The reason for this latter change in distribution is not clear but may be related to prey availability.

While lake whitefish body condition remains in a state of flux, growth appears to have stabilized at a new lower level. Pothoven et al. (2001) found that decreased lake whitefish body condition and growth in southern Lake Michigan were associated with the loss of the high energy prey resource *Diporeia* and the consumption of prey with lower energy content such as dreissenid mussels. This would appear to be the case in eastern Lake Ontario. Diet studies in 1998 and 2001 confirmed that *Diporeia* were virtually absent from the eastern Lake Ontario lake whitefish diet. Shelled benthic invertebrates, primarily dreissenid mussels, but also gastropods and sphaerid clams, dominated the lake whitefish diet. Lake whitefish growth will not likely increase on this new lower energy content diet, even with further improvements in body condition.

While growth rate stabilized at a lower level after 1997, mean age at first maturity for female lake whitefish increased steadily from age-4 in the early to mid-1990s to age-7 by 2002. A strong year-class has not been produced since 1995, and reproductive success has been marginal since 1998. The most straightforward hypothesis for

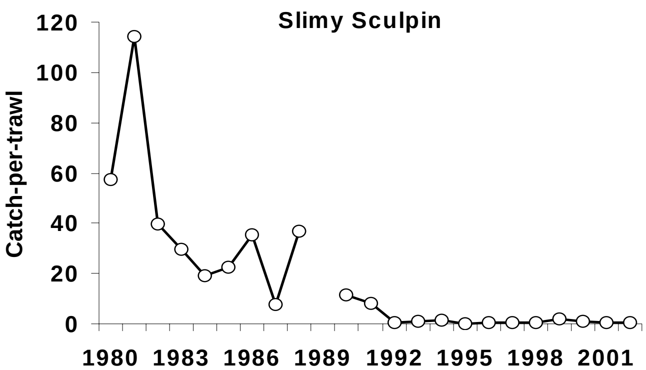

FIG. 12. Slimy sculpin abundance (catch-per-trawl at EB02 and EB06) in the Kingston Basin, Lake Ontario, 1980 to 2002 (no trawling in 1989).

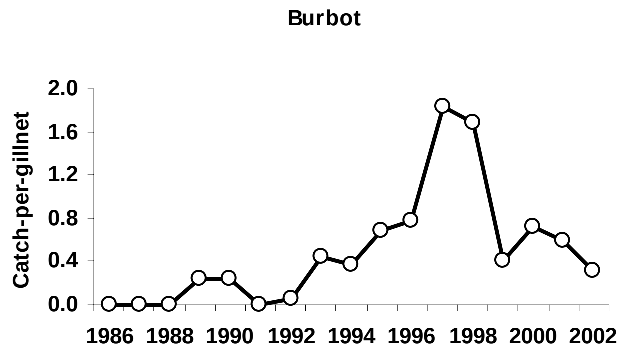

FIG. 13. Burbot abundance (catch-per-gillnet) in the Kingston Basin, Lake Ontario, 1986 to 2002.

reduced reproductive success is that poor body condition in adult fish, symptomatic of low lipid reserves, has caused reduced egg/fry viability. Egg quality, for example, may be positively related to adult nutritional status, and in turn give rise to offspring exhibiting better feeding success, faster growth, greater resistance to starvation, and lower mortality rate (Johnston 1997). Resistance to starvation may be particularly critical in a species, like lake whitefish, whose offspring hatch early in the spring prior to the pulse of zooplankton production. Larval lake whitefish growth and survival, and ultimately year-class strength, is positively related to zooplankton prey density in the early stages of life (Freeberg et al. 1990, Brown and Taylor 1992).

Another potential factor contributing to poor reproductive success in recent years is unfavourable weather conditions. Weather conditions have been correlated with lake whitefish production. Cooler Novembers and warmer Aprils were both associated with higher subsequent catches (Christie, 1963). Presumably, these conditions enhanced the survival and development of lake whitefish eggs and fry. Christie developed thermal indices that incorporated the effects of cold Novembers followed by warm Aprils and associated them with strong year-classes, with the opposite combination associated with weak ones (Christie, 1963; Christie and Regier, 1971). Early winter inshore water temperatures were significantly higher than the long-term average in three of five years between 1996 and 2000 (Casselman 2002).

Slimy Sculpin

Slimy sculpin abundance remained low in the Kinston Basin of Lake Ontario (Fig. 12). The decline in abundance was likely related to intense predation pressure by stocked lake trout. Low abundance levels are likely maintained by the same factors that are limiting lake whitefish—changes in the benthic food web due to impacts by dreissenid mussels.

Burbot

Burbot catches in the Kingston Basin of Lake Ontario, although modest, increased steadily through the late-1980s and 1990s time-period. Catches have been steady for the past three years (Fig. 13).

Deepwater sculpin

No deepwater sculpin have been captured in the past four years, although only a small amount of bottom trawling was conducted in areas suitable for this species.

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4

Lake Ontario Nearshore Fish

J.A. Hoyle, J.N. Bowlby, T. Schaner, and A. Mathers

Introduction

The Lake Ontario nearshore zone is defined as shallow coastal waters less than 15 m deep, plus all associated embayments following Stewart et al. 1999. Total area within this zone is limited due to the straight, regular shoreline that slopes rapidly into deeper water and is found throughout most of Lake Ontario. The largest area of nearshore habitat is found in eastern Lake Ontario, particularly in and around the Kingston Basin (also known as the Outlet Basin or Eastern Basin). This area also includes some of Lake Ontario's largest bays including the Bay of Quinte (Fig. 1).

Environmental conditions (e.g. wind and wave exposure, up-welling which causes rapid temperature variations), water quality (e.g. nutrient levels) and physical habitat (e.g. aquatic plants, bottom substrate and relief) vary greatly between exposed coastal waters and protected embayments, with corresponding impacts on fish production and fish species composition. Fish production is greatest and species composition most rich in embayment areas and, generally speaking, in the more protected eastern portion of the lake. Although most species of fish make some use of the nearshore zone during some portion of their life cycle, this chapter will concentrate on those species that live primarily within the nearshore zone during the warmest months of the year (i.e., warm-water and cool-water fish species). In keeping with the relative size and importance of these nearshore areas, fish monitoring programs have focused on eastern Lake Ontario and the Bay of Quinte. This chapter reports on the status of important nearshore fish stocks in these areas.

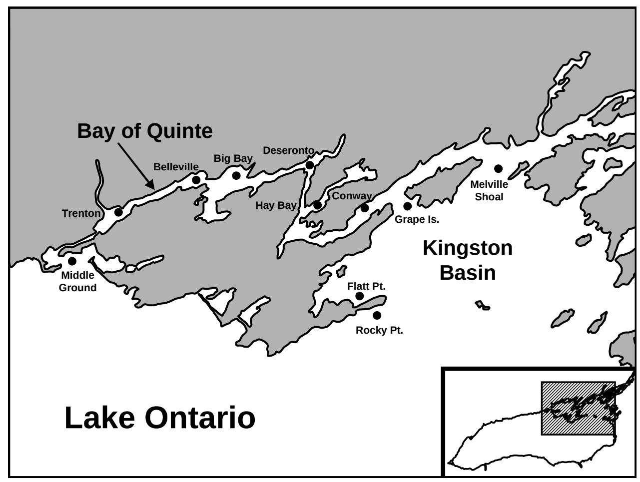

FIG. 1. Map of eastern Lake Ontario showing fish community index gillnetting and trawling locations in and around the Kingston Basin and the Bay of Quinte.

Nearshore Fish Assemblage

There are six common top predators in nearshore areas: longnose gar, bowfin, northern pike, smallmouth bass, largemouth bass, and walleye. Smallmouth bass and walleye are the most common, and also provide important fisheries. Muskellunge are rare in comparison to the other piscivores. Other common species include gizzard shad, common carp, various species of minnows and suckers, brown bullhead, channel catfish, American eel, trout-perch, white perch, several sunfishes (e.g., rock bass, pumpkinseed, bluegill, black crappie), yellow perch, and freshwater drum. The alewife, primarily an offshore pelagic species (see Chapter 1 in this report), utilizes the nearshore as a spawning and nursery area and can be seasonally very abundant in nearshore areas. The lake sturgeon—which inhabits a wide-range of water depths—is a formerly common species showing a modest resurgence in recent years.

Several nearshore fish species of particular interest have shown dramatic changes in abundance in the past decade. Walleye abundance, having recovered to very high levels through the early 1980s and early 1990s, has declined in recent years. The decline was due to reduced year-class strength and was associated with changes in habitat and fish community structure in the Bay of Quinte. Smallmouth bass, which maintained a moderate to high abundance throughout the 1980s, declined dramatically in eastern Lake Ontario after 1992. Yellow perch increased dramatically during the 1990s in the Bay of Quinte. This species appears to have capitalized on changes in habitat (i.e., increased water clarity, increased levels of aquatic vegetation) and a decline in competitor and predator levels following the invasion and proliferation of zebra mussels. By way of contrast, yellow perch abundance in eastern Lake Ontario has remained comparatively low.

More detailed, species-specific stock status reports are presented below for walleye, smallmouth bass, yellow perch, white perch, largemouth bass and other centrarchids, and sturgeon. The status of American eel is reported with the St. Lawrence River fish community (see Chapter 5 in this report) since all recruitment to Lake Ontario of this panmictic species comes through the St. Lawrence River. A recent exotic invader, the round goby, will also be briefly discussed since it is expected to both increase to high levels of abundance and play an important role in the nearshore food web.

Major Fisheries

A variety of fisheries depend on nearshore fish species production. There is recreational fishing for smallmouth bass, walleye and yellow perch in eastern Lake Ontario and a large recreational fishery (open-water and ice fisheries) for walleye in the Bay of Quinte (see Chapter 8 in this report). There is a small but locally important commercial fishery primarily in the Ontario nearshore waters east of Brighton, including the Bay of Quinte (see Chapter 6 in this report). Nearshore fish species prominent in the commercial harvest include yellow perch, eel, walleye, brown bullhead and sunfish. Finally, there are two aboriginal fisheries that focus on walleye in the Bay of Quinte, a spring spear-fishery, and a fall/winter/spring gillnet fishery.

Factors Influencing Distribution and Abundance

Various abiotic and biotic factors have major influence on the distribution and abundance of Lake Ontario's nearshore fish stocks.

Annual weather patterns influence water temperature and ultimately the reproductive success of many nearshore fish species, most dramatically for those at the northern edge of their range. Climate warming trends (i.e., global warming) have caused increasing water temperatures in nearshore waters (Casselman 2002). This has had a positive effect on increasing recruitment of warm-water species such as centrarchids. For example, midsummer water temperature is significantly positively correlated with recruitment of smallmouth bass (Casselman et al. 2002). Also, extremely cold winters can result in fish-kills in species such as alewife, white perch and gizzard shad. Global warming may also favor these species.

Large reductions in primary productivity in Lake Ontario due to changes in nutrient loading (cultural eutrophication/oligotrophication) and nutrient cycling (dreissenid mussel impacts) have impacted fish production. These changes also have indirect impacts through habitat modification or energy flow through the food web that eventually result in shifts in fish community interactions and structure.

Biotic factors often act through predation or competitive mechanisms to influence fish abundance. Alewife, the most abundant species in Lake Ontario, exerts a major influence on nearshore fish stocks via a variety of mechanisms. Alewife is a predator of, and competitor with, larval/juvenile fishes such as yellow perch. Alewife is also important in the diet of the piscivores, especially walleye and smallmouth bass.

Predation by an avian predator, the double-crested cormorant (*Phalacrocoax auritus*), is becoming a major driving factor in some areas of Lake Ontario for nearshore fish species including yellow perch (Burnett et al. 2002) and smallmouth bass (Casselman et al. 2002).

Dreissenid mussels, which invaded and colonized Lake Ontario in the early 1990s have had a major impact on the nearshore food web and fish community. The mussels have caused increased water clarity, increased aquatic plant production (especially in embayments), and generally channeled energy from pelagic to benthic pathways (Mills et al. 2003). Round goby, a recent invader to Lake Ontario, is expected to increase rapidly to high levels of abundance, and become a driving force in the fish community.

Sampling and Assessment Programs and Techniques

There are several intensive and on-going surveillance programs, many of which are long-term, that provide information on nearshore fish stocks and associated fisheries in Lake Ontario and the Bay of Quinte. Most of the information presented below come from the eastern Lake Ontario and Bay of Quinte fish community index netting program (gillnets and bottom trawls; Fig. 1). For a complete list of species-specific catches in this program see Appendix B in this report. Additional information on largemouth bass and round goby was obtained from surveys of the Bay of Quinte recreational angling fishery (see Chapter 8 in this report). Finally, a catch summary is presented for the nearshore community index netting program (NSCIN). This program (Appendix 4.1), first implemented in 2001 on the upper Bay of Quinte only, was designed to target fish species inhabiting the littoral area; an area of the Bay of Quinte that has expanded greatly since the mid-1990s after the arrival of dreissenid mussels.

Status of Major Fish Stocks

This section describes abundance trends, factors regulating abundance, and current and future status of the major nearshore zone fish stocks.

Walleye

Most of Lake Ontario walleye production comes from one large stock (Chapter 11 in this report) that spawns primarily in the major tributaries and shoreline of the Bay of Quinte. Marking/tagging studies indicate that juvenile walleye inhabit the Bay of Quinte year-round, while mature walleye migrate to the nearshore waters of eastern Lake Ontario after spawning in spring and back to the Bay in the fall (Payne 1963, Bowlby et al. 1991, LOMU unpublished data). Walleye population age structure in summer assessment netting reflects this life history behavior (Fig. 2). Much smaller populations of walleye are associated with other embayments and river mouths of Lake Ontario including the Niagara River and the Pickering Generating Station (Bowlby et al. 1991).

The walleye is the dominant piscivore in the Bay of Quinte and, together with smallmouth bass, throughout eastern Lake Ontario's nearshore waters. Walleye exert top-down control of fish community structure, especially on planktivores (Hurley 1986, Hurley et al. 1986, Ridgeway et al. 1990). Walleye diet is comprised primarily of alewife but other species such as yellow perch, white perch, rainbow smelt, and gizzard shad are important seasonally (Hurley and Christie 1977, Hurley 1986, Bowlby et al. 1991).

Bay of Quinte walleye abundance changed significantly during the last several decades (Fig. 3). Variation in walleye abundance appears to be governed by a combination of changes in the trophic status of the Bay (including water quality and habitat characteristics) and fish community interactions--especially with exotic species. Walleye abundance was moderate in the 1950s but the stock collapsed in the 1960s due to cultural eutrophication and the invasion of an

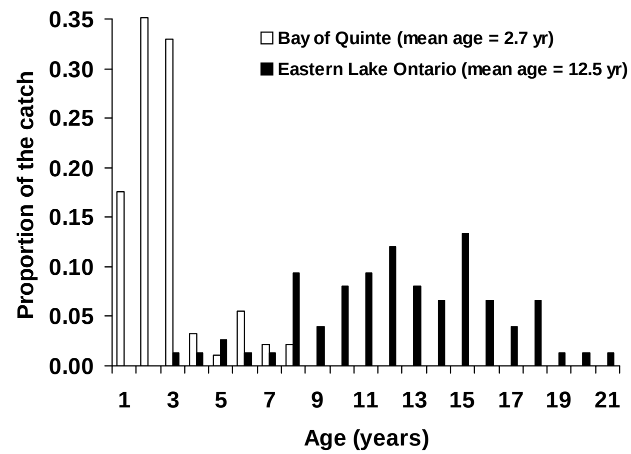

FIG. 2. Walleye age distributions in gillnets in the Bay of Quinte (Big Bay and Hay Bay) and eastern Lake Ontario (Melville Shoal), summer 2002.

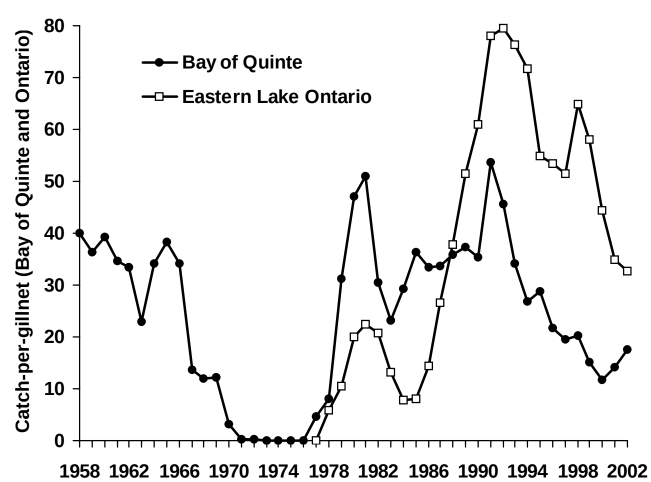

FIG. 3. Walleye abundance (3-year running average) in gillnets in the Bay of Quinte (Big Bay and Hay Bay), 1958-2002 and in eastern Lake Ontario (Melville Shoal), 1977-2002.

exotic larval fish predator, the white perch (Hurley and Christie 1977). Walleye recovered in the late-1970s and 1980s after water quality improvements (phosphorus input control; Minns at al. 1986) and a major climatic driven event (i.e. selective alewife and white perch winter-kill; Hurley 1986, Bowlby et al. 1991). Walleye abundance peaked in the early 1990s and declined thereafter, most notably after the invasion of dreissenid mussels in 1994. The recent decline in walleye abundance is again consistent with changes in trophic status. This decline is similar to observations on Lake Erie following dreissenid mussel invasion (Ryan et al. 1999).

The altered Bay of Quinte habitat in the late-1990s (e.g. increased water clarity and submergent aquatic plants) may have been less suited to walleye and more suited to other species including walleye competitors and predators. For example, yellow perch abundance increased dramatically at this time, and age-0 walleye were observed in the stomachs of yellow perch caught in routine gillnet and trawling sampling programs (unpublished data). The recent decline in walleye abundance can be accounted for by lower year-class strength beginning about 1996 (Fig. 4, Bowlby and Hoyle 2002, Schaner at al. 2002). The two most recent year-classes may exemplify the expected range of recruitment in the current Bay of Quinte ecosystem; very good in 2001 and very poor in 2002 (Fig. 4A).

Recruitment of age-2 walleye appears to have stabilized at a lower level (Bowlby and Hoyle 2002), consistent with current trophic and fish community characteristics of the Bay. The lower recruitment level is currently working its way through the walleye population age-structure. Predicted population sizes of age-2 walleye for 2003 and 2004, based on relationships between age-0 and/or age-1 abundance indices (Fig. 4), are 310,065 (multiple regression estimate) and 47,952, respectively (Table 1). The 2003 age-2 estimate increased compared with that estimated in 2001 (see Fig. 10 in Bowlby and Hoyle 2002) with inclusion of another year of data.

Total annual adult mortality, depicted in Fig.5 for three time stanzas, has not changed significantly, and has ranged from 31 to 36%.

The population estimates of walleye age-2 to age-6 and age-7 and older are given in Table 2. The population of age-3 and older walleye for 2002 (January 1) is about 400,000 fish (Table 2).

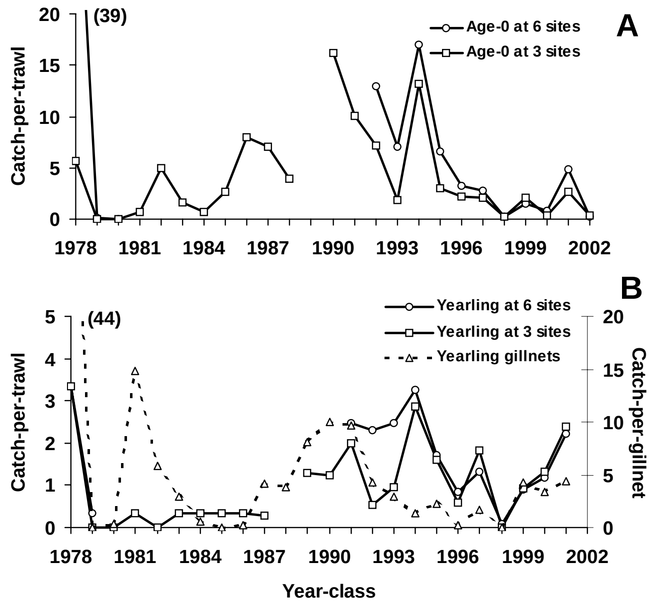

FIG. 4. Walleye year-class strength indices from bottom trawls and gillnets: A) age-0 walleye in bottom trawls at 6 sites (1978-1980 and 1992-2002) and 3 sites (1978-2002, excluding 1989); and B) yearling walleye in bottom trawls at 6 sites (1978-1979 and 1991-2001) and 3 sites (1978-2001), and in gillnets (1978-2001), in the Bay of Quinte.

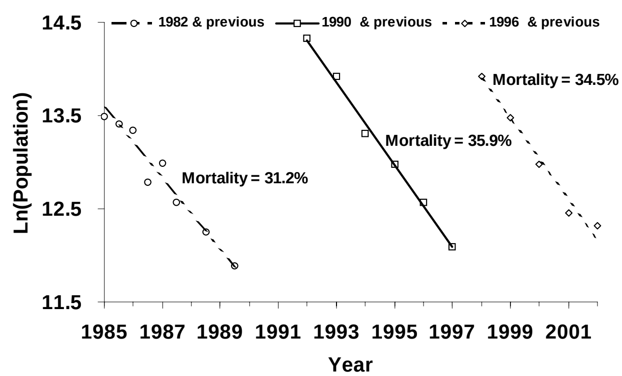

FIG. 5. Mortality curves for walleye in eastern Lake Ontario from 1985 to 2002. Data are combined for the selected year-classes as indicated. Accordingly, the ages of fish in each group increase each year. For instance, the 1996 & previous year-classes were age-2 and older in 1998, age-3 and older in 1999, and so on.

The anticipated short-term outlook, based on recently observed reproduction levels and exploitation rates, is for a relatively stable population size of about 400,000 fish (age-3 and older) compared to about 1 million a decade ago (Schaner et al. 2002).

The future impact on walleye of a rapidly expanding round goby population in the Bay of Quinte is not known.

*TABLE 1. Power function equations based on linear regression used to project the population (**P**) of age-2 walleye in eastern Lake Ontario for the years 2003 and 2004 (2001 and 2002 year-classes). **T** and **G** refer to catch rate indices in bottom trawls and gillnets, respectively. Subscripts refer to the age of walleye in the catch or the population. Equations are year-class specific.*

			Predicted Age-2 Population	
Dependent Variable	Equation	R^2	2003	2004
Age-0 in trawls	$\mathbf{P}_2 = 112{,}255.5 * \mathbf{T}_0^{(0.542243)}$	0.95	263,159	47,952
Age-1 in trawls	$\mathbf{P}_2 = 212{,}548.4 * \mathbf{T}_1^{(0.678040)}$	0.96	366,119	n/a
Age-1 in gillnets	$\mathbf{P}_2 = 228{,}440.9 * \mathbf{G}_1^{(0.337700)}$	0.82	376,473	n/a
Multiple regression	$\mathbf{P}_2 = 142{,}745.4 * \mathbf{T}_0^{(0.347068)} * \mathbf{T}_1^{(0.086800)} * \mathbf{G}_1^{(0.108692)}$	0.98	310,065	n/a

TABLE 2. Population of walleye on January 1, 2002 in eastern Lake Ontario. Populations were initially estimated with index netting-CAGEAN regressions (Bowlby and Hoyle 2002: Appendix 3.2). Then, these estimates were adjusted assuming constant natural mortality (Bowlby and Hoyle 2002: Appendix 3.3).

	Age							
	2	3	4	5	6	7 & older	Total	3 & older
Unadjusted	141,349	100,306	67,654	34,506	68,775	154,162	566,753	425,404
Adjusted	159,598	117,984	20,402	53,291	46,599	148,933	546,807	387,209

Smallmouth Bass

Smallmouth bass is one of the most important species in the Lake Ontario nearshore fish community. The species is common or abundant throughout eastern Lake Ontario, is one of the primary targets sought by nearshore recreational fishermen, and, along with walleye is abundant enough to exert significant top-down influence on the fish community.

Abundance has fluctuated over the years in different areas of Lake Ontario in response to a number of influencing factors, including variations in year-class strength and predation. An analysis by Casselman et al. (2002) showed that a correlation existed between July-August water temperatures and smallmouth bass year-class strength. The strongest year-classes were produced in years with the warmest temperature; often associated with El Niño events. The relative mortality of juvenile smallmouth bass in New York waters of the eastern basin increased with higher predation by double-crested cormorants (Lantry et al. 2002). These increases in mortality were large enough that even strong year-classes (e.g., 1995), can be dramatically reduced before the fish are recruited to either the adult spawning stock or to the recreational fishery (Lantry et al. 2002, Hoyle and Schaner 2002).

Smallmouth bass catches from eastern Lake Ontario were high from the 1970s through 1992 (Fig. 6). Variations in abundance during this period are attributable to variations in year-class strength, with the highest abundance due to the strong 1973, 1975, 1980 and 1983 year-classes. Abundance declined since 1991, with the lowest catches on record observed in 2001. This decline correlates with increased mortality of juvenile smallmouth bass, and has occurred despite moderate to strong year-classes produced in the warm summers of 1995 and 1998 (Fig. 7).

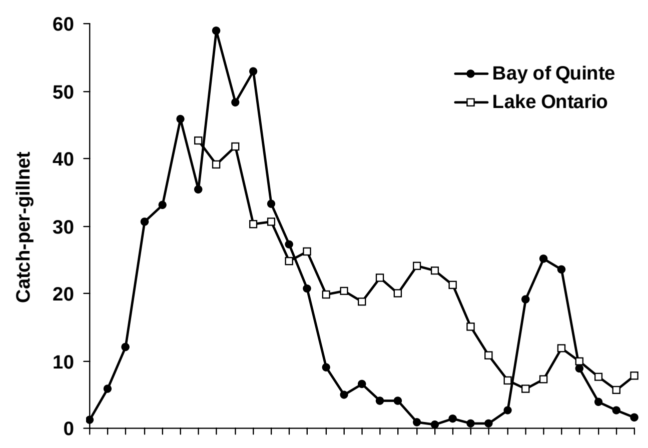

FIG. 6. Smallmouth bass abundance (3-year running averages) in gillnets in eastern Lake Ontario (Melville Shoal, Grape Island, and Rocky Point), 1978-2002 and in the Bay of Quinte (Big Bay and Hay Bay), 1981-2002, during summer.

Smallmouth bass abundance in the Bay of Quinte was high in the late-1970s and early-1980s (Fig. 6). Abundance declined dramatically through the mid-1980s, and very few smallmouth bass were caught during the late 1980s and early 1990s. Abundance increased during the mid- to late-1990s, due to a strong 1995 year-class but declined thereafter. By 2001, no fish from the 1995 year-class were caught (Hoyle and Schaner 2002). The low smallmouth bass abundance during the late-1980s and early-1990s was associated with very high abundance levels of another top predator—walleye. The strong 1995 smallmouth bass year-class was associated with a warm summer. The rapid disappearance of this year-class was not anticipated. As appears to be the case in eastern Lake Ontario with cormorant predation (see discussion above), another factor may now be of increased importance in regulating smallmouth bass abundance in the Bay of Quinte.

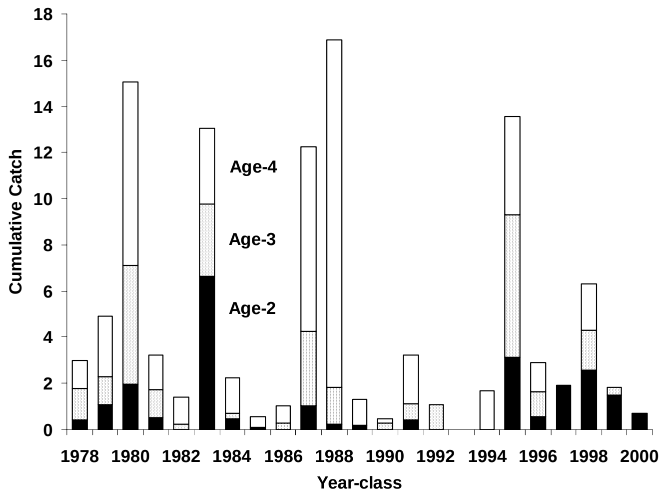

FIG. 7. Smallmouth year-class strength measured as the cumulative catch-per-gillnet of age-2 to age-4 fish for the 1978 to 1998 year-classes (age-2 and age-3 for 1999, and age-2 for 2000 are also shown; stacked bars).

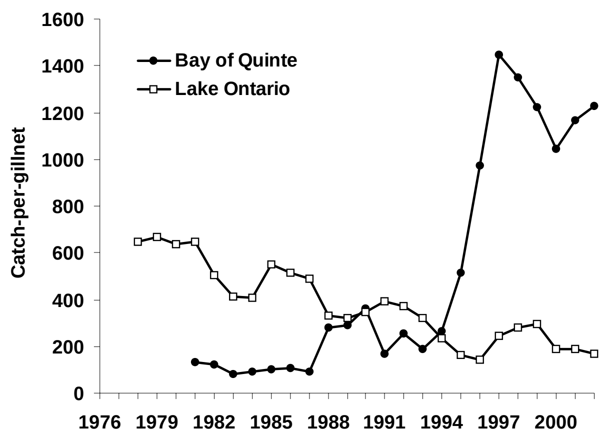

FIG. 8. Yellow perch abundance (3-year running averages) in gillnets in the Bay of Quinte (Big Bay), 1981-2002 and eastern Lake Ontario (Melville Shoal, Grape Island, and Flatt point), 1978-2002, during summer.

Yellow Perch

Yellow perch is one of the most numerous and widespread nearshore species caught in our assessment programs. It is most common in and around embayments and much less abundant in open coastal waters of Lake Ontario proper. Yellow perch feed on a wide variety of prey items from macrobenthic invertebrates to zooplankton and small fishes. In turn, the yellow perch is an important forage species for nearshore piscivores and double-crested cormorants. In those areas of Lake Ontario where they are abundant, yellow perch provide for important recreational and commercial fisheries.

Yellow perch abundance in eastern Lake Ontario was very high in the late-1970s and early-1980s, declined to moderate levels during the mid-1980s and remained relatively stable thereafter (Fig. 8). High abundance levels in the 1970s may have been related to elevated productivity levels, associated with cultural eutrophication of the lake at that time, as well as depressed piscivore levels (Hurley and Christie 1977). Interactions with Lake Ontario's most abundant species, alewife, are also considered important in structuring yellow perch populations (Brandt et al. 1987, O'Gorman and Burnett 2001). Alewife predation on larval yellow perch appears to be a particularly important factor (Brandt et al. 1987). Following a massive alewife die-off in winter 1976-77, yellow perch abundance and harvest rose dramatically. Yellow perch abundance and harvest subsequently declined as alewife rebounded. Most recently, predation by cormorants appears to be exerting a dominant force in structuring yellow perch populations in eastern Lake Ontario, negating increases in age-0 abundance observed in the 1990s (Burnett et al. 2002). The short-term outlook for yellow perch abundance in eastern Lake Ontario is that it will not likely increase.

Trends in yellow perch abundance in the Bay of Quinte contrast those of the main lake. Yellow perch abundance was low in the 1980s and increased dramatically during the mid-1990s coincident with the arrival of dreissenid mussels. Abundance of age-0 perch increased dramatically beginning in 1995 (Fig. 9). Presumably this was facilitated by the tremendous increase in aquatic macrophytes, which offered protection from predators and a competitive advantage over open-water species such as alewife, gizzard shad and white perch.

White Perch

White perch is an exotic invader to Lake Ontario (Scott and Christie 1963). First specimens were found around 1950 and the species was very abundant by the early 1960s in Lake Ontario and in the Bay of Quinte. White perch proliferated throughout the nearshore areas of eastern Lake Ontario in the 1960 and 1970s.

White perch in the Bay of Quinte suffered a severe and selective die-off during the winter of 1977-78 (Minns and Hurley 1986) and never recovered to former levels of abundance (Fig. 10). Coincident with the white perch die-off, and in addition to improvements in water quality, the remnant walleye stock of the Bay of Quinte produced an exceptional year-class that led to recovery of the walleye stock. These observations lead to the hypothesis that white perch negatively impact walleye populations through predation on walleye fry. Walleye, once released from this pressure, rebounded, became the dominant nearshore piscivore in the system, and helped to control white perch numbers thereafter.

In eastern Lake Ontario, white perch catches in assessment nets were high from 1978-1982, declined gradually to 1987, increased moderately from 1988-1990, and dropped to near zero by 1996 (Fig. 10).

A relatively large, commercial gillnet fishery for white perch occurred in the 1960s and 1970s when white perch abundance was extremely high. Much of the harvest was taken during the winter months in the deep waters of the lower Bay of Quinte. In these deep waters during winter months, the white perch diet consisted primarily of the deepwater amphipod, *Diporeia sp* (Johnson and McNeil 1986). The decline in white perch abundance to near zero in the Bay of Quinte after the disappearance of *Diporeia* (1993-95 time-period, Dermott 2001) leads to the speculation that white perch, as was the case for lake whitefish (Hoyle et al. In Press) and other benthic fish species (Owens et al. In Press), was negatively impacted by this disruption in the benthic food-web. The near-term outlook for white perch is that abundance will remain relatively low.

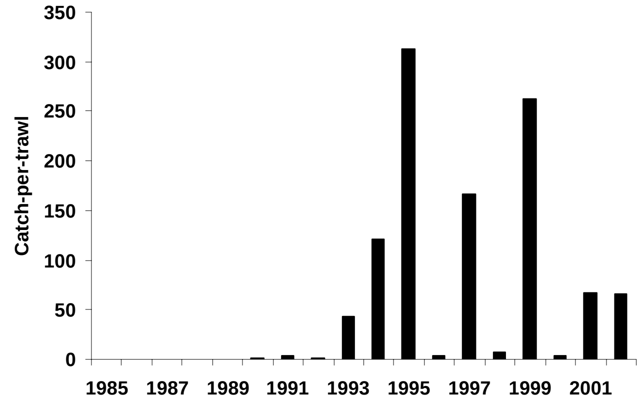

FIG. 9. Age-0 yellow perch abundance (catch-per-trawl) in the Bay of Quinte (mean of six sites: Trenton, Belleville, Big Bay, Deseronto, Hay Bay, and Conway), 1985-2002.

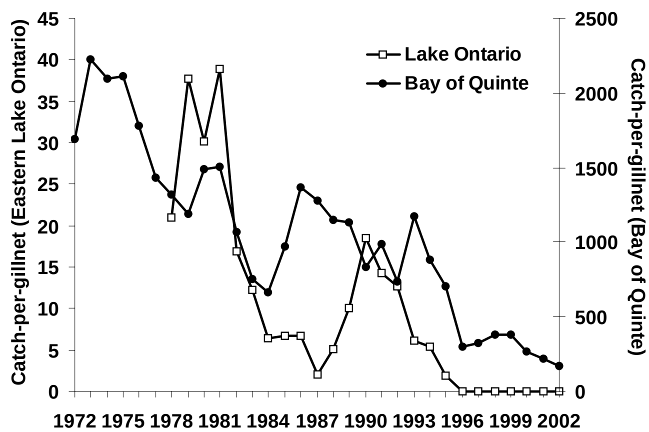

Fig. 10. White perch abundance (3-year running averages) in gillnets in eastern Lake Ontario (Melville Shoal), 1978-2002 and in the Bay of Quinte (Big Bay), 1972-2002, during summer.

Largemouth Bass and Other Centrarchids

Largemouth bass, while moderately abundant in many Lake Ontario embayments, have recently significantly increased in abundance in the Bay of Quinte (Fig. 11). Presumably this is related to an increase in suitable habitat as a result of ecosystem changes in the Bay following zebra mussel invasion including clearer water and more aquatic vegetation, as well as favorable climatic conditions (i.e., warm summers; see smallmouth bass). Like the largemouth bass, other centrarchids that associate with aquatic plants have also flourished including pumpkinseed, bluegill, and black crappie (Fig. 11). Presumably the abundance of these species will continue to rise until the carrying capacity of the changed Bay of Quinte ecosystem is reached.

Catches in the recently implemented nearshore community index netting program (Table 3) reflect the increased prevalence of centrarchids in the littoral area of the Bay of Quinte.

Sturgeon

Historically, the lake sturgeon was abundant in Lake Ontario, supporting a commercial fishery that yielded a peak harvest of over 225,000 kg in 1890. However, by the start of the twentieth century this species had declined to commercially insignificant levels. Christie (1973) cited lake sturgeon as the exemplar victim of over-fishing. Water quality had scarcely changed at the time of its decline and no great changes in the biota that could have influenced the sturgeon were known (Christie 1973). The role of habitat degradation in the decline is unclear but the damming and degradation of tributary spawning areas may have been significant. Commercial harvest of lake sturgeon in Lake Ontario was banned in New York State in 1976, and in Ontario in 1978. In 1983, the species was listed as “threatened” in New York State (Carlson 1995).

Prior to 1996, only two lake sturgeon were observed in the long-term assessment gillnet surveys in eastern Lake Ontario and the Bay of Quinte. Since 1997, 12 sub-adult lake sturgeon were caught although none was caught in 2002. These fish ranged from 473 mm to 741 mm in total length. This increase in lake sturgeon catch may be attributable to either increased natural reproduction within Lake Ontario and its’ tributaries, or movements of juvenile sturgeon stocked into waters adjacent to the eastern basin. In the mid-1990s adult lake sturgeon were observed during the spawning period in the Trent River (Ontario) suggesting that increased natural reproduction may explain the increased catches. Commercial fish reports also indicate an increase in lake sturgeon with up to fifty juveniles captured annually in eastern Lake Ontario since 1996.

In the short-term it seems likely that lake sturgeon numbers will remain at low levels in Lake Ontario but the recent increased catches of sub-adult sturgeon are encouraging.

Round Goby

Round goby were first observed in western Lake Ontario in 1998, and in the Bay of Quinte (eastern Lake Ontario) in 1999. The former sighting, near the mouth of Welland canal is probably the result of infestation from Lake Erie, while the quick jump in the following year to eastern Lake Ontario suggests transport in ballast water. It appears that the gobies are now spreading from these two centers of distribution.

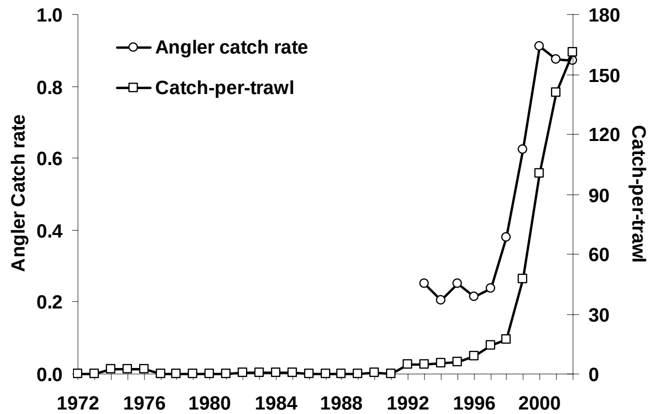

FIG. 11. Largemouth bass catch rate (number of fish-per-targeted angler hour; 3-year running average) in the Bay of Quinte open-water recreational angling survey, and combined abundance of pumpkinseed, bluegill, and black crappie (3-year running averages in bottom trawls) in the Bay of Quinte (1972-2002), during summer.

The current extent of the round goby in Lake Ontario is poorly known. In western Lake Ontario, sightings have been reported from the Niagara River through St. Catherines, Hamilton, including Hamilton Harbor, and Toronto. In eastern Lake Ontario gobies can now be found in most of the Bay of Quinte, and east as far as Kingston and the mouth of the St. Lawrence River. A single report from the Presqu'ile area suggests that the eastern population is now also spreading westward along the north shore of the lake. Along the south shore of Lake Ontario, fishermen have reported catching gobies in the Rochester area.

Round gobies will undoubtedly have a profound effect on the nearshore ecosystem of Lake Ontario, if only through the sheer densities they can achieve. Gobies feed extensively on dreissenid mussels (French and Jude 2001, Taraborelli and Schaner 2002), are readily preyed upon by predators such as smallmouth bass, and may prove to be an important new link in the nearshore benthic food web. Gobies have been described as voracious foragers with a diverse diet (Taraborelli and Schaner 2002), and will undoubtedly compete on many levels with other fish species.

Summary

A summary of species-specific fish community objectives (taken from Stewart et al. 1999), recent population status, and future outlook for major

*TABLE 3. Species-specific catch in the 2002 NSCIN trapnet program on the Bay of Quinte. Statistics shown include total catch, arithmetic mean catch-per-trapnet (number and weight) and percent relative standard error of the mean log10(catch by number + 1). %RSE = 100*SE/Mean.*

	Upper Bay				Lower Bay			
Species	Total	Number Mean	RSE (%)	Weight Mean (kg)	Total	Number Mean	RSE (%)	Weight Mean (kg)
Bluegill	5,135	142.64	7	11.53	453	12.58	11	1.02
Brown bullhead	3,450	95.83	7	26.83	2,501	69.47	7	19.45
Pumpkinseed	2,631	73.08	7	5.61	4,087	113.53	8	8.72
Black crappie	540	15.00	11	2.85	209	5.81	14	1.11
Largemouth bass	220	6.11	12	1.58	181	5.03	12	1.47
Yellow perch	123	3.42	17	0.28	117	3.25	25	0.27
Freshwater drum	119	3.31	20	2.71	186	5.17	17	4.24
White perch	104	2.89	31	0.23	39	1.08	29	0.09
Walleye	89	2.47	13	3.40	164	4.56	15	6.82
Channel catfish	78	2.17	18	5.62	41	1.14	18	2.89
Smallmouth bass	60	1.67	29	0.94	28	0.78	31	0.47
White sucker	53	1.47	13	1.55	107	2.97	10	3.28
Gizzard shad	52	1.44	18	0.86	27	0.75	29	0.37
Rock bass	24	0.67	24	0.05	51	1.42	21	0.16
Northern pike	21	0.58	26	0.93	42	1.17	17	1.83
Moxostoma sp.	15	0.42	34	0.52	-	-		-
Longnose gar	12	0.33	47	0.31	13	0.36	38	0.34
Bowfin	5	0.14	42	0.30	24	0.67	19	1.99
American eel	5	0.14	42	0.25	6	0.17	49	0.34
White bass	5	0.14	42	0.03	1	0.03	100	0.01
Common carp	4	0.11	48	0.18	12	0.33	34	1.20
Goldfish	-	-		-	1	0.03	100	0.01
Golden shiner	-	-		-	3	0.08	100	0.00
Rudd	-	-		-	1	0.03	100	0.02
Number of Species	21				23			

TABLE 4. Summary of species-specific fish community objectives (FCO; taken from Stewart et al. 1999), recent population status, and future outlook for major nearshore fish species.

Species	FCO Objective	Recent Population Status	Future Outlook (5-year)
Walleye	-maintain existing populations and expand range	-abundance has declined; dependent on production from the Bay of Quinte	-stabilize at lower abundance level (about 400,000 age-3 and older fish)
Smallmouth bass	-population levels attractive to anglers	-population has declined in some areas (cormorants) but increased in others	Global warming favors recruitment but cormorants cause high sub-adult mortality
Yellow perch	-maintain existing populations and expand range	-abundance generally relatively low; high abundance in Bay of Quinte but small size	-remain at low/moderate abundance level
White perch	-none	-low abundance	-continued low abundance
Largemouth bass	-population levels attractive to anglers	-abundance has reached level in Bay of Quinte attractive to anglers	-further increases or stable population levels
Other sunfish	-population levels attractive to anglers	-increased abundance in Bay of Quinte; commercial fishery benefits	-further increases or stable population levels
Sturgeon	-population recovery	-modest recovery (young fish observed)	-continued modest recovery?
Gobies	-none	-recent invader	-increasing abundance and ecological impacts

nearshore fish species is presented in Table 4. Major factors currently driving abundance of nearshore fish stocks include: climate warming trends, on-going dreissenid mussel impacts, alewife and cormorant abundance. Climate warming acts directly to increase recruitment and over-winter survival, and indirectly by influencing nearshore habitat. Dreissenid mussel impacts include biological oligotrophication (e.g., clear water and lower productivity) and nearshore habitat changes (e.g., more aquatic plants). Alewife, partly by virtue of dominant abundance levels, is pivotal because it is prey, predator and competitor in the nearshore food web. Cormorant abundance has increased to a level such that their role in controlling nearshore fish abundance in eastern Lake Ontario is likely becoming significant (e.g. Burnett et al. 2002, Casselman et al. 2002.

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Appendix 4.1. Survey information for the 2002 NSCIN trapnet program on the Bay of Quinte.

	Upper Bay	Lower Bay
Survey dates	Sep 4 to Sep 24	Sep 5 to Sep 26
Water temperature (^{o}C)	Mean = 21.8 (range = 19.6-24.7)	Mean = 21.0 (range = 17.9-25.4)
No. of trapnet lifts	36	36
No. sites by depth (m):		
Target (2-2.5 m)	10	16
> Target (max)	18 (4.0 m)	20 (4.2 m)
< Target (min)	8 (1.8 m)	0 (2.0 m)
No. sites by substrate:		
Hard	23 (64%)	14 (39%)
Soft	13 (36%)	22 (61%)
No. sites by cover:		
None	0	1 (3%)
1-25%	14 (39%)	18 (50%)
25-75%	17 (47%)	15 (42%)
>75%	5 (14%)	2 (6%)

5

St. Lawrence River Fish

A. Mathers and B.J. Morrison

Introduction

The upper St. Lawrence River fish community is dominated by a rich assemblage of warm-water species; over 85 fish species have been reported. Smallmouth bass and northern pike are the most abundant top predators, while other important members of the fish community include yellow perch, rock bass, brown bullhead, and pumpkinseed. Other less abundant, but important, fish species inhabiting the St. Lawrence River include walleye, lake sturgeon and muskellunge. In the Lake St. Francis area, yellow perch are the focus of an important recreational fishery (Bendig 1994). In addition, yellow perch and eel support a commercial fishery in some areas (Chapter 7 in this report).

The waters of the St. Lawrence River, and the Great Lakes in general, have undergone dramatic changes over the past two decades. Nutrient levels have declined, zebra mussels have invaded, and water clarity has increased. Fish populations of the St. Lawrence River have also undergone changes in response to both environmental changes and fishing pressures. Fish population levels declined throughout the early 1990s, but in many cases have reached a new equilibrium, one that is consistently lower than that experienced in the 1980s. In Lake St. Francis, yellow perch populations have declined substantially from the levels observed during the early 1990s, despite implementation of a reduced angling season and bag-limit in 1997.

American eel spawn in the Sargasso Sea (Scott and Crossman 1973). Some of the larval eel are carried by ocean currents to the Gulf of St. Lawrence where they migrate up the St. Lawrence River and into Lake Ontario. The eels reside in Lake Ontario for several years before migrating back to sea. While in Lake Ontario and the upper St. Lawrence River, eels provide a highly valued commercial fishery (Stewart et al. 1997). Eel populations show evidence of drastic decline in many areas of eastern Canada and particularly in Lake Ontario and the upper St. Lawrence River (Ritter et al. 1997, ICES 2001). Declines have been attributed to habitat loss, hydroelectric dam passage and mortality, contaminants, over-fishing and environmental changes in the northern Atlantic Ocean.

This chapter summarizes index-gillnetting catches in Lake St. Francis for all species during 2002 and updates trends in abundance for yellow perch, smallmouth bass, northern pike and American eels.

Information Sources

Fisheries assessment activities on the St. Lawrence River have included standardized fall gillnetting, creel surveys, and monitoring the eels migrating over the ladder at the R.H. Saunders Hydroelectric Dam in Cornwall. The fall gillnetting program is designed to detect long-term changes in the fish communities and has been established in four distinct sections of the river; Thousand Islands, Middle Corridor, Lake St. Lawrence, and Lake St. Francis. These programs have been coordinated with the New York State Department of Environmental Conservation (NYDEC) assessment programs to provide ‘river-wide’ coverage of fisheries resources.

The 2002 netting in Lake St. Francis was conducted between September 9 and 19, 2002, using methods described by Morrison and Mathers (2002). This program maintained the database established in 1984 and represented the ninth netting program in Lake St. Francis section of the St. Lawrence River. The 2002 netting program differed from previous years in that a new gillnet standard was introduced. Due to insufficient stock from the supplier, monofilament nets were used during the 2002 field program in addition to the multifilament nets used in previous years. A complete description of net construction details is provided in Edwards et al. (2002). In order to compare the catches of the new and old net designs, half of the gillnet sets were made with multifilament nets and the other half of the sets were made with monofilament nets.

An eel ladder was installed at the R.H. Saunders Hydroelectric Dam in Cornwall in 1974 to assist with the upstream migration of eel. Annual counts and a new index of recruitment, based on mean daily counts, was reported for the years 1974 to 1995 (Casselman et al. 1997). This report provides estimates for the total number of eels ascending the ladder and updates the recruitment index for 2002.

Species Population Trends

Preliminary examination of the data indicated that for most species the monofilament gillnet catches were higher than those for the multifilament gillnets (Fig. 1). The limited amount of data precludes assigning species specific conversions at this time. Based on the analysis by Edwards et al. (2002), a correction factor of 1.58 was used to convert the historical multifilament catch rates to the new monofilament standard.

The overall catch during 36 gillnet sets in the 2002 Lake St. Francis project included 412 fish of 16 species (a complete summary of standardized gillnet catch-per-unit-effort is listed in Appendix 5.1). The average number of fish captured per standard net (13.8 fish) during 2002 was the lowest observed in the program. There has been a gradual decline in the number of fish caught per net from the start of the program in 1984 (Fig. 2).

Yellow Perch

Although yellow perch continued to be the most abundant fish captured in the Lake St. Francis gillnet program, the catches during 2002 showed a continuation of the trend of declining catch that started in 1990. In addition, the catch rate of large yellow perch (greater than 220 mm total length), which have been the focus of the angling fishery in Lake St. Francis, declined in 2002 to 0.16 fish per net. This level is less than 2 percent of the catch rates for large perch observed prior to the 1990s (Fig. 3).

Yellow perch catches in the Lake St. Lawrence area declined between 1985 and 1989 then catches were stable until 1998. Catches in recent years have been below the long-term average (Klindt and Town 2003). Catches of yellow perch in the

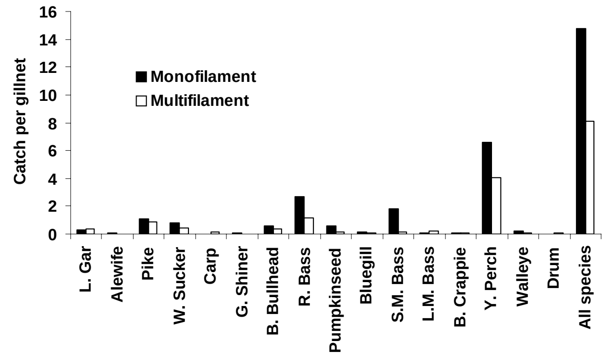

FIG. 1. Catch (number of fish) per standard multifilament and monofilament gillnets in the Lake St. Francis area, 2002.

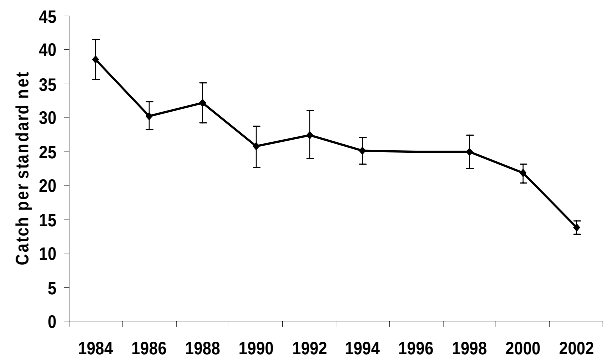

FIG. 2. Mean catch of all species of fish (number of fish +/- SE) in standard gillnets set in the Lake St. Francis area 1984 to 2002).

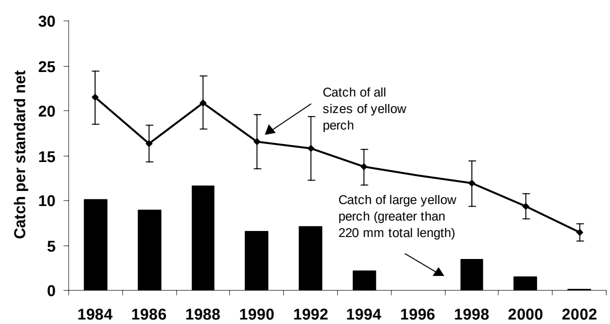

FIG. 3. Catches of large yellow perch (number of fish greater than 220 mm in length shown in bars) and all sizes of yellow perch (line +/- SE) in standard gillnets set in the Lake St. Francis area 1984 to 2002.

Thousand Islands area (McCullough et al. 2003, Edwards et al. 2002) and eastern Lake Ontario (Chapter 4 of this report) have remained relatively stable since the 1990s.

Smallmouth Bass

Smallmouth bass catches in gillnets set in Lake St. Francis during 2002 increased from those observed in 2000 but no clear trend in abundance is apparent in recent years (Fig. 4). Catches in

Lake St. Lawrence are slightly higher than those observed in Lake St. Francis but follow a very similar trend (Klindt and Town 2003). Smallmouth bass catches have declined during the 1990s in the Thousand Islands (McCullough et al. 2003) and in the Eastern Basin of Lake Ontario (Chapter 4 in this report).

Northern Pike

Pike catches in Lake St. Francis during 2002 declined to 31 percent of the catches observed in previous surveys after a period of remarkably stable prior to 2002 (Fig. 5). Catches of small northern pike (less than 500 mm total length) have also declined.

Pike catches in Lake St. Lawrence have been relatively stable but are generally lower than those observed in Lake St. Francis (Klindt and Town 2003). In the Thousand Islands area, northern pike catches has been low since 1996 (McCullough et al. 2003).

Walleye

Walleye catches in Lake St. Francis have remained relatively low and stable in recent years (Fig. 6). Walleye catches in Lake St. Lawrence are generally increasing and are higher that those observed in Lake St. Francis (Klindt and Town 2002).

Other Species

Pumpkinseed, brown bullhead and rock bass are also monitored by this program and are commercially harvested in Lake St. Francis. In recent years, catches of pumpkinseed have declined while catches of bluegill have increased. During 2002, catches of brown bullhead and rock bass were similar to the long-term average (Appendix 5.1).

American Eel

The eel ladder was opened on June 12 and closed on November 1 (143 days). Counts were made manually every week by installing the counting net at the top of the ladder and returning to count the number of eel captured the following day. The recruitment index (Casselman et al. 1997) was calculated to be 55.2 eels/day, based on the 31-day peak migration period occurring from July 7 to August 6. This value was similar to those observed since 1998 but is 3-orders of magnitude lower than the recruitment indices observed during the early 1980s (Fig. 7). The estimated total number of eels migrating upstream (2,663 eels) was similar to the number observed in recent years.

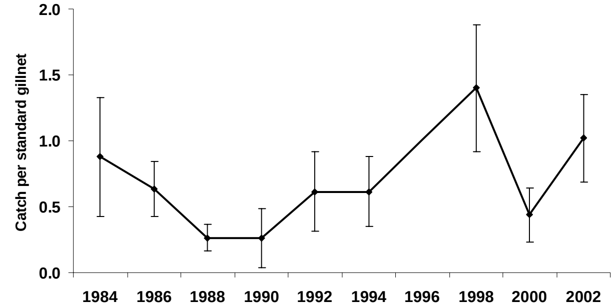

FIG. 4. *Mean smallmouth bass catch (number of fish +/- SE) in standard gillnets set in the Lake St. Francis, 1984 to 2002.*

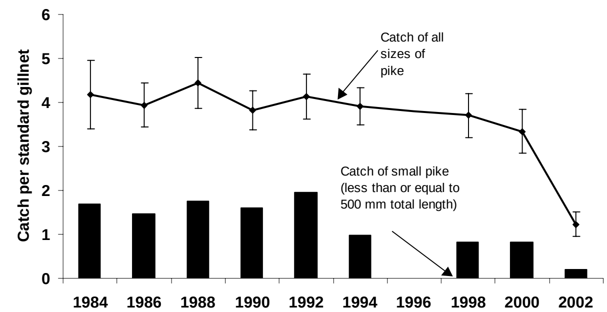

FIG. 5. *Catch of small northern pike (number of fish less than 500 mm in length shown in bars) and catch of all pike (number of fish, all sizes, +/- SE shown by line) in standard gillnets set in the Lake St. Francis, 1984 to*

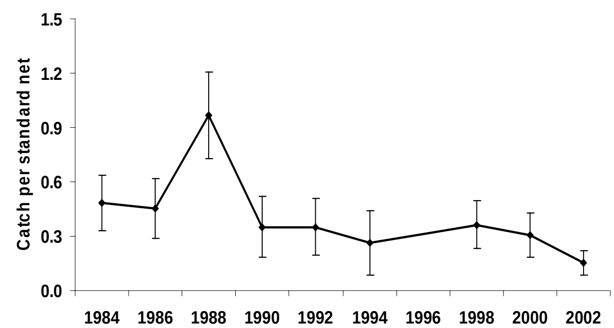

FIG. 6. *Mean walleye catch in standard gillnets (number of fish +/- SE) set in the Lake St. Francis area, St. Lawrence River, 1984 to 2002.*

Management Implications

The outlook for the yellow perch angling and commercial fisheries in Lake St. Francis is not promising for the near future. The continued decline of yellow perch catches in the index gillnets suggests that the management actions implemented to reduced fishing mortality in 1997 have not been successful in increasing the abundance of large yellow perch. Additional management actions to reduce yellow perch mortality rates should be considered. Johnson et al. (2003) found that double crested cormorants that nest in Lake St. Lawrence consume large numbers of yellow perch. Casual observations of the movements of cormorants in this area suggest that some of the cormorants from the Lake St. Lawrence colony feed in Lake St. Francis.

The low number of new eel recruits moving upstream at the eel ladder at the R.H. Saunders dam accounts for the low harvest levels above the dam (Chapter 7 in this report), and the continued low harvest in Lake Ontario (Chapter 6 in this report). Harvest below the dam (Chapter 7 in this report), prior to the eels ascending the ladder, now represents the majority of the harvest from the upper St. Lawrence River and Lake Ontario. During 2002, an eel ladder was operated at the Beauharnois Dam, downstream of the R.H. Saunders Dam. Additional ladders have been proposed for both the Beauharnois and R.H. Saunders Power Dams. If implemented, this could eventually lead to somewhat higher eel abundance in the upper St. Lawrence River and Lake Ontario.

A review of available data by the International Council for Exploration of the Sea (ICES 2001) confirmed either declining or neutral abundance of American eel in Canada and USA. In particular, eels in the St. Lawrence River/Lake Ontario system showed large declines in both recruitment of young eels and escapement of large fecund female silver eels. ICES advised that eel management agencies in the St. Lawrence River/ Lake Ontario system should cooperate in meeting the management objectives for the stock. Further, ICES found evidence that reductions in human-induced mortality (which includes both fisheries and hydro dam turbine mortalities) of yellow and silver eels may be required for this area. However, the data to develop escapement biomass limits are not currently available but need to be developed and implemented as soon as possible.

Assessment and Research Needs

Estimates of angler harvest in Lake St. Francis and the rest of the upper St. Lawrence River are needed. Additional analysis to determine the mortality rates of yellow perch in Lake St. Francis during recent years should be conducted. Estimation of the exploitation rate of yellow eel in the upper St. Lawrence River and Lake Ontario would greatly enhance our ability to effectively manage eels. Additional information on the impact of double crested cormorant on the fish community of Lake St. Francis would be valuable for fisheries management efforts in this area.

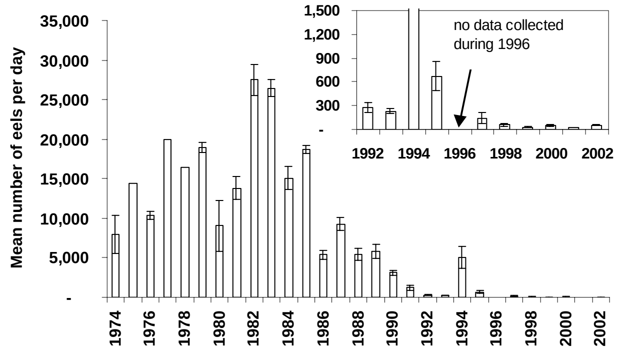

FIG. 7. *Mean number of eels ascending the eel ladder per day at the R.H. Saunders Hydroelectric Dam, Cornwall, Ontario, during a 31-day peak migration period for 1974 to 2002. Vertical bars indicate the 95% confidence intervals. No counts were available for 1996. (Data from 1974-1995 re-drawn from data provided in Casselman et al. 1997).*

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APPENDIX 5.1. *Catch-per-standard-gillnet lift (CUE) and the standard error of catch (SE) for Lake St. Francis area, St. Lawrence River 1984 to 2002. All catches prior to 2002 have been adjusted by a factor of 1.58 to be comparable to the new netting standard used in 2002.*

	1984		1986		1988		1990		1992		1994		1998		2000		2002	
No. of gillnet sets	36		35		36		36		36		36		35		36		36	
	CUE	SE	CUE	SE	CUE	SE	CUE	SE	CUE	SE	CUE	SE	CUE	SE	CUE	SE	CUE	SE
Lake Sturgeon	0.00	-	0.00	-	0.00	-	0.00	-	0.00	-	0.00	-	0.00	-	0.04	0.04	0.00	-
Longnose Gar	0.00	-	0.23	0.15	0.09	0.06	0.00	-	0.66	0.45	0.26	0.12	0.14	0.08	0.13	0.10	0.40	0.17
Bowfin	0.04	0.04	0.00	-	0.00	-	0.00	-	0.00	-	0.00	-	0.00	-	0.00	-	0.00	-
Alewife	0.04	0.04	0.00	-	0.00	-	0.00	-	0.00	-	0.00	-	0.00	-	0.00	-	0.03	0.03
Salvelinus sp.	0.00	-	0.00	-	0.04	0.04	0.00	-	0.00	-	0.00	-	0.00	-	0.00	-	0.00	-
Northern Pike	4.18	0.78	3.93	0.50	4.44	0.58	3.82	0.44	4.13	0.51	3.91	0.42	3.71	0.50	3.34	0.51	1.23	0.28
Muskellunge	0.00	-	0.00	-	0.04	0.04	0.00	-	0.00	-	0.00	-	0.00	-	0.00	-	0.00	-
White Sucker	1.71	0.34	2.17	0.38	1.01	0.28	1.71	0.30	1.41	0.28	1.67	0.30	1.99	0.49	1.63	0.29	0.74	0.20
Moxostoma sp.	0.00	-	0.00	-	0.04	0.04	0.18	0.18	0.04	0.04	0.09	0.07	0.18	0.09	0.09	0.06	0.00	-
Common Carp	0.13	0.10	0.00	-	0.00	-	0.09	0.06	0.00	-	0.00	-	0.00	-	0.00	-	0.09	0.06
Golden Shiner	0.00	-	0.00	-	0.00	-	0.00	-	0.00	-	0.04	0.04	0.00	-	0.00	-	0.03	0.03
Creek Chub	0.00	-	0.00	-	0.00	-	0.00	-	0.00	-	0.00	-	0.09	0.06	0.00	-	0.00	-
Fallfish	0.00	-	0.00	-	0.00	-	0.09	0.09	0.00	-	0.00	-	0.00	-	0.00	-	0.00	-
Brown Bullhead	1.14	0.47	1.27	0.48	0.62	0.37	0.40	0.21	0.70	0.53	0.44	0.19	0.95	0.33	3.25	1.95	0.54	0.18
Rock Bass	3.52	0.48	3.48	0.81	2.81	0.55	1.36	0.27	2.15	0.40	2.11	0.66	2.58	0.57	1.85	0.34	2.26	0.34
Pumpkinseed	4.97	1.57	1.72	0.54	0.84	0.20	0.75	0.30	1.49	0.40	1.76	0.39	1.54	0.46	1.06	0.27	0.41	0.15
Bluegill	0.00	-	0.00	-	0.00	-	0.00	-	0.00	-	0.00	-	0.05	0.05	0.04	0.04	0.10	0.06
Smallmouth Bass	0.88	0.45	0.63	0.21	0.26	0.10	0.26	0.22	0.62	0.30	0.62	0.26	1.40	0.48	0.44	0.21	1.02	0.33
Largemouth Bass	0.04	0.04	0.00	-	0.09	0.06	0.09	0.06	0.00	-	0.04	0.04	0.09	0.06	0.13	0.07	0.20	0.11
Black Crappie	0.04	0.04	0.09	0.09	0.04	0.04	0.04	0.04	0.09	0.06	0.13	0.07	0.00	-	0.09	0.06	0.07	0.05
Yellow Perch	21.45	2.93	16.32	2.02	20.88	2.94	16.57	3.04	15.83	3.56	13.72	1.97	11.89	2.54	9.36	1.43	6.49	0.95
Walleye	0.48	0.15	0.45	0.17	0.97	0.24	0.35	0.17	0.35	0.16	0.26	0.18	0.36	0.13	0.31	0.12	0.16	0.07
Freshwater Drum	0.00	-	0.00	-	0.00	-	0.00	-	0.00	-	0.00	-	0.00	-	0.00	-	0.04	0.04
All species	38.64	4.65	30.30	3.28	32.18	3.55	25.72	3.39	27.48	3.97	25.06	2.68	24.96	2.98	21.76	2.54	13.81	1.20

6

Lake Ontario Commercial Fishery

J. A. Hoyle, P. A. Edwards, and B. J. Morrison

Introduction

Lake Ontario supports a relatively small but locally important commercial fish industry. The commercial harvest comes primarily from the Canadian waters of Lake Ontario east of Brighton, including the Bay of Quinte (Fig. 1). Total commercial harvest from the Canadian waters of lake Ontario averaged about 1 million lbs during the past decade. By way of comparison, commercial harvest from New York waters averaged less than 1/10th of that from Canadian waters over a similar time period (LaPan 2002).

The modern day fishery takes place in nearshore waters. The catch is comprised of a variety of nearshore, warm- and cool-water fish species as well as lake whitefish and lake herring that are primarily taken at or near spawning time in nearshore areas. The most important species in the commercial harvest include yellow perch, lake whitefish, walleye, eel, brown bullhead, and sunfish.

This chapter updates the 2002 commercial harvest statistics for the Canadian waters of Lake Ontario.

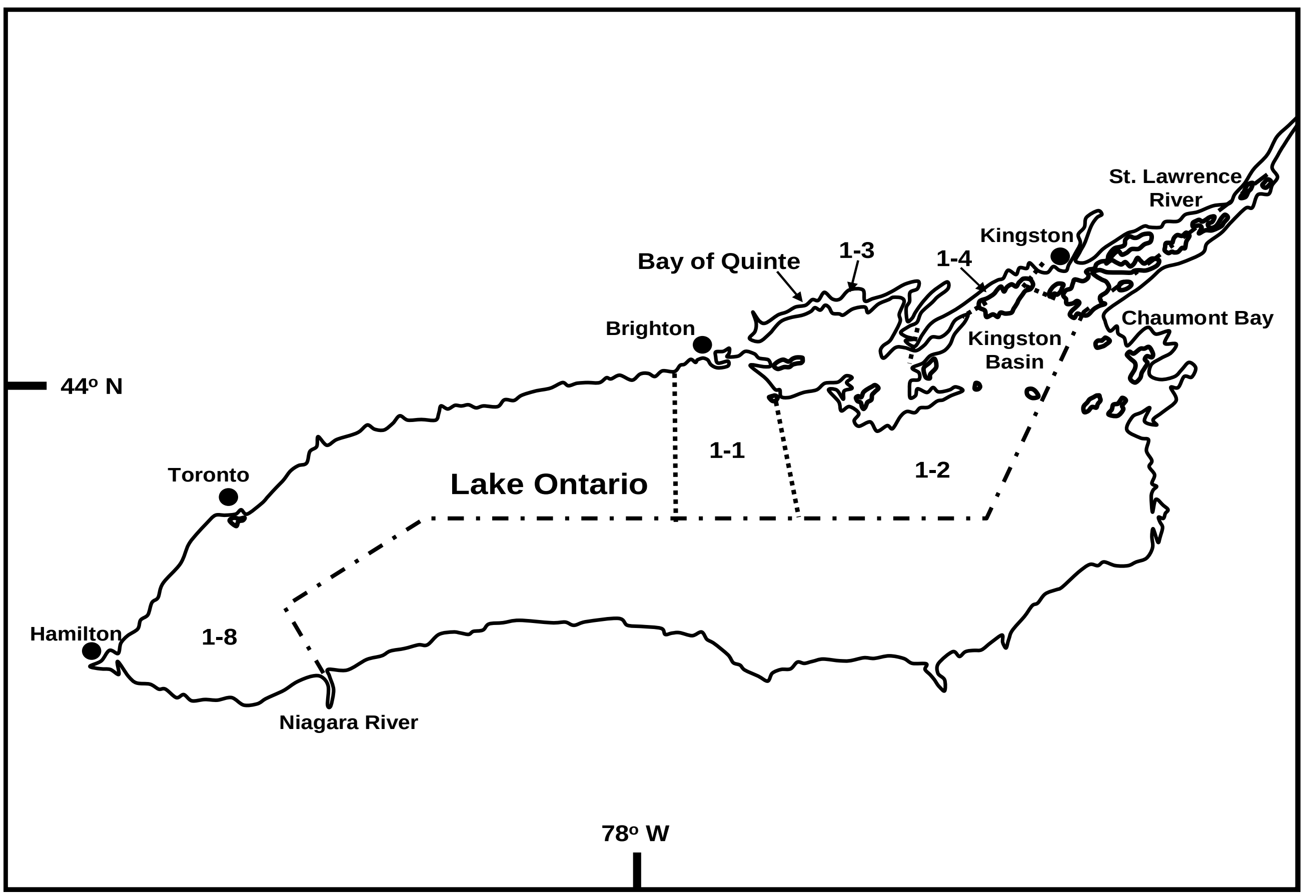

Fig. 1. Map of Lake Ontario showing commercial fishing quota zones in Canadian waters.

Commercial Fish Management

Decisions on commercial allocation are made on a quota zone basis (Fig. 1). Fish species for which direct harvest controls are necessary to meet fisheries management objectives are placed under quota management (Table 1). Managed species include ‘premium’ commercial species, species with large allocations to other users, and species at low levels of abundance or requiring rehabilitation. Changes to commercial fish licensing conditions in 2002 included adjustments to quota; compare Table 1 in this report to Table 1 in Hoyle et al. (2002). Commercial fish licenses contain conditions designed to conserve fish stocks, reduce problems of incidental catch, manage the harvest and sale of fish that exceed human consumption guidelines for contaminants, and minimize conflicts with other resource users.

Lake Ontario Liaison Committee

The Lake Ontario Liaison Committee (LOCL) was re-established in 2002. The membership of the committee is comprised of representatives from the Lake Ontario Management Unit (LOMU), Ontario Commercial Fisheries’ Association (OCFA) and industry-elected representatives from the Lake Ontario commercial fishing industry. The purpose of the LOCL is to provide a forum for increased communications and transparency among the LOMU, OCFA, and the commercial fishing industry. The primary objectives of the LOLC are: to provide LOMU with a vehicle through which information related to the management of the fishery can be presented (e.g. stock status, research and assessment updates, proposed management and regulation changes); and to allow local commercial fishing industry representatives the opportunity to provide feedback and information to LOMU.

One of the first tasks of the Liaison Committee was to participate with the LOMU in an extensive review of license conditions; changes in license conditions, quotas and harvests from 1991-2002 were documented as part of this review. Throughout the period of quota management on Lake Ontario there have been continued changes to the quotas, seasons, gear, and size restrictions; all of which appear as conditions of the licenses. The goal of the license condition review was to systematically update and, in some cases, standardize these conditions across quota zones for the benefit of both LOMU and the Industry. A sub-group was struck to review the changes proposed by the Ministry and to provide recommendations to the Liaison Committee and, in turn, to all licensees at a general meeting in 2003. The goal was to have recommended changes incorporated into the 2003 licenses as in-year amendments.

Information Sources

Commercial harvest statistics were compiled from daily catch report (DCR) records as stored in the Commercial Fisheries Harvest Information System (CFHIS). This system was developed by the Ministry of Natural Resources in 1998/99, in collaboration with the Ontario Commercial Fisheries Association (OCFA), to manage records related to the commercial food fishing industry in Ontario. In addition, a commercial catch sampling program was conducted to obtain biological information on lake whitefish harvest.

Commercial Harvest Summary

Commercial harvest statistics for 2002 are

TABLE 1. Commercial harvest quotas (lb) for the Canadian waters of Lake Ontario, 2002. See Fig. 1 for a map of the quota zones.

	Quota Zone					
Species	1-1	1-2	1-3	1-4	1-8	Total
American eel	10,406	55,805	17,412	7,196	2,287	93,106
Black crappie	4,540	2,500	14,810	800	2,800	25,450
Lake herring	15,690	15,300	7,250	7,337		45,577
Lake whitefish	22,643	235,607	49,381	63,463	1,280	372,374
Round whitefish	10,000					10,000
Walleye	4,790	42,322		10,922	800	58,834
Yellow perch	35,585	182,506	96,128	126,168	13,000	453,387

shown in Table 2. In 2002, there were 112 commercial fishing licenses on Lake Ontario. The total harvest of all species was 602,379 lb ($475,261.61) in 2002, and has declined over 50% since 1996 (Fig. 2).

Lake whitefish

Lake whitefish harvest was 187,964 lb, 50% of the quota (Table 3), in 2002. The annual lake whitefish harvest has declined over 70% since 1996 (Fig. 2).

Eel

Eel harvest was 10,818 lb, 12% of the quota, in 2002. Eel harvest has declined dramatically in the last decade.

Yellow perch

Yellow perch harvest was 114,551 lb, 25% of the quota, in 2002. Yellow perch harvest had increased significantly from 1996 to 1999 but declined by over 50% between 1999 and 2002.

Walleye

Walleye harvest was 7,184 lb 12% of the quota, in 2002. In 2002, the walleye harvest was the lowest it has been since commercial fishing for this species was reestablished in 1989.

Other species

Commercial harvest of all other species of note, including brown bullhead, sunfish, black crappie, white perch, and freshwater drum, declined in 2002.

Biological Characteristics of the Harvest

Lake whitefish

Lake whitefish were monitored for biological characteristics. Sampling activities focused on the fall spawning run fisheries: October/November trapnet fishery in the Bay of Quinte (Quota Zone 1-3), and the November gillnet fishery on the

TABLE 2. Commercial fish harvest (lb) and value ($) for fish species in the Canadian waters of Lake Ontario, 2002.

	Harvest by quota zone (lb)								
Species	1-1	1-2	1-3	1-4	1-8	Total	Price-per-lb		Value
American eel	393	4,207	2,783	1,162	2,279	10,825	$ 2.42	$	26,173.09
Black crappie	76	225	4,799	4	45	5,150	$ 1.97	$	10,144.57
Bowfin	1,154	271	3,453			4,878	$ 0.24	$	1,167.20
Brown bullhead	3,879	1,660	102,246	9,301	2,799	119,885	$ 0.40	$	47,694.08
Burbot		-	3	-		3		$	-
Channel catfish		7		-	3,588	3,595	$ 0.39	$	1,384.07
Common carp		3,935	2,476	9,722	6,935	23,067	$ 0.15	$	3,481.04
Freshwater drum	172	2,907	15,863	1,145	11,765	31,852	$ 0.10	$	3,287.06
Lake Herring	6	66	818	359		1,248	$ 0.27	$	334.49
Lake whitefish	454	145,898	33,731	7,881		187,964	$ 0.62	$	115,926.64
Lepomis sp.	1,304	1,974	72,611	116	73	76,078	$ 0.97	$	73,765.83
Longnose gar			39			39		$	-
Rock bass	521	2,259	2,646	112	1,159	6,697	$ 0.43	$	2,905.43
Suckers	10	95	3,440	-	3,310	6,854	$ 0.11	$	741.19
Walleye	40	1,967	-	4,790	388	7,184	$ 1.81	$	13,017.08
White bass		1	6	18	180	206	$ 0.55	$	112.26
White perch	7	83	1,862	165	534	2,651	$ 0.50	$	1,330.44
Yellow perch	1,177	48,562	30,529	32,771	1,512	114,551	$ 1.52	$	173,969.36
Total	9,194	214,116	277,305	67,545	34,566	602,726		$	475,433.84

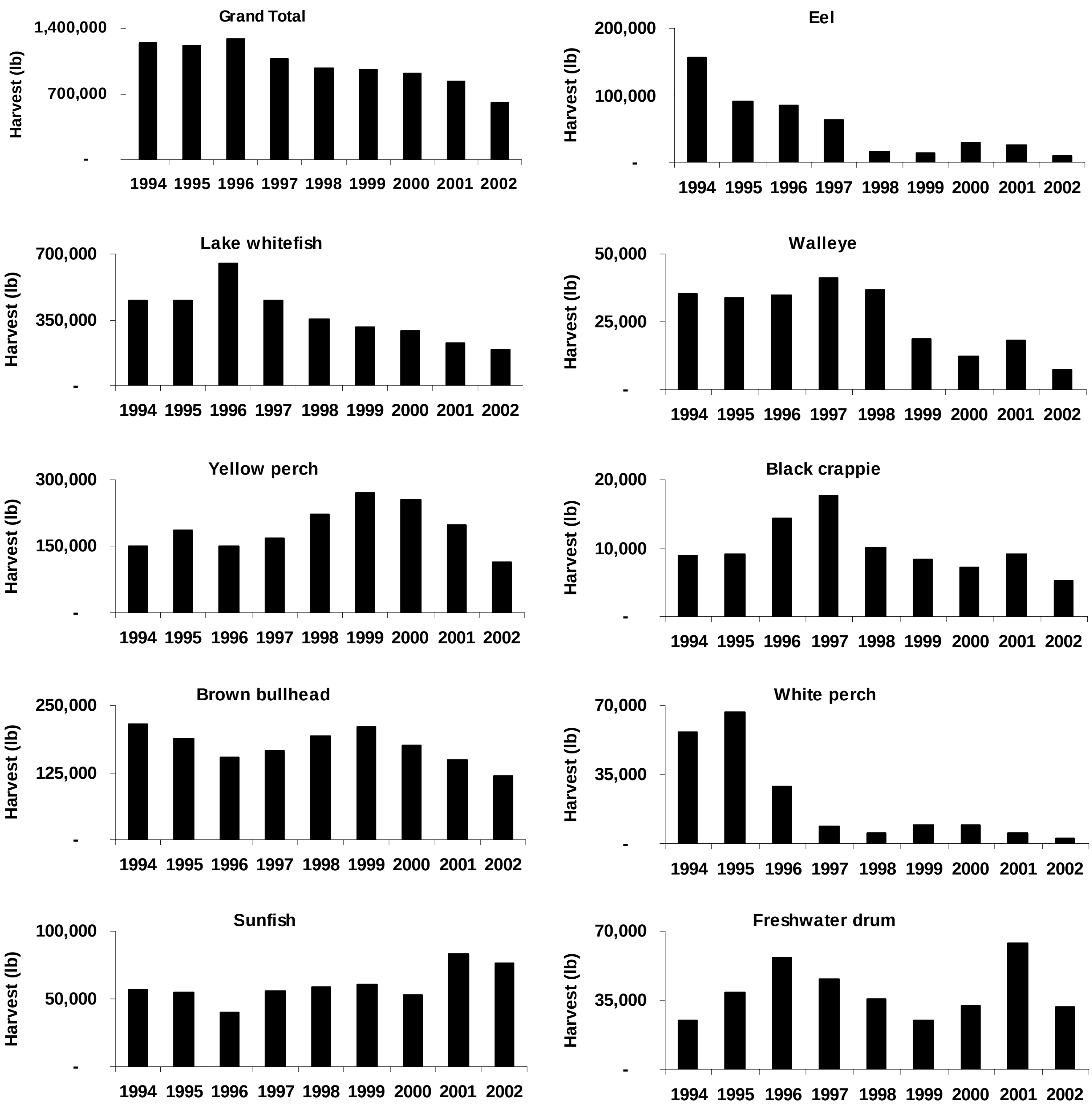

FIG. 2. Harvest trends for several common species and the total for all species in the Lake Ontario commercial fishery, 1994-2002.

south shore of Prince Edward County (Quota Zone 1-2). As such, the sampling covered the largest components of the total annual lake whitefish harvest.

Mean length and age in Quota Zone 1-2, representing the Lake Ontario whitefish stock, were 480 mm (Fig. 3) and 9.7 yrs-old (Fig. 4), respectively. The 1992 and 1995 lake whitefish year-classes contributed 50% of the harvest. In the Bay of Quinte (Quota Zone 1-3), the mean length and age were 484 mm (Fig. 3) and 10.1 yrs-old (Fig. 4), respectively. For nine years in succession, the 1991 year-class has dominated the harvest, accounting for 31% in 2002.

Mean age of commercial harvested lake whitefish has increased steadily since 1995 in quota zones 1-2 and 1-3 (Fig. 5). Also, age at first recruitment to the commercial fishery has increased from age-3 or age-4 in the early 1990s to age-6 or age-7 in 2002 (Appendix 6.1 and 6.2).

TABLE 3. Commercial harvest (% of quota) for the Canadian waters of Lake Ontario, 2002.

	Quota Zone					
Species	1-1	1-2	1-3	1-4	1-8	Total
American eel	4%	8%	16%	16%	100%	12%
Black crappie	2%	9%	32%	0%	2%	20%
Lake herring	0%	0%	11%	5%		3%
Lake whitefish	2%	62%	68%	12%	0%	50%
Round whitefish	0%					0%
Walleye	1%	5%		44%	48%	12%
Yellow perch	3%	27%	32%	26%	12%	25%

Discussion

Lake Ontario commercial harvest declined steadily since 1996, from about 1.2 million lb to 600,000 lb. Much of the decline was due to a decline in the harvest of lake whitefish and eel but other species, including yellow perch, brown bullhead, walleye, and white perch, also declined during that time-period.

Although commercial fishing gear remained largely unchanged, the age distribution of lake whitefish in the harvest changed significantly in recent years. The age at which lake whitefish first recruit to the commercial fishery has increased substantially from age-3 or age-4 in the early 1990s to age-6 or age-7 in 2002. This change can be accounted for by reduced growth rates, delayed age at first maturity (Chapter 3 in this report), and the resulting impact on gear selectivity and vulnerability of fish in these largely spawning-time fisheries. Mean age of the harvest has increased from age-6 in the early 1990s to age-10 in 2002 (Fig. 5 and Appendix 6.1 and 6.2). Mean age also increased in summer assessment index gillnet catches during this time period (Fig. 5). The increase in mean age in summer assessment gillnets is primarily due to lack of new recruitment to the gear, and is consistent with poor year-class strength after 1995 (Chapter 3 in this report).

The 1994 and 1995 year-classes of lake whitefish, which were strong as young-of-the-year in index trawling surveys (Chapter 3 in this report), are just now recruiting to the fisheries. These two year-classes along with previous strong year-classes (e.g., 1992, 1991 and 1987) will have to sustain lake whitefish commercial harvest for several years because after 1995, year-classes

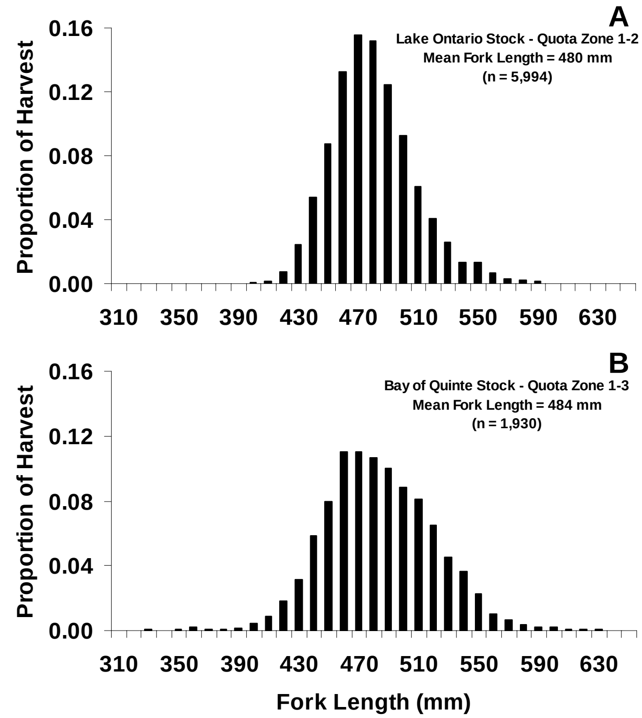

FIG. 3. Fork length (mm) distribution of lake whitefish in Quota Zone 1-2 (A) and 1-3 (B) in the 2002 commercial harvest.

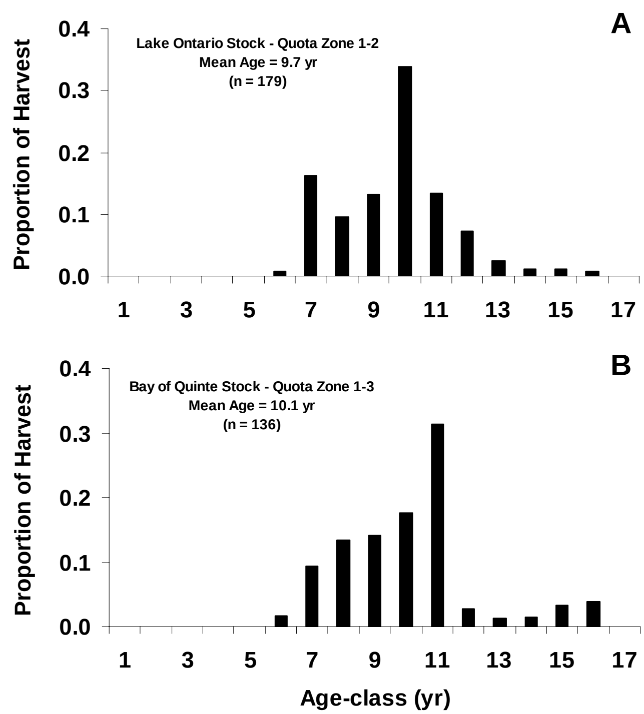

FIG. 4. Age distribution of lake whitefish in Quota Zone 1-2 (A) and 1-3 (B) in the 2002 commercial harvest.

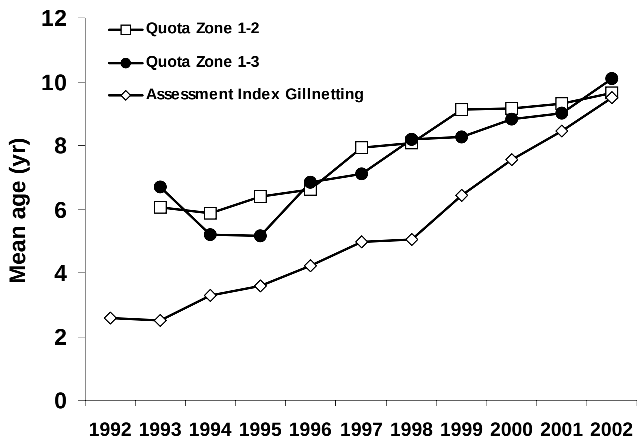

FIG. 5. Mean age of lake whitefish caught in the fall commercial harvest (quota zones 1-2 and 1-3) and in summer index gillnetting, 1992-2002.

have been weak or failed (see Chapter 3 in this report). This will negatively impact the future commercial harvest.

The low numbers of new eel recruits moving up the St. Lawrence River and passing over the Cornwall dam eel ladder (Chapter 5 in this report) accounts for continued low commercial harvest levels in Lake Ontario. The future outlook for eel commercial fishing in Lake Ontario is bleak, and dependent on the future status of American eels throughout their range.

Yellow perch abundance in eastern Lake Ontario began to increase in the late-1990s from low abundance levels of the mid-1990s. However, yellow perch abundance (Chapter 4 in this report) and commercial harvest (Fig. 2) have fallen for the past three years. The short-term outlook for yellow perch abundance in eastern Lake Ontario is that it will not likely increase. Yellow perch abundance in the Bay of Quinte is currently very high but the size structure is skewed in favor of small fish.

The commercial fishery for walleye is composed of a production quota taken from live capture gear (trap and hoop nets), and an incidental harvest allowance taken in gillnets targeting lake whitefish and based on a percentage of lake whitefish quota. In 2002, the commercial harvest of walleye in quota zones 1-1 and 1-2 took a sharp decline from that seen in previous years. The reasons for this decline are not clear and may have to do with a poor whitefish season. However, when expressed as a percentage of the observed harvest of lake whitefish, the decline in walleye harvest was more than expected in quota zone 1-2. There is also a size restriction for walleye, 38.1 to 58.4 cm (15 to 23 inches), that also might account for the very low harvests in quota zone 1-2. Walleye outside this size range can not be sold. Walleye in quota zone 1-2 are primarily older than age-7 and many would be too large to sell. The walleye harvest in quota zones 1-4 and 1-8 were similar to that in 2001 at about 50% of the quota. The walleye fishery in zones 1-1 and 1-2 will decline in 2003 in response to a significantly reduced whitefish quota. The fishery in quota zone 1-4 may see an increase in harvest with two relatively strong year classes entering the allowable size range.

Other species under quota management include lake herring, round whitefish, and black crappie. Lake herring and round whitefish populations are low in eastern Lake Ontario and cannot support a viable commercial fishery. Black crappie harvest occurs primarily in quota zone 1-3, the Bay of Quinte. Recent ecosystem changes in the Bay of Quinte may favor black crappie and the sunfishes generally.

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Appendix 6.1. Lake whitefish age distribution in the Quota Zone 1-2 commercial harvest, 1993-2002.

	Age Distribution (proportion by number)									
Age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.071	0.015	0.000	0.000	0.006	0.000	0.000	0.000	0.000
4	0.050	0.206	0.093	0.158	0.001	0.030	0.000	0.000	0.000	0.000
5	0.282	0.193	0.220	0.136	0.075	0.066	0.000	0.001	0.002	0.000
6	0.342	0.246	0.197	0.296	0.179	0.247	0.067	0.020	0.054	0.008
7	0.249	0.220	0.212	0.093	0.270	0.205	0.238	0.156	0.093	0.163
8	0.068	0.014	0.222	0.102	0.096	0.090	0.238	0.267	0.166	0.096
9	0.000	0.006	0.028	0.159	0.140	0.060	0.067	0.253	0.292	0.132
10	0.000	0.003	0.002	0.034	0.133	0.108	0.076	0.105	0.219	0.338
11	0.000	0.004	0.000	0.009	0.094	0.060	0.067	0.063	0.070	0.134
12	0.008	0.004	0.000	0.000	0.003	0.060	0.210	0.033	0.034	0.074
13	0.000	0.007	0.001	0.003	0.000	0.030	0.029	0.070	0.018	0.024
14	0.000	0.002	0.006	0.000	0.000	0.018	0.000	0.013	0.031	0.012
15	0.000	0.003	0.000	0.003	0.002	0.006	0.000	0.018	0.020	0.011
16	0.000	0.000	0.004	0.003	0.001	0.006	0.000	0.000	0.000	0.007
17	0.000	0.000	0.000	0.001	0.003	0.000	0.000	0.000	0.000	0.000
18	0.000	0.021	0.000	0.001	0.004	0.006	0.010	0.000	0.000	0.000
19	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.000
20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000
Mean Age	6.0	5.9	6.4	5.6	7.9	8.1	9.1	9.2	9.3	9.7

Appendix 6.2. Lake whitefish age distribution in the Quota Zone 1-3 commercial harvest, 1993-2002.

	Age Distribution (proportion by number)									
Age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.014	0.293	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.093	0.232	0.617	0.079	0.000	0.000	0.039	0.012	0.000	0.000
5	0.106	0.069	0.161	0.385	0.104	0.088	0.070	0.010	0.000	0.000
6	0.306	0.122	0.016	0.145	0.527	0.140	0.109	0.055	0.101	0.017
7	0.237	0.115	0.040	0.047	0.075	0.390	0.101	0.179	0.150	0.094
8	0.119	0.093	0.053	0.047	0.087	0.081	0.450	0.172	0.068	0.133
9	0.057	0.031	0.066	0.119	0.058	0.015	0.062	0.409	0.178	0.141
10	0.014	0.009	0.028	0.097	0.057	0.037	0.008	0.051	0.448	0.176
11	0.027	0.031	0.013	0.044	0.058	0.074	0.031	0.000	0.000	0.314
12	0.013	0.004	0.000	0.004	0.015	0.096	0.023	0.011	0.005	0.027
13	0.014	0.001	0.002	0.017	0.010	0.066	0.054	0.021	0.033	0.013
14	0.000	0.000	0.000	0.006	0.000	0.015	0.031	0.068	0.004	0.014
15	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.001	0.008	0.032
16	0.000	0.000	0.002	0.000	0.009	0.000	0.000	0.001	0.000	0.039
17	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.008	0.000	0.000
18	0.000	0.000	0.000	0.003	0.000	0.000	0.016	0.001	0.004	0.000
19	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.003	0.000	0.000
20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mean Age	6.7	5.2	5.2	6.9	7.1	8.2	8.3	8.8	9.0	10.1

7

St. Lawrence River Commercial Fishery

A. Mathers and J.A. Hoyle

Introduction

The St. Lawrence River supports a commercial fishery that until recently has had an annual harvest of over 350,000 lb and a landed value of over $400,000. The most important species in the harvest are yellow perch, sunfish, brown bullhead, eel and black crappie. This chapter updates 2002 commercial harvest statistics for the Ontario waters of the St. Lawrence River.

Quota Management

Decisions on commercial allocation are made on a quota zone basis (Fig. 1). Fish species that require direct harvest control, in order to meet fisheries management objectives, are placed under quota management (Table 1). These species include premium commercial species such as eel, black crappie and yellow perch.

Changes to commercial fish licensing conditions in 2002 included minor adjustments to quota; compare Table 1 in this report to Table 1 in Hoyle (2002). Commercial fish licenses contain conditions designed to conserve fish stocks, reduce problems of incidental catch, manage the harvest and sale of fish that exceed human consumption guidelines for contaminants, and minimize conflicts with other resource users.

Information Sources

Commercial harvest statistics were compiled from daily catch report (DCR) records as stored in the Commercial Fisheries Harvest Information

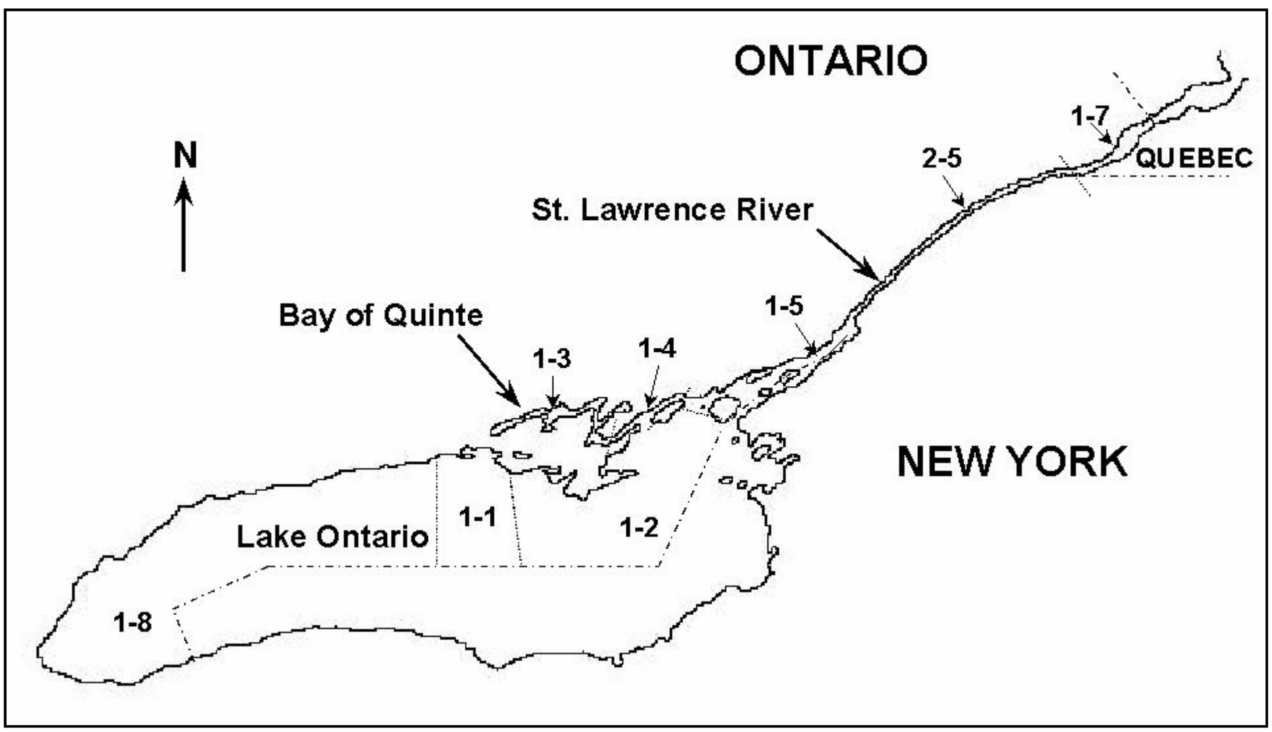

FIG. 1. Commercial fish quota zones on the Ontario waters of Lake Ontario and the St. Lawrence River.

System (CFHIS). This system was developed by the Ministry of Natural Resources in 1998/99 to manage records related to the commercial food fishing industry in Ontario.

Commercial Harvest Summary

Commercial harvest statistics for 2002 are shown in Tables 2 and 3. During 2002, there were 32 commercial fishing licenses in the Ontario waters of the St. Lawrence River. The total harvest of all species was 269,154 lb with a landed value of $267,673 during 2002. Total harvest and landed value declined during 2001 and 2002 after a period of relative stability during 1996 to 2000. During 1996 to 2000, the average annual total harvest was 377,465 lb with an average annual landed value of $413,538.

TABLE 1. *Commercial harvest quotas (lb) for the Ontario waters of the St. Lawrence River, 2002. See Fig. 1 for a map of the quota zones.*

Species	Quota (lb) by Quota Zone		
	Napanee (1-5)	Brockville (2-5)	Cornwall (1-7)
American eel	8,661	5,745	31,624
Black crappie	18,590	18,140	4,840
Yellow perch	66,675	83,173	5,760

Eel

Eel harvest in Ontario waters of the St. Lawrence River was 23,734 lb during 2002, down from 37,988 lb during 2001. The harvest represented 52% of the quota allocated for this species (Table 3). In the past, eel harvests in the St. Lawrence River had been consistent and small relative to the harvests observed in the Bay of Quinte and Lake Ontario (Fig. 2). Harvest below the dam (Quota Zone 1-7) now represents approximately 69% of the total harvest from all Ontario waters of the Upper St. Lawrence River and Lake Ontario. Prior to 1990, harvest in this area represented approximately 15% of the harvest from all quota zones. The dramatic decline in the eel harvest levels observed since 1992 (particularly in Lake Ontario and the Bay of Quinte) have occurred in spite of increasing value of the fish harvested (Fig. 2).

Yellow perch

Yellow perch harvest was in the St. Lawrence River was 50,774 lb during 2002, down slightly from 58,390 lb during 2001. The harvest represented 39% of the total quota for this species

TABLE 2. *Commercial fish harvest (lb) and value ($) for fish species in the Ontario waters of the St. Lawrence River, 2002.*

Species	Harvest by Quota Zone (lb)			Total	Price-per-lb	Value
	Napanee (1-5)	Brockville (2-5)	Cornwall (1-7)			
American eel	2,481	409	20,844	23,734	$2.42	$ 57,387.57
Black crappie	14,757	675	796	16,227	$1.97	$ 31,966.96
Bowfin	2,000	-		2,000	$0.24	$ 478.54
Brown bullhead	23,899	15,409	76,418	115,726	$0.40	$ 46,039.56
Channel catfish	19	3		22	$0.39	$ 8.56
Common carp	160	-		160	$0.15	$ 24.10
Freshwater drum	120	10		130	$0.10	$ 13.37
Sunfish	28,233	17,184	9,093	54,509	$0.97	$ 52,852.11
Rock bass	366	262		629	$0.43	$ 272.69
Suckers		-	2,827	2,827	$0.11	$ 305.69
White perch	2,417			2,417	$0.50	$ 1,212.62
Yellow perch	26,813	20,909	3,052	50,774	$1.52	$ 77,111.54
Total	101,264	54,861	113,030	269,154		$ 267,673.00

TABLE 3. *Commercial harvest (% of quota) for the Ontario waters of the St. Lawrence River, 2002.*

Species	Harvest (% of Quota) by Quota Zone			
	Napanee (1-5)	Brockville (2-5)	Cornwall (1-7)	Total
American eel	29%	7%	66%	52%
Black crappie	79%	4%	16%	39%
Yellow perch	40%	25%	53%	33%

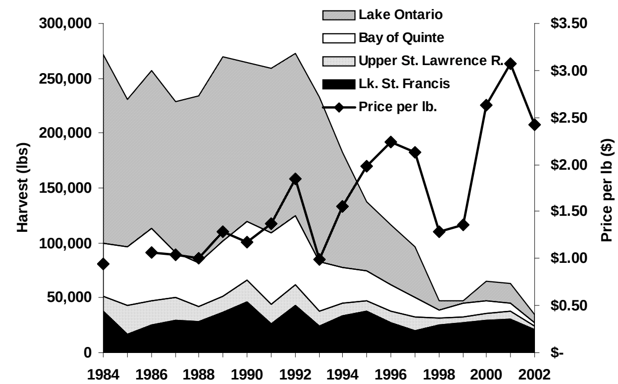

FIG. 2. *Commercial harvest of American eel (lb) for areas in the Ontario waters of Lake Ontario and the St. Lawrence River for 1984 to 2002. Data for Lake Ontario includes Quota Zones 1-1, 1-2, and 1-8. Data for the Bay of Quinte includes Quota Zones 1-3 and 1-4. Data for the upper St. Lawrence River includes Quota Zones 1-5 and 2-5. Data for Lake St. Francis includes Quota Zone 1-7.*

(Table 3). Yellow perch harvest below the dam at Cornwall (Quota Zone 1-7) has been small and consistent relative to harvests observed in the upper St. Lawrence River (Quota Zones 1-5 and 2-5) which have declined consistently from the relatively high levels observed during 1995 to 1999 (Fig. 3).

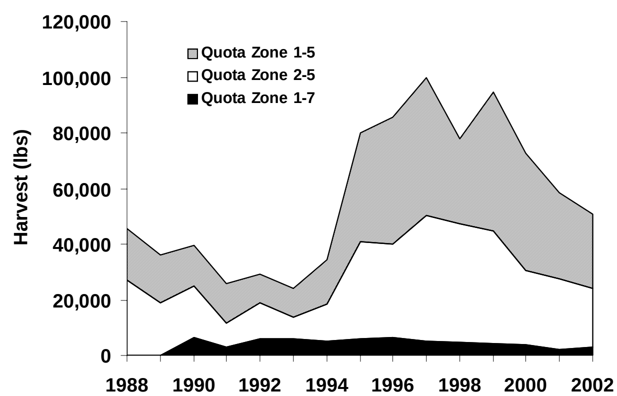

FIG. 3. *Commercial harvest of yellow perch (lb) for the Ontario waters of the St. Lawrence River for 1988 to 2002.*

Other species

Bullhead harvests in Quota Zones 1-5 and 2-5 have declined in recent years, while the harvest in Quota Zone 1-7 has tended to increase (Fig. 4). The commercial harvest of black crappie in 2002 (16,227 lb), was considerably higher than in 2001 (7,934 lb). As in previous years, most of the black crappie harvest came from Quota Zone 1-5. Sunfish harvest during 2002 (54,509 lb), was similar to the harvest reported for 2001 but lower than the levels reported during 1995 to 1999 (over 80,000 lb annually during most years).

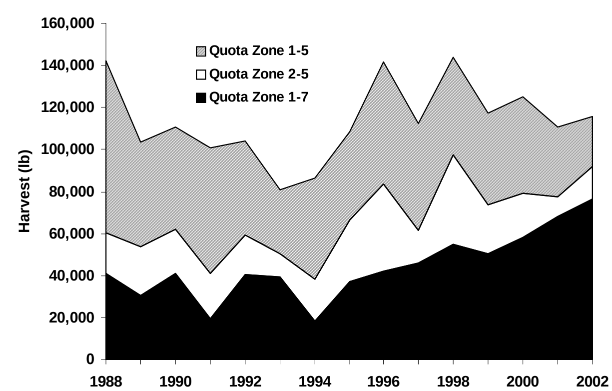

FIG. 4. *Commercial harvest of brown bullhead (lb) for the Ontario waters of the St. Lawrence River for 1988 to 2002.*

Discussion

Casselman et al. (1997) found that the index of upstream migration of eel at the ladder located at the R.H. Saunders Power Dam is strongly correlated with the commercial harvest in waters above the power dam. This suggests that the low numbers of eel migrating upstream for the last decade (Chapter 5 in this report), can account for the declining eel harvest in the upper St. Lawrence River and the continued low harvest in Lake Ontario (Chapter 6 in this report). The inverse relationship between market value and harvest (Fig. 2) is consistent with declining abundance of eel. The low numbers of eel migrating upstream into this system, suggest that the harvest of eel in areas upstream of the power dam may stay below 20,000 pounds for the foreseeable future.

A review of available data by the International Council for Exploration of the Sea (ICES 2001) confirmed either declining or neutral abundance of American eel in Canada and USA. In particular, eels in the St. Lawrence River/Lake Ontario system showed large declines in both recruitment of young eels and escapement of large fecund female silver eels. ICES advised that eel management agencies in the St. Lawrence River/ Lake Ontario system should cooperate in meeting management objectives for the stock. Further, ICES found evidence that reductions in human-induced mortality (which included both fisheries and hydro dam turbine mortalities) of yellow and silver eels may be required for this area.

During 2002, an eel ladder was operated at the Beauharnois Dam (located downstream of the R.H. Saunders Power Dam) for the first time. Additional ladders have been proposed for both the Beauharnois and R.H. Saunders Power Dam. If implemented, these actions should lead to somewhat higher eel abundance in the upper St. Lawrence River and Lake Ontario but will not lead to a return to eel abundance seen prior to the 1990s. Sustainable management practices, throughout the range of this panmictic species, will be required to restore eel abundance to the levels observed in Lake Ontario and the upper St. Lawrence River prior to the 1990s.

The decline in yellow perch harvest in the St. Lawrence River over the past two years is consistent with declines in index gillnetting catches (Chapter

5 in this report, McCullough et al. 2003). Yellow perch commercial harvest and abundance in index netting surveys in eastern Lake Ontario and the Bay of Quinte (Chapters 4 and 6 in this report) also declined somewhat from 1999 to 2002. These recent declines in perch abundance come after a period of generally increasing abundance in the mid-1990s.

The recent decline in brown bullhead harvest in the upper section of the St. Lawrence River (Quota Zones 1-5 and 2-5) occurred at a time when the bullhead population was at a relatively high level (Edwards et al. 2002, McCullough et al. 2003), and it is at least partly due to the presence of small white grubs in the flesh of bullhead. Susan Wade (Cornell University, College of Veterinary Medicine) identified grubs from bullhead collected in this area as *Hystermorpha triloba*. This organism does not pose a danger to human health as long as the fish are properly cooked, however, the heaviest infestations are noticeable and several fishers no longer market bullhead caught in this area. The life cycle of this organism involves fish-eating birds, snails, and some fish species including bullhead. The double-crested cormorant population in this area has increased dramatically since the mid-1990s, cormorants from this area are known to consume bullhead (Johnson et al. 2003) and cormorants from this area are known to be a host to this organism. Therefore, it seems likely that the cormorant could play a role in the declines observed in the bullhead fishery in these quota zones and other zones in Lake Ontario.

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8

Bay of Quinte Recreational Fishery

J. A. Hoyle

Introduction

The Bay of Quinte supports a popular and economically important recreational fishery. There are two major components to the recreational fishery, a winter ice fishery and an open-water fishery. Walleye have been the dominant species sought and harvested since the early 1980s. The recreational fishery developed and grew when the walleye population, initiated by production of a very large year-class of fish in 1978, recovered through the 1980s. Angler participation peaked in 1996 at over one million hours of angling effort. Total annual walleye harvest peaked sooner, in 1991, at about 220,000 fish.

Walleye fishing success and participation in the fishery declined in the 1990s. The decline in the fishery paralleled declines in the walleye population that occurred in response to dramatic changes in the Bay of Quinte ecosystem, particularly after zebra mussel invasion. Specifically, the production of young walleye declined, from the high levels of the late-1980s and early 1990s, to lower levels that were consistent with the changed Bay of Quinte ecosystem. While the production of young walleye appears to have stabilized at a lower level after the mid-1990s, the walleye population as a whole declined throughout the late-1990s and into 2000. The current walleye population appears to be stabilizing at about 400,000 fish (Schaner et al. 2002), and indeed, fishing success in the open-water fishery increased in 2001 after nine consecutive years of decline (Hoyle 2002).

An important characteristic of Bay of Quinte walleye is the migration of large, mature walleye to eastern Lake Ontario, following spawning in the Bay of Quinte each spring, where they spend the summer months. Young walleye (e.g., age-0 to age-4 yrs-old) reside in the Bay of Quinte year-round. This migratory behavior is important because it influences the size and age of walleye available for harvest seasonally in various areas of the Bay of Quinte and eastern Lake Ontario.

The Bay of Quinte ecosystem changes included increased water clarity and aquatic plants that favored fish species such as yellow perch, largemouth bass and other centrarchids (pumpkinseed, bluegill, and black crappie). These species have become more prominent in angler catches in recent years.

This chapter updates the results of ice and open-water recreational angling surveys conducted in 2002.

Information Sources

Recreational angling surveys are conducted annually on the Bay of Quinte, from Trenton in the west to Glenora in the east (Fig. 1), during the walleye angling season (January 1 to February 28 and first Saturday in May to December 31). Angling effort is measured using aerial counts during ice fishing surveys, and a combination of aerial counts and on-water counts during open-water surveys. On-ice and on-water angler interviews provide information on catch/harvest rates and biological characteristics of the harvest. Hoyle (2001, 2002) reports detailed survey designs for ice and open-water surveys, respectively.

Fisheries Update

Ice Fishery

Ice angling effort in 2002 was estimated to be 37,129 angler-hours (Table 1). Effort was down 52% from the previous year and down 82% from the previous 5-yr average to its lowest level since winter ice angling surveys began in 1982 (Fig. 2). Ice conditions were particularly poor in 2002. An estimated 2,601 walleye were caught of which

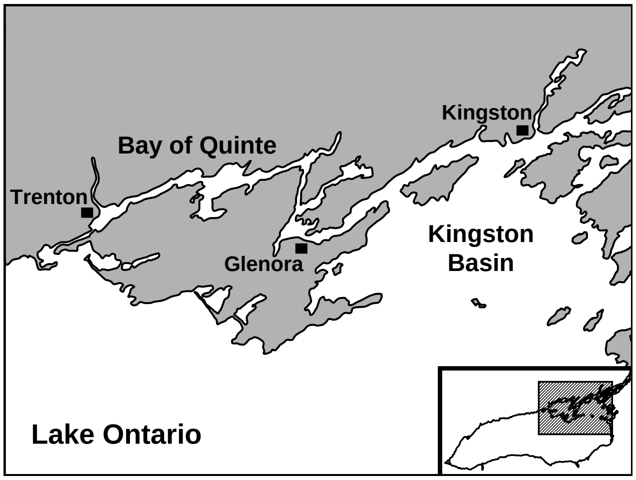

FIG. 1. Map of the Bay of Quinte showing the extent of recreational angling surveys from Trenton in the west to Glenora in the east.

2,468 were harvested. The number of walleye harvested was up from the previous year, as a result of a higher fishing success rate, but down over 80% compared with the previous 5-yr average (Fig. 2). The average walleye harvested during the ice fishery was 563 mm fork length and weighed 2.4 kg.

Open-water Fishery

Open-water angling effort was estimated to be 154,570 angler-hours (Table 1, Fig. 2). Angling effort has declined for six consecutive years to its lowest level since 1979. Walleye catch was estimated at 28,813 fish of which 17,903 were harvested. The number of walleye harvested was down over 35% from last year and down 60% compared to the previous 5-yr average (Fig. 2). Improved walleye angling success observed in 2001 was maintained in 2002 (0.186 and 0.113 walleye caught and harvested-per-rod-hour, respectively; Fig. 2). The increased fishing success in 2001 was attributed to recruitment of the 1999 walleye year-class. This year-class along with age-2 fish from the 2000 year-class (Fig. 3) dominated the 2002 open-water walleye harvest; combined they made up over 91% of the harvest. These age-2 and age-3 fish had an average fork length of 320 mm and 397 mm, and weighed 0.4 and 0.8 kg, respectively.

A new feature of the 2002 walleye recreational fishery was implementation of a 48 cm (18.9 in) total length maximum size limit with an allowance for one fish over 63 cm (24.8 in). The new regulation was implemented in time for the beginning of the open-water fishery in May. During the recreational angling survey, anglers

TABLE 1. Bay of Quinte walleye recreational angling statistics, 2002. Effort, catch, and harvest statistics are for anglers targeting walleye. No survey was conducted during the opening weekend season; opening weekend statistics were estimated based on effort, catch, and harvest statistics for the rest of May 2002, and using a relationship between effort, catch or harvest during opening weekend versus the rest of May for the years 1993 to 2001.

Season	Effort (angler-hours)	Catch	Harvest
Ice Fishery:			
Ice-fishing total	37,129	2,601	2,468
Open-water fishery:			
Opening weekend	38,410	1,725	1,064
May	33,540	5,363	3,799
June	15,104	5,596	2,493
July	21,862	8,794	6,317
August	25,256	5,125	3,697
Fall	20,398	2,210	533
Open-water total	154,570	28,813	17,903
Annual total	191,699	31,414	20,371

were asked about the size of walleye that they had released. Results varied seasonally but the overall release rate was 39% (Table 2); of those fish released, most were smaller than the 48 cm size restriction (71.1%). Most of the remainder (28.5%) were between 48 and 63 cm; very few (0.3%) were greater than 63 cm. The overall walleye release rate increased from 2001 to 2002. Some of this increase may have been due to the new size limit regulation but even the 2002 release rate remained less than that observed during the 1988-1996 time-period. Release rate during the open-water fishery is likely more influenced by the abundance of small walleye recruiting to the fishery. Release rates declined from 1996 to 2000 when recruitment of age-2 walleye into the fishery was low but increased again in 2001 with recruitment of the 1999 year-class (Fig. 4).

Although total angling effort remains largely focused toward walleye (87% in 2002), other species, particularly largemouth bass are beginning to receive some targeted fishing pressure (12% in 2002; Fig. 5). Figure 5 shows both the positive relationship between catch rate and angling effort as well as the divergent trends in catch rate and angling effort since 1993 for walleye and largemouth bass. Other species in the open-water fishery (Table 3) are, for the most

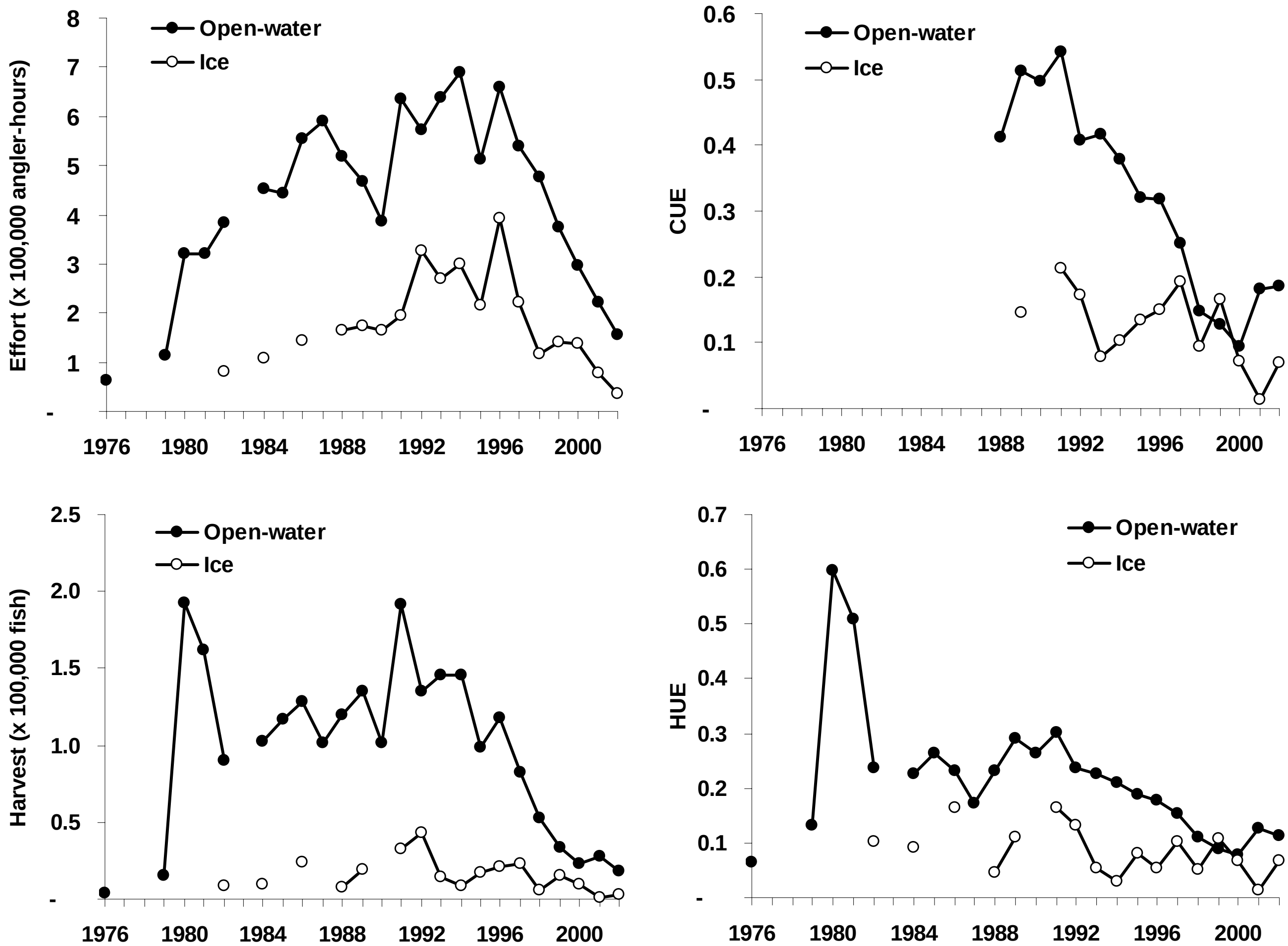

FIG. 2. Walleye angler effort, harvest, catch-per-unit-effort (CUE) and harvest-per-unit-effort (HUE) during the Bay of Quinte ice and open-water recreational fisheries, 1976 to 2002.

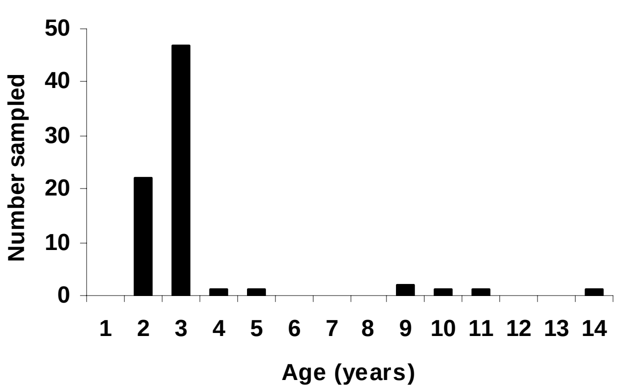

FIG. 3. Age distribution of walleye harvested in the open-water recreational fishery, Bay of Quinte, 2002.

part, caught incidentally by walleye anglers. However, catch rates for other species have generally been on the rise as walleye catch rates decline. These trends in catches are consistent with a changing ecosystem. Increased water clarity and aquatic vegetation not only favor these other species but also may make fishing for walleye more difficult.

The round goby, an exotic fish species, was first reported in the Bay of Quinte in 1999. Goby catches, mainly caught incidentally by anglers targeting other species, have been on the rise in the open-water recreational fishery. About 8,000 gobies were caught in summer 2002. The extent to which round gobies will impact the Bay of Quinte ecosystem, and thus the recreational fishery, is not known.

Discussion

Fish community objectives for Lake Ontario (Stewart et al. 1999) proposed that walleye

TABLE 2. Proportion of walleye released by size class (corresponding to angling size limit restrictions) by month in the open-water recreational fishery, Bay of Quinte, 2002. Also shown are the total number of walleye released and release rate by month and the overall percentage of walleye released in each size category. 1 does not include opening weekend of walleye season.

	Size category				
	<48 cm	48-63 cm	>63 cm	Number released	Release rate
May[1]	0.22	0.78	0.00	1,564	29%
June	0.88	0.12	0.00	3,102	55%
July	0.91	0.09	0.00	2,540	29%
August	0.44	0.56	0.00	1,789	35%
Fall	0.83	0.14	0.02	1,677	76%
Total number released	7,590	3,046	37	10,673	39%
% released by size	71.1%	28.5%	0.3%		

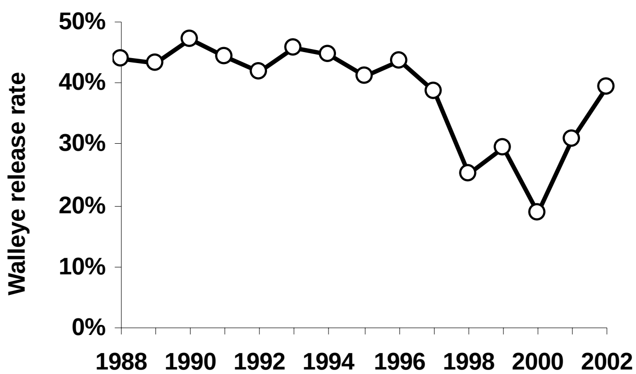

FIG. 4. Walleye release rate in the open-water recreational fishery, Bay of Quinte, 1988-2002.

fisheries be maintained at early-1990s catch rates. This objective is not realistic given the environmental changes that have occurred in the Bay of Quinte. Ecosystem changes reduced the potential sustainable yield of walleye. The Bay of Quinte recreational fishery was severely impacted by declines in walleye abundance during most of the 1990s.

The open-water recreational fishery is dependent on young walleye (age-2 to age-4 yrs). Walleye fishing success increased in 2001 and again in 2002 because of better recruitment of

TABLE 3. Angling statistics for the Bay of Quinte open-water fishery, May to November 2002. Catch and harvest (by number) are by all anglers; catch and harvest rates (CUE and HUE, the number of fish caught or harvested-per-angler-hour, respectively) are for anglers targeting the specific species.

	Catch	Harvest	CUE	HUE
Northern pike	7,084	1,148	0.217	0.100
Sunfish	22,413	958	0.392	0.381
Smallmouth bass	3,657	652	0.265	0.067
Largemouth bass	13,165	2,724	0.744	0.161
Yellow perch	104,071	3,876	1.530	0.380
Walleye	29,459	17,903	0.186	0.113
Total	179,849	27,262		

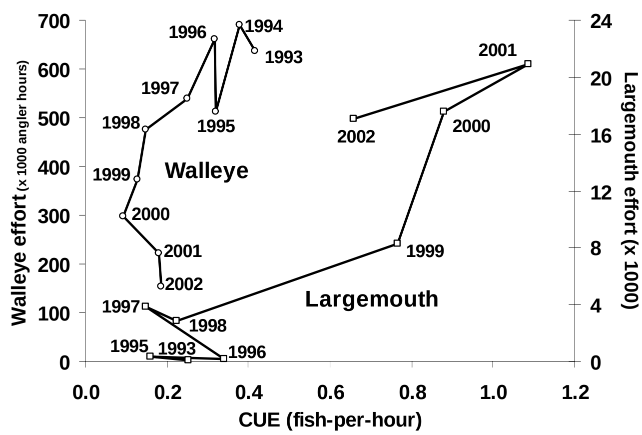

FIG. 5. Relationships between catch-per-unit-effort (CUE) and targeted fishing effort for walleye and largemouth bass, in the open-water recreational fishery, Bay of Quinte, 1993-2002.

young fish; specifically, the 1999 year-class in 2001 and both the 1999 and 2000 year-classes in 2002. The 2001 year-class appears to be at least as abundant as the 1999 year-class; therefore, walleye catch rates should be as high or higher in 2003 compared to 2002. The 2002 walleye year-class appears to be very poor, therefore walleye catch rates may decline in 2004. Nonetheless, the expectation is that walleye catch rates will fluctuate around levels observed during the last few years.

Largemouth bass catches have increased in recent years. As a result, there has been some increase in the number of anglers targeting this species (Fig. 5). To date, much of the increased attention toward largemouth bass has come from tournament fishing. There is potential for further increases in recreational angling for largemouth bass.

The outlook for the ice fishery is somewhat different. Potential walleye harvest rates will decline with the recent implementation of walleye size restrictions. The average size of walleye harvested in the ice fishery is within the restricted 48-63 cm size limit (e.g., see Hoyle 2002). Unlike the open-water fishery, no alternative species to walleye has increased in angler catches. Yellow perch increased in abundance in the Bay of Quinte in the mid-1990s but the average size has remained very small, and not attractive to anglers.

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9

Western Lake Ontario Boat Fishery for Salmon and Trout

J. N. Bowlby

Introduction

Angling for salmon and trout in Lake Ontario entered a new era with the introduction of coho salmon by New York State in 1968. The Province of Ontario began stocking coho the following year. In subsequent years Ontario stocked chinook salmon, rainbow trout, brown trout, Atlantic salmon, and lake trout. Although stocking has formed the foundation of this fishery, natural reproduction of salmon and trout has increased in recent years. Salmon and trout are the principal recreational species in Lake Ontario, accounting for more than three-quarters of the angling fisheries on the Ontario side of Lake Ontario (Savoie and Bowlby 1991). The boat fishery for salmon and trout in western Lake Ontario represents about one-third of the salmon and trout fishery; stream and shoreline fisheries account for the remaining two-thirds. We have relied on the boat fishery survey in western Lake Ontario as an index of relative abundance of salmon and trout populations, since 1982. This survey provides the primary biological monitoring of salmon and trout in the Ontario waters of western Lake Ontario, and the only statistics for this fishery. The status of chinook salmon, rainbow trout, and lake trout populations are described in Chapters 2 and 3 of this report. This chapter describes the status of the boat fishery for salmon and trout in western Lake Ontario.

Information Sources

The portion of the salmon and trout fishery that launches boats from ramps in western Lake Ontario was monitored in 2002. This survey design was consistent with our surveys from 1985 to 2001 (Bowlby 2002).

The design was based on seasonal stratification by month from April to September, and spatial stratification into six sectors from the Niagara River to Wellington (Fig. 1). This spatial

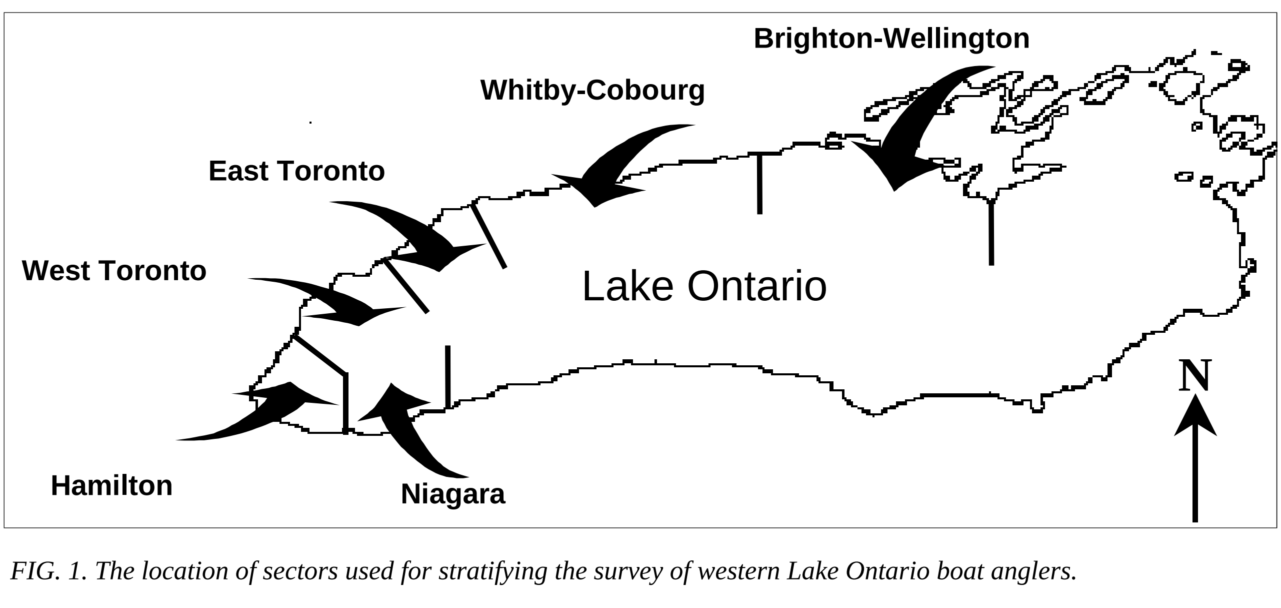

FIG. 1. The location of sectors used for stratifying the survey of western Lake Ontario boat anglers.

stratification was based on consistency in the composition of angler catch. However, these sectors coincidentally correspond to temperature zones in Lake Ontario as described by El-Shaarawi and Kwiatkowski (1977). Anglers were interviewed after fishing was completed at several launch ramp locations: St. Catharines Game and Fish, Fisherman's Wharf, Port Credit, Bluffers Park, Whitby, Port Darlington, Port Hope Harbour, Cobourg Yacht Club, and Wellington. Boat trailers were counted to estimate effort at all ramps from the Niagara River to Wellington (Table 1), and these counts were used to scale up effort, catch, and harvest, accordingly. Interviews were conducted at the ramps (above) on 4 weekdays and 4 weekend days each month to cover time periods from 0900 to 2100. Estimates for the total fishery were made using the ratio of effort, catch, and harvest between launch daily and marina based fisheries in 1995 (Hoyle et al. 1996). In 2002 sampling commenced in June. Effort, catch, and harvest estimates for these missing strata were based on the 2001 values, adjusted by the ratio of effort between the years.

Fisheries Update

Effort

During 2002, the effort of launch daily anglers and all boat anglers was estimated at 239,610 and 405,730 angler-hours, respectively. Effort scarcely changed from 2001(Fig. 2). Effort in the western Lake Ontario boat fishery had been relatively stable with a slight decline after 1994. In the past, effort in this fishery has responded more to an announcement of stocking reductions and the closing of major fishing derbies than changes in fishing success. Effort in this fishery is driven by the major fishing derbies. More than half of this effort in 2002 occurred in July and August (Table 1) during the Great Ontario Salmon Derby, similar to other years.

A regulation change allowing two rods per angler in Lake Ontario came into effect during summer 1998. This resulted in effort in rod-hours exceeding angler-hours from 27% to 36% in 2002 (Fig.2). The relationship between catch rate with one rod or two rods is not straightforward. Rather, this relationship differs with the number of anglers onboard to the extent that increasing the number of rods results in no increase in catch/ angler-hr for larger parties with more rods (Bowlby and Stewart 2000). Surveys prior to 1999 indicated that a few anglers fished with two

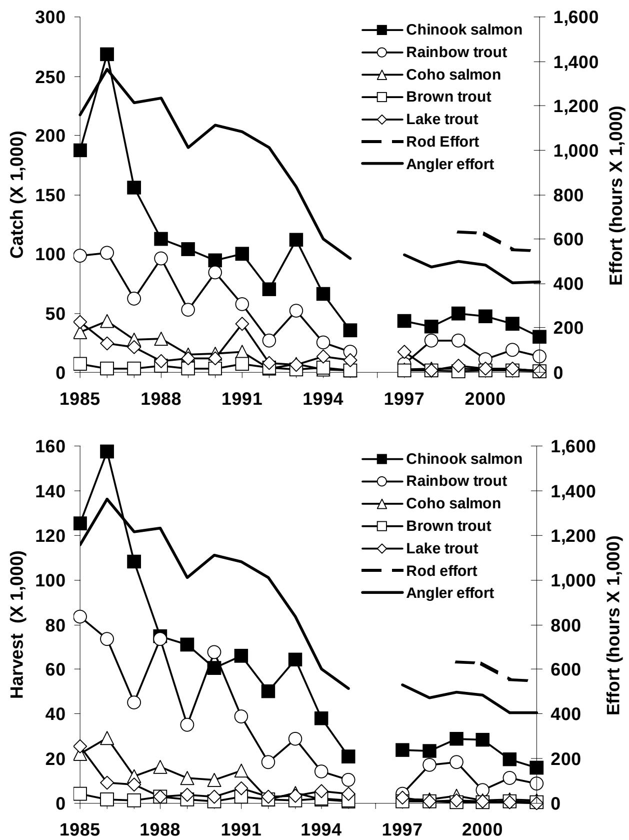

FIG. 2. Catch, harvest and effort in the boat fishery for salmon and trout in western Lake Ontario (Ontario portion), from 1985 to 2002. In 1996 the survey was incomplete.

rods before it was legal. We suspect the number may have been higher than indicated in the surveys.

Catch and Harvest

Chinook salmon and rainbow trout accounted for 92% of the salmon and trout harvest in the western Lake Ontario boat fishery in 2002 (Table 2). These were the only species that were consistently targeted in this fishery. The catch and harvest of chinook salmon in 2002 were the lowest observed since 1985 (Fig. 2). The decline in effort explains much of the decline in catch and harvest. Catch and harvest rates of chinook salmon have varied less over the last 5 years than prior to 1996 (Fig. 3). Yet, catch and harvest rates were also low in 2002, perhaps as a result of unusual weather patterns resulting in unusual seasonal distributions of fish. Chinook salmon catch rates around the lake vary seasonally, but patterns are usually consistent from year to year (Fig. 4). Minor changes in the seasonal and spatial

TABLE 1. Average daily trailer count on weekend days in 2002 during 1000 - 1400 hours at launch ramps along western Lake Ontario (Ontario portion). Ramps (and values) where anglers were counted and interviewed are indicated with italics.

Sector	Ramp	Jun	Jul	Aug	Sep	Total
Niagara	Queenston Sand Docks	4.8	2.0	2.0	3.5	12.3
	Welland Canal	6.8	4.8	7.5	17.5	36.5
	St.Catharines Game and Fish	***10.3***	***6.5***	***9.8***	***14.3***	***40.8***
	Beacon Motor Inn	4.3	7.5	4.3	2.5	18.5
	Sector total	26.0	20.8	23.5	37.8	108.0
Hamilton	Grimsby Municipal Ramp	1.5	0.5	0.3	0.3	2.5
	Foran's Marine	5.3	3.5	3.5	3.0	15.3
	Lakecourt Marina	0.5	0.0	0.3	0.5	1.3
	HRCA 50 Pt. Ramp	9.8	7.3	9.8	7.3	34.0
	Fisherman's Wharf	***18.8***	***23.5***	***29.0***	***12.0***	***83.3***
	Bronte Beach	8.0	18.0	21.3	16.5	63.8
	Shipyard Park	1.5	6.5	12.5	5.5	26.0
	Busby Park	0.0	0.3	1.3	0.0	1.5
	Sector total	45.3	59.5	77.8	45.0	227.5
West Toronto	***Port Credit Ramp***	***8.3***	***17.5***	***44.8***	***24.0***	***94.5***
	Lakefront Promenade Park	9.0	19.8	35.3	19.8	83.8
	Marie-Curtis Park	1.3	3.3	4.3	1.0	9.8
	Humber Bay West	11.5	19.3	17.5	14.5	62.8
	Sector total	30.0	59.8	101.8	59.3	250.8
East Toronto	Ashbridges Bay	3.5	16.8	11.0	5.0	36.3
	Bluffers Park	***5.8***	***27.3***	***25.8***	***5.0***	***63.8***
	Frenchman's Bay West	0.8	3.0	3.3	2.0	9.0
	Frenchman's Bay East	1.8	4.3	5.5	1.8	13.3
	Duffin Creek	0.0	0.8	0.3	0.0	1.0
	Sector total	11.8	52.0	45.8	13.8	123.3
Whitby-Cobourg	Port Whitby Marina	1.0	0.3	8.3	1.8	11.3
	Whitby Ramp	***1.5***	8.3	3.3	1.8	14.8
	Port Oshawa Marina	0.8	6.5	3.5	2.5	13.3
	CLOCA P. Darlington Ramp	***2.3***	***15.8***	***16.8***	***2.8***	***37.5***
	Port Newcastle	0.3	2.5	3.0	0.0	5.8
	Port Hope Harbour	1.0	7.5	14.5	***3.5***	26.5
	Cobourg Yacht Club	***0.5***	2.5	3.8	0.0	6.8
	Sector total	7.3	43.3	53.0	12.3	115.8
Brighton-Wellington	Ontario Street Ramp	0.3	3.5	4.3	2.3	10.3
	Brighton Marina	0.0	0.0	0.3	0.5	0.8
	Gosport Gov't Ramp	0.0	1.3	1.3	0.0	2.5
	Camp Barcovan	0.3	0.3	1.0	0.3	1.8
	McSaddens Marina	1.5	3.5	3.0	0.8	8.8
	Wellers Bay Marina	0.0	1.5	0.5	1.0	3.0
	North Shore Park	0.5	0.3	1.3	0.3	2.3
	Wellington Harbour Ramps	***7.5***	***21.3***	***12.0***	***4.0***	***44.8***
	Sector total	10.0	31.5	23.5	9.0	74.0
All sectors	Total	130.3	266.8	325.3	177.0	899.3

patterns of catch may be related to variations in weather, particularly how wind speed and direction affect the currents and water temperature in Lake Ontario. Catch rates usually peak in all sectors during July or August (Fig. 4). In 2002, catch rates peaked in September at Whitby-Cobourg, West Toronto, and Hamilton sectors (Fig. 5), with higher values than the average of the previous 3 years. Evidently, chinook salmon returned to staging areas in typical numbers before heading upstream to spawn.

The catch and harvest of rainbow trout declined slightly in 2002 (Fig. 2). Catch and harvest rates of rainbow trout were typical of the last decade (Fig. 3). Rainbow trout catch rates tend to be higher in Ontario waters of Lake Ontario during years with warmer springs (Bowlby and Daniels 2003). During 2002, the rainbow trout catches in Ontario waters were consistent with a moderate spring temperature.

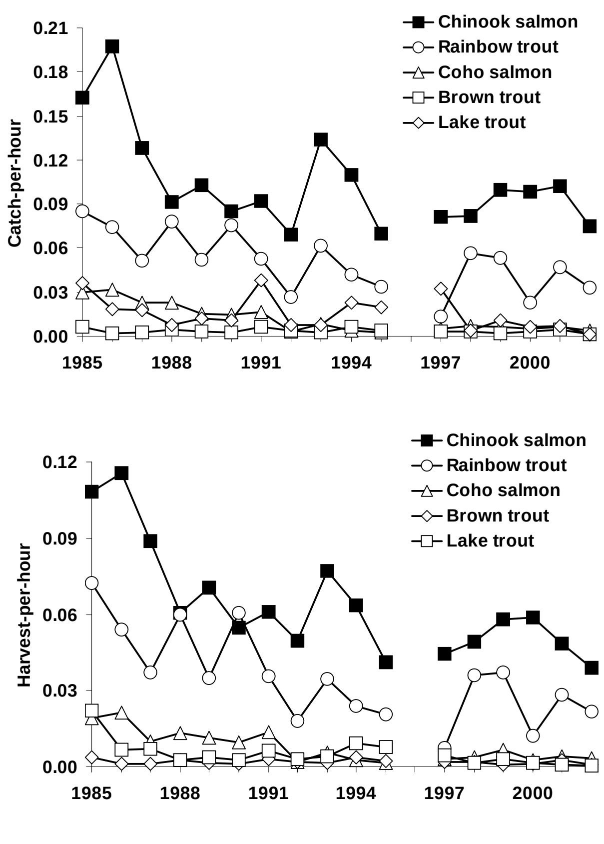

FIG. 3. Catch and harvest rates is the boat fishery for salmon and trout in western Lake Ontario (Ontario portion), from 1985 to 2002.

Catch and harvest of coho salmon, brown trout and lake trout remained typically low, because anglers target chinook salmon and rainbow trout.

Atlantic salmon were not observed in the survey because stocking levels are focused on research rather than creating a fishery at this time. The reported catch may also be low due to misidentification. Anglers and survey technicians have difficulty with Atlantic salmon

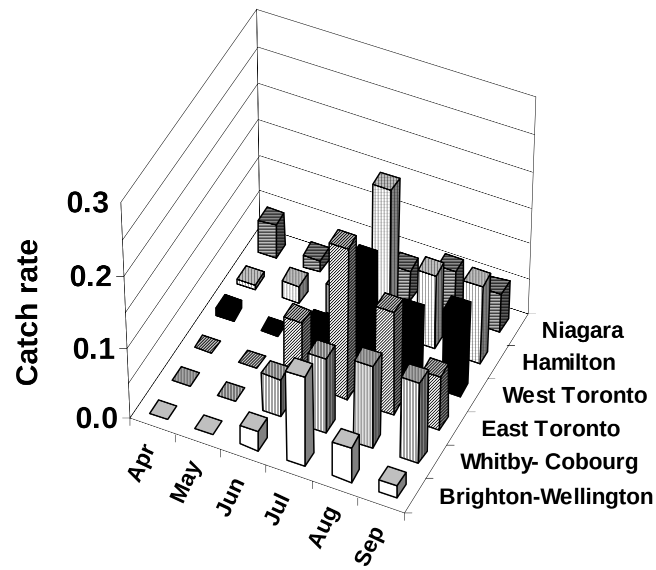

FIG. 4. The average seasonal and spatial pattern of catch rate of chinook salmon by launch daily anglers in western Lake Ontario from 1999 to 2001.

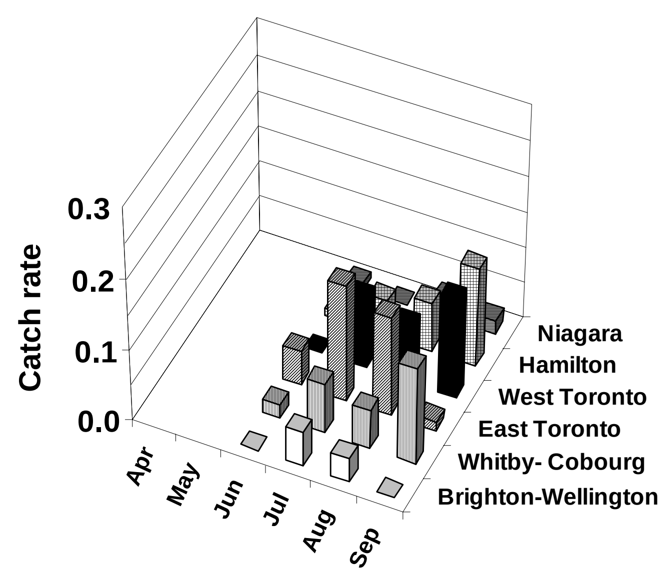

FIG. 5. The seasonal and spatial pattern of catch rate of chinook salmon by launch daily anglers in western Lake Ontario during 2002.

TABLE 2. Angling statistics for salmonid boat fisheries in western Lake Ontario (Ontario portion) during April to September 2002.

	Launch Daily Anglers					All Boat Anglers				
Species	Catch	Harvest	Catch rate (fish/ anger-hour)	Harvest rate (fish/ anger-hour)	Release Rate (%)	Catch	Harvest	Catch rate (fish/ anger-hour)	Harvest rate (fish/ anger-hour)	Release Rate (%)
Chinook salmon	19,205	8,670	0.0801	0.0362	55	30,313	15,840	0.0747	0.0390	48
Rainbow trout	5,818	3,059	0.0243	0.0128	47	13,503	8,756	0.0333	0.0216	35
Coho salmon	1,309	858	0.0055	0.0036	34	1,568	1,382	0.0039	0.0034	12
Brown trout	478	222	0.0020	0.0009	54	639	277	0.0016	0.0007	57
Lake trout	327	72	0.0014	0.0003	78	567	117	0.0014	0.0003	79
Atlantic salmon	0	0	0.0000	0.0000		0	0	0.0000	0.0000	
Unidentified salmonine	1,159	112	0.0048	0.0005	90	3,593	347	0.0089	0.0009	90
Total salmonines	28,296	12,993	0.1181	0.0542	54	50,184	26,718	0.1237	0.0659	47

identification, and tend to report them as unidentified. A vast majority of tag returns of stocked adult Atlantic salmon from anglers in since 1998 were reported as chinook salmon, coho salmon, brown trout or rainbow trout (L. Carl, personal communication).

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Appendix 9.1. Corrections of errors in 2000 (Chapter 8, Table 1) and 2001 (Chapter 8, Table 1) Annual reports: average daily trailer counts during 1000-14000 hours at launch ramps along western Lake Ontario (Ontario por-

Table entry	Apr	May	Jun	Jul	Aug	Sep	Total
2000							
Brighton-Wellington sector total	3.2	27.8	8.5	38.8	12.0	11.3	101.4
All sectors total	56.7	114.3	109.2	379.5	237.3	128.3	1025.1
Ramps with Angler Interviews	21.0	37.3	41.0	175.0	94.8	53.8	422.8
Ramps with Angler Interviews (%)	37%	33%	38%	46%	40%	42%	41%
2001							
Brighton-Wellington sector total	4.0	15.8	13.3	42.8	30.8	11.8	118.3
All sectors total	81.0	86.5	148.5	320.3	366.5	184.8	1187.5

10

Two Decades of Commercial Fishery Management on Lake Ontario, 1981-2001

P.A. Smith[1] and P.A. Edwards

Introduction

The fisheries management actions of the Ontario Ministry of Natural Resources (OMNR) on Lake Ontario over the last two decades should be considered in the context of the history of the Lake Ontario fishery.

Following European settlement, the fishery was exploited primarily to meet community needs and fishing was generally limited to nearshore areas and tributary streams. As nearshore fishery resources declined, commercial fishing activity moved further into the open lake. With improved technology and larger vessels, the scale and intensity of fishing increased. The introduction of nylon gill nets after World War II significantly increased fishing efficiency.

The historic pattern is one of successive depletion of fish stocks. Overfishing was implicated as "the major destabilizing influence" (Christie, 1973). Other factors such as changes in water quality and fish habitat, invasion of exotic species and predation by sea lamprey contributed to the destabilization of the fish community.

Atlantic salmon stocks collapsed in the 1830s and lake sturgeon declined to commercially insignificant levels by 1900. Whitefish, lake trout and burbot stocks collapsed during the 1940s and deepwater ciscoes were virtually extinct by the 1950s. By the early 1960s, blue pike had disappeared and Bay of Quinte herring and white bass suffered major declines. Walleye, abundant in the 1950s, declined through the 1960s.

Over several decades, the commercial fishery switched from one fish species to another in response to the collapse of species such as lake trout, herring, ciscoes, whitefish and walleye. By the early 1980s, the Lake Ontario gill net fishery relied heavily on yellow perch; exerting extreme pressure on perch stocks.

Until the 1980s, OMNR efforts to manage the commercial fishery focused on the licensing of fishing activities, including the type of fishing gear to be used. These limited measures were ineffective in dealing with a commercial fishery characterized by overfishing, overcapitalization and related biological, social and economic issues.

Provincial Initiative to Modernize Ontario's Commercial Fishery

Representatives of OMNR and the commercial fishing industry came together in the early 1980s to examine strategies for improving management of the commercial fishery across the province. The jointly authored "Report of the Committee on Modernizing Ontario's Commercial Fishery" (1982) recognized that open access and essentially unlimited harvest of fish stocks were no longer appropriate. Similar deliberations on the east and west coasts of Canada came to the same conclusion.

Establishment of Quota Management

Fishery managers in many jurisdictions saw individual harvest quotas as the best solution to "the tragedy of the commons" (Hardin, 1968). Limiting entry to the fishery and/or reducing overcapitalization of the fishery through buy-back programs were also seen as potential ways to address the excess fishing capacity that had developed in many commercial fisheries.

In Ontario, the implementation of a "modernization" program, involving the

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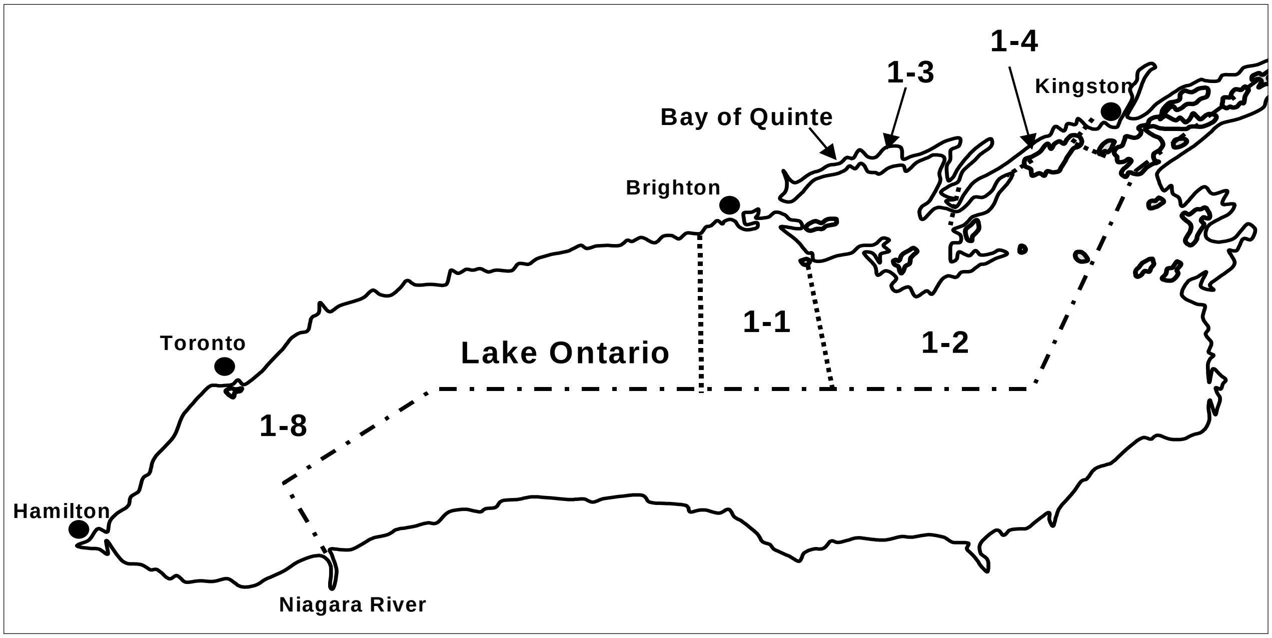

FIG. 1. Quota areas used in commercial fish management in Lake Ontario. Quota area 1-2 includes East, West and Consecon Lakes. The boudary between quota areas 1-3 and 1-4 is the Glenora ferry.

introduction of individual species quotas, was widely supported by the commercial industry and the Ontario Fish Producers Association. While some individual licence holders challenged the quota system, both politically and in the courts, most industry participants supported the overall principles of modernization. The courts confirmed the Ontario Government's authority to limit resource exploitation through the quota system.

Initiating Quota Management on Lake Ontario

Eastern Lake Ontario was one of the first areas of the province with individual species quotas. Quotas were implemented for American eel in 1980, as a result of concern about the long-term future of eel stocks. In the early 1980s, several experimental permits were issued with small whitefish quotas, to assist in monitoring the status of whitefish stocks.

In 1985, quota management was introduced for most commercial species in the Lake Ontario fishery, as part of the province-wide modernization program. Considerable disagreement emerged over the determination of initial commercial allocations and the subsequent division of allocations among individual licence holders.

Past performance (i.e. commercial harvests in the years immediately prior to the introduction of quotas) became an important basis for determining both overall industry allocations and the quota "share" assigned to individual fishers. For several premium fish species such as yellow perch and eel, the overall allocation to the industry exceeded the total allowable catch (TAC) recommended by fisheries assessment staff of the Lake Ontario Unit. While it appeared that heavy fishing effort in the late 1970s and early 1980s had resulted in "fishing up" of some stocks, the commercial fishing industry successfully argued that significant reductions in allocation from previous harvest levels would impose significant hardship on licence holders.

The setting of species quotas for individual fishing licences became extremely controversial. OMNR invited the local industry to participate in the development of equitable mechanisms for dividing overall species allocations into individual quotas. However, internal disputes among various fishers and the inability of the local industry association to agree on fundamental principles for quota sharing, meant that the process was largely developed and implemented by OMNR fishery managers. Essentially, a licence holder's share of the commercial allocation was based on a "best three out of five" year harvesting history for each licence.

Those fishers who had substantial harvests in the 1979 to 1984 period generally benefited from the formula for assigning quota. Licence holders with low harvests or intermittent fishing activity did not fare as well. Some of those disadvantaged by the "past performance" approach complained that licencees who had fished with prohibited gear (smaller gill net mesh than legally prescribed), had reported harvests in excess of actual catches or had engaged in other illegal practices, were rewarded for their failure to abide by the regulations. Many fishers accessed the appeal process set up to review quota decisions and cases of genuine hardship (e.g. low fishing activity due to illness). Some individual quotas were adjusted as a result of those appeals. However, hard feelings within the industry - and between some licence holders and OMNR - have persisted for nearly two decades regarding the initial allocation of quotas in the Lake Ontario fishery.

The 1985 commercial allocations are summarized in Table 1.

Restructuring of the Lake Ontario Commercial Fishery 1985-88

An Overcapitalized Fishery

Through much of its history, the Lake Ontario commercial fishery has been characterized by a large number of participants relative to the overall landings and landed value of the catch (the familiar phenomenon of too many fishermen chasing too few fish).

In 1985, there were 194 commercial fishing licences in eastern Lake Ontario, held by over 100 licencees. This included 86 gill net licences. The landed value of the commercial harvest in the early 1980s ranged from $1.0 to $1.5 million.

User Group Conflicts and Incidental Catch

By the mid-1980s, a significant recreational fishery had developed in the Bay of Quinte, based primarily on the dramatic recovery of walleye stocks. There was also growing interest in offshore angling for trout and salmon, as the combined effects of sea lamprey control and fish stocking by both Ontario and New York State resulted in substantial numbers of salmonids in the eastern basin of Lake Ontario.

While commercial fishermen target particular species such as yellow perch and lake whitefish, gill nets are not species-specific. A good deal of "species mixing" occurs and incidental catch ("by-catch") of non-target fish in gill nets can be very high. OMNR studies and on-board monitoring of commercial gill net operations during the 1980s indicated large numbers of non-target species such as lake trout, juvenile walleye and smallmouth bass were caught incidentally in gill nets at certain times of the year. Instances were observed where the weight of incidentally caught fish actually exceeded the catch of target commercial species.

User group conflicts between recreational and commercial fishermen intensified as the recreational fishery expanded. Initially, issues involved the physical placement of commercial gear in areas used by recreational fishermen. However, concern about incidental catch of non-target, non-commercial species in the gill net fishery became a much larger issue. Opinion leaders in the recreational fishery and the outdoor media made the incidental catch problem a high priority in their dealings with OMNR. Incidental catch had the potential to slow the progress of fisheries management programs for species such as lake trout, which was the focus of international rehabilitation efforts through the Great Lakes Fisheries Commission.

The commercial industry on Lake Ontario was slow to recognize the significance of the incidental catch issue. Their position was that Ontario MNR and their counterparts in New York State had created much of the problem through their aggressive lake trout stocking programs. Industry representatives continued to complain

TABLE 1. Commercial fishing quotas (lbs) in eastern Lake Ontario, 1995.

	Quota Area				
Species	1-1	1-2	1-3	1-4	Total
American Eel	75,000	435,717	116,146	60,239	687,802
Brown Bullhead	173,478	193,135	616,417	43,673	1,026,703
Lake Herring	0	1,000	0	0	1,000
Lake Whitefish	13,644	44,343	2,200	40,932	101,119
Sunfish	55,133	49,716	32,666	10,940	148,455
Walleye	0	0	0	0	0
Yellow Perch	125,215	488,746	182,429	150,049	946,439

TABLE 2. OMNR commercial fishery buy-out programs on Lake Ontario, 1985-1988.

	Impact on Gill Net Fishery			
Quota Area	Licences Prior to 1985	Licences Purchased by MNR 1985-87	Licences Purchased by MNR 1988	Licences Remaining in 1989
1-1 (Brighton)	11	3	4	4
1-2 (Eastern Basin)	39	17	7	15
1-4 (North Channel)	36	10	9	17
Total	86	30	20	36

- Licenced gill net yardage reduced 42% (from 420,750m in 1984 to 178,750 m in 1989)
- Number of gill netting operations reduced 42% (from 55 in 1984 to 23 in 1989). A "gill netting operation" was defined as one or more gill netting licences held by a single licensee or partnership.

about the lack of an allocation to the commercial fishing for walleye or northern pike, pointing out that these were designated commercial species on other Great Lakes.

Other factors such as high contaminant levels in some Lake Ontario top predators influenced the range of options available for addressing the incidental catch situation.

Addressing Gill Netting Issues

Restructuring of the commercial fishery in the late 1980s involved reducing the number of participants and encouraging more biologically and socially acceptable harvesting methods. Fisheries managers tried to achieve a greater level of resource management control, particularly with respect to the commercial gill net fishery. This included several management actions:

Gill net reduction (buy-out) programs

Between May of 1985 and December of 1988, two buy-out programs were instituted by OMNR to purchase gill net licences and associated commercial fishing operations offered for sale (i.e. on a willing seller-willing buyer basis). The objectives of the buy-out programs were to more closely align the capacity of the industry with the biological capability of the fisheries resource, to reduce the incidental catch of non-target fish in gill nets and to reduce related conflicts among resource users.

MNR paid in excess of $2 million to commercial gill net fishermen to reduce the quantity of licensed gill net in eastern Lake Ontario. Over the three years of the program, 50 of the 86 gill net licences were purchased, reducing the quantity of licensed gill net by 58 per cent. Table 2 summarizes the results of the buy-outs.

Gear experimentation and conversion:

Commercial licence holders were encouraged to use alternative fishing gear (other than gill nets) through incentives such as extended fishing seasons, quota adjustments (e.g. walleye allocation to impounding gear licences) and various types of experimental permits.

Gill netting restrictions

Up until the 1980s, there were few seasonal limitations on the commercial gillnet fishery in waters outside the Bay of Quinte, with the exception of a few specific embayments or nearshore areas. Between 1985 and 1988, gill netting seasons were established to minimize incidental catch of non-target species such as trout, salmon and smallmouth bass in the Lake Ontario gill net fishery. For example, the setting of 4 ½ inch gill net for lake whitefish was permitted only during the late fall along the south shore of Prince Edward County; this was when the highest concentrations of whitefish occurred and the percentage of other, non-target species was lower than at other times of the year. The setting of small mesh gill nets for yellow perch was also restricted at times of the year when incidental catch was known to be significant.

The broad management objective of these measures was to allow the harvest of commercial fish stocks within biologically sustainable levels while minimizing adverse impacts on non-commercial species and promoting harmonious use among various users of the fishery resources.

The final 1989 commercial allocations are summarized in Table 3. These 1989 allocations reflect the quota reductions associated with the 1985 to 1988 buy-out programs. The resulting number of Lake Ontario commercial fishing licences is summarized in Table 4.

OMNR Management Approach Through the 1990s

Through a variety of incentives and regulatory/ licensing amendments, OMNR fishery managers tried to assist the industry in adjusting to the restructured fishery that resulted from the 1985-88 buy-out programs. Measures included increased quota allocations where stocks were improving (e.g. lake whitefish), greater flexibility in quota transfers, realignment of unused quota within the industry, and extended fishing seasons where feasible.

Fishery managers have tried to maintain an appropriate level of management control with respect to incidental catch of non-target fish species. At the same time, OMNR has worked with the industry to institute "test fishing" programs to monitor incidental catch levels associated with longer gill netting seasons.

Through the 1990s, in response to requests from the industry, season extensions were negotiated, with particular focus on whitefish and yellow perch gill netting seasons. These season adjustments were generally based on test fishing, on-board monitoring or field observations of incidental catch. Examples include:

- Earlier fall harvesting of lake whitefish in 4 ½ inch mesh gill nets in Quota Areas 2 and 4.
- The closed season for small mesh in the spring was discontinued in Quota Area 2, to allow year-round fishing for yellow perch.
- The harvest of walleye from trap nets in Quota Areas 1, 2, and 4 was significantly extended beyond the May-June experimental fishery originally established in 1989.

Commercial Allocation/ Quota Setting

Commercial allocations are adjusted annually through the quota system. In establishing annual quotas, OMNR managers attempt to find an appropriate balance among biological, social, and economic considerations, within the overall objective of resource sustainability.

The status of individual species/stocks of fish is the principal factor influencing quota decisions. The determination of stock status involves the review of available fisheries assessment information (e.g. index fishing, commercial catch sampling), trends in commercial harvests in preceding years, and input and observations from the local commercial licence holders. The interests of other resource users (i.e. aboriginal, recreational and tourism interests) are also considered in broad allocation decisions.

While the Ontario commercial fishing industry has generally accepted quota management as fundamental to sound fisheries management, the annual adjustment of quotas has been a continuing source of tension between Lake Ontario licence holders and fishery managers. Fishers have often resisted even modest reductions in allocation when fish stocks are in decline. On the other hand, local industry spokesmen have voiced concern

TABLE 4. Number of Lake Ontrario (excluding the St.Lawrence River) commercial fishing licences by gear type after the buy-out. Gill net licence may also include hooklines and impoundment gear. Imoundment licence may also include hooklines. Carp net licence authorizes only 8 inch or larger mesh.

	Number of Licences			
Quota Area	Gill Net	Hoop/ Trap Net	Hook-line	Carp Gill Net
1-1	4	9	1	5
1-2	15	16	7	2
1-3	0	18	6	14
1-4	15	2	2	1
1-8	3	2	0	0
Total	37	47	16	22

TABLE 3. The 1989 commercial fishing quotas in eastern Lake Ontario (lbs).

	Quota Area				
Species	1-1	1-2	1-3	1-4	Total
American Eel	47,405	270,662	100,185	44,446	462,698
Brown Bullhead	121,840	176,265	623,429	30,655	952,186
Lake Herring	1,800	5,600	0	3,400	10,800
Lake Whitefish	15,600	209,000	16,600	42,500	283,700
Sunfish	43,914	46,231	32,681	9,556	132,382
Walleye*	1,900	28,500	0	0	30,400
Yellow Perch	75,995	172,026	167,303	67,790	483,114

* commercial walleye quota established for impounding gear only in quota areas 1-1 and 1-2 in 1989.

that OMNR managers are too slow to respond with significant quota increases when fish populations are expanding.

Annual quotas and commercial harvests and landed value for the four principal quota species on Lake Ontario are summarized in Fig. 2 for the years 1980 to 2001. Detailed information for all commercially harvested species for years 1981, 1991 and 2001 is shown in Table 5.

Yellow Perch

Through the 1980s, yellow perch were the mainstay of the eastern Lake Ontario gill net fishery. Although yellow perch stocks declined through the 1980s and into the early 1990s, yellow perch remained an important component of the gill net fishery.

The 1985-88 buy-out programs reduced Lake Ontario yellow perch quotas from a peak of 946,000 lbs. in 1985 to 483,000 lbs. by 1989. In response to stock status concerns, perch quotas were further reduced each year between 1990 and 1996, reaching a low allocation of 235,000 lbs. in 1996. Quota increases after 1996 brought the total commercial allocation for Lake Ontario back over 440,000 lbs. by 2001. However, while some recovery of perch stocks was observed in Bay of Quinte and eastern basin perch populations after 1996, stocks of marketable perch in the Brighton and Middle Ground areas remained at depressed levels throughout the 1990s.

Whitefish and Herring

As recovery of some coregonid species progressed, commercial quotas were increased. In the late 1980s and early 1990s, lake whitefish populations were expanding dramatically from the low levels that followed the collapse of the 1950s. Beginning in 1990, significant increases in lake whitefish quota were allocated to the industry for several successive years. In 1996, the lake whitefish allocation peaked at over 800,000 lbs. At the request of the industry, quotas of lake herring and round whitefish were also allocated to reflect increased incidence of these species in

TABLE 5. Total harvest, price per pound, and landed value of commercially caught fish in Lake Ontario in years 1981, 1991 and 2001.

	1981			1991			2001		
	Harvest (lbs)	Price ($/lb)	Landed Value ($)	Harvest (lbs)	Price ($/lb)	Landed Value ($)	Harvest (lbs)	Price ($/lb)	Landed Value ($)
Bowfin	60	0.50	30	3,143	0.24	754	7,073	0.28	1,980
Brown bullhead	307,450	0.45	137,177	221,239	0.35	77,434	149,245	0.32	47,758
Carp	160,444	0.12	19,088	70,380	0.33	23,225	24,493	0.23	5,633
Channel catfish	110,950	0.15	16,097	25,668	0.31	7,957	8,713	0.30	2,614
Black crappie	27,523	0.62	17,148	12,463	1.49	18,554	9,146	2.16	19,755
Drum	906	0.13	117	28,952	0.17	5,020	64,258	0.15	9,639
American eel	239,776	1.05	252,636	213,202	1.37	292,709	24,815	2.13	52,856
Lake herring	5,318	0.47	2,504	9,126	0.47	4,305	1,441	0.28	403
Lake whitefish	1,655	1.03	1,699	262,758	0.74	193,596	224,898	0.73	164,176
Rock bass	19,308	0.23	4,431	12,435	0.29	3,620	11,478	0.57	6,542
Sunfish	131,255	0.41	54,114	51,103	0.35	18,119	83,368	1.00	83,368
Suckers	10,230	0.14	1,444	2,441	0.12	304	9,121	0.13	1,186
White bass	5,319	0.46	2,421	9,032	0.77	6,922	90	1.01	91
White perch				58,152	0.41	23,911	5,080	0.64	3,251
Walleye	3,113	1.21	3,761	25,179	1.43	30,559	18,302	2.01	36,787
Yellow perch	1,236,867	1.09	1,345,604	206,995	1.43	296,919	199,036	2.14	425,937
Coho salmon	55	0.00	0						
Smelt	74,301	0.30	21,946						
Pike	35,835	0.37	13,162						
Round whitefish	40	0.54	22						
Shad	678	0.09	58						
Sturgeon	661	2.40	1,587						
Lake trout	100	0.00	0						
TOTAL	2,371,844		1,895,044	1,212,268		1,003,909	840,557		861,978

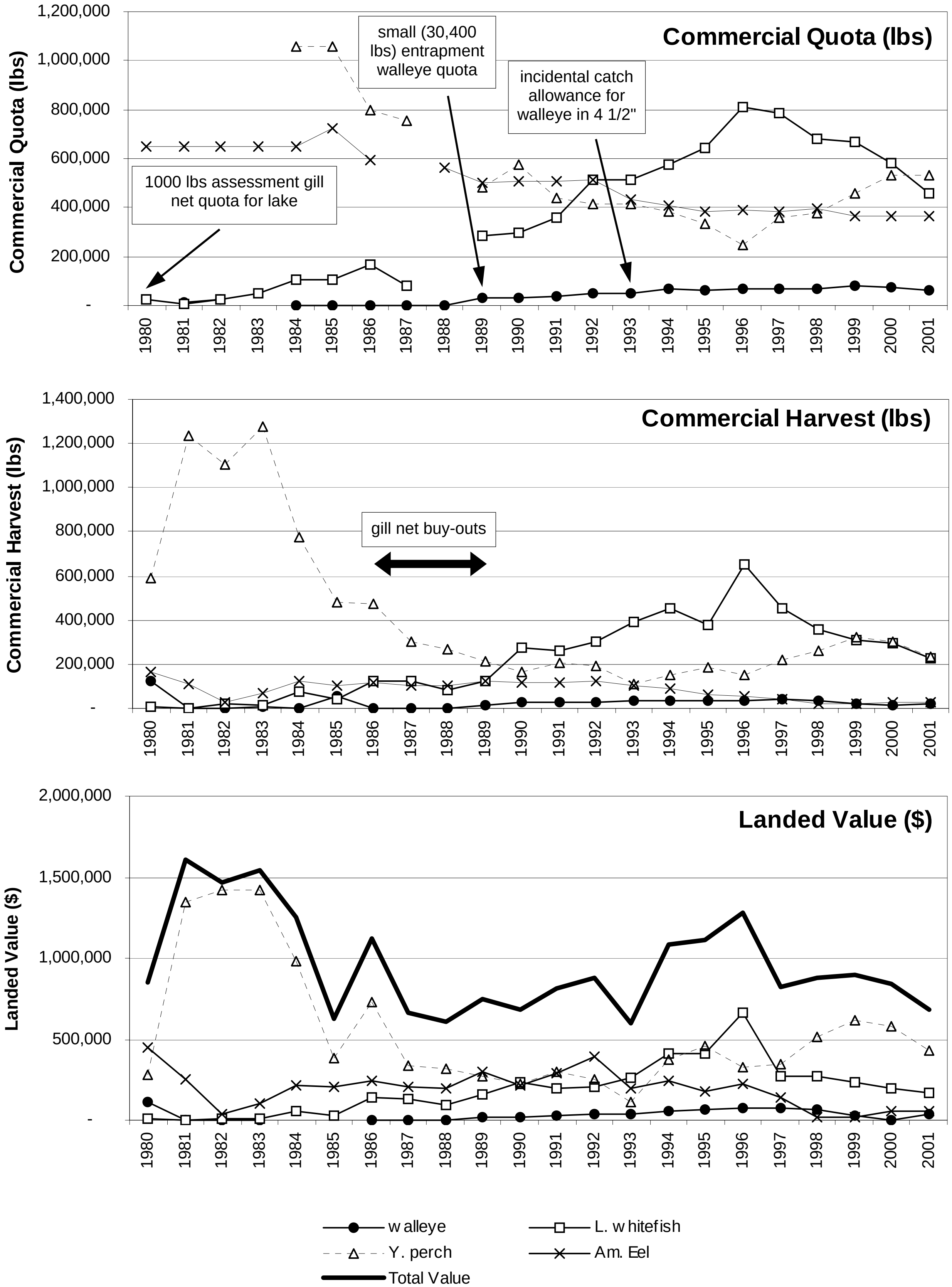

Figure 2. Commercial quota, harvest and landed value of four principal fish species of the Lake Ontario commercial fishery for the period of 1980-2001.

commercial catches.

Poor recruitment of whitefish stocks through the late 1990s has resulted in declining commercial whitefish harvests in recent years. By 2001, the commercial whitefish allocation was reduced to 450,000 lbs. Licence holders generally resisted quota reductions, and they have requested longer gill netting seasons to assist them in achieving former harvest levels.

American Eels

Precipitous declines in eel stocks through the 1990s have resulted in much lower harvests and diminished value to the commercial fishery. In 1989, commercial eel harvest from Lake Ontario exceeded 218,000 lbs. but by 2001 total eel harvest was less than 30,000 lbs. Since eels are taken in impounding gear and on hooklines, those fishers who converted from gill net to trap net operations have been particularly disadvantaged by the eel decline.

Largely at the urging of the industry, eel quotas remained relatively stable through the early 1990s. However, OMNR fishery assessment, research and management staff warned the industry of projected declines in the eel fishery. These projections were based primarily on the annual declines in the number of elvers ascending the eel ladder at the Moses Saunders Dam at Cornwall.

By 2001, OMNR fishery managers had reduced the Lake Ontario eel allocation to 182,000 lbs., reflecting the deteriorating status of eel populations. The industry has continued to oppose quota reductions for eel. Eels are catadromous. They are subject to a variety of environmental stresses (e.g. mortality at hydro-electric facilities, effects of global warming on ocean currents) and are commercially harvested in several jurisdictions. Lake Ontario commercial fishermen feel that harvest restrictions in Ontario waters will do nothing to address the larger issues facing Atlantic eel populations originating in the Sargasso Sea.

Through much of the 1980s, all Lake Ontario eels had to be exported (primarily to Europe) because of concerns about elevated contaminant levels. By the 1990s, as a result of updated contaminant testing, the sale of eels below 2.2 lbs. (1.0 kg.) was permitted on domestic Canadian markets. In 2000, based on recommendations by the CFIA and Health Canada, size restrictions were removed on eels sold within Canada.

Walleye

There has been no quota of walleye to the commercial gill net fishery since the stock collapse of the 1970s. Through the 1980s, as walleye stocks recovered in the Bay of Quinte and expanded out into eastern Lake Ontario, the commercial industry made repeated requests for a formal walleye allocation. On at least two occasions, licence holders instituted legal action in an effort to pressure OMNR to allocate walleye to the commercial gill net fishery (these actions did not proceed to court).

Beginning in 1989, an experimental allocation of 30,400 lbs. of walleye was made to commercial fishermen using live capture gear in eastern Lake Ontario. No walleye harvest was permitted within the Bay of Quinte upstream of the Glenora Ferry. The restricting of commercial walleye harvest to impounding gear was intended to encourage commercial fishermen to employ live capture gear in their operations, minimize incidental catch problems and allow the tailoring of walleye harvest to specific size ranges of fish.

As walleye populations in eastern lake Ontario and the Bay of Quinte expanded through the 1980s, incidental catch of walleye continued to be a significant issue. With increases in fishing effort and harvest of lake whitefish, the problem of mature walleye being caught in 4 ½ inch mesh gill nets was a particular cause of concern.

As a result of extensive discussions between OMNR and the commercial industry at both the local and provincial levels, an agreement was reached to institute incidental catch allowances for walleye in the gill net fishery for whitefish. The allowances were based on observations of past incidental walleye catches, and were calculated on a percentage of whitefish quotas for each gill net licence in Quota Areas 1-1 (12%), 1-2 (3%), and 1-4 (5%). These allowances were allocated to accommodate incidentally caught fish only; there was to be no targeting of walleye in gill nets. A slot-size limit was in effect. The initial 24 inch maximum size limit was intended to prevent the marketing of large walleye above the recommended contaminant level for unrestricted human consumption (the maximum size limit was changed to 23 inches in the late 1990s due to updated contaminant testing of large walleye done at the request of the industry).

Crappies

Crappies are harvested primarily in impounding gear, from Lake Ontario embayments (including West and East Lakes) and the Bay of Quinte. Quota management of crappies was instituted in 1993, in light of the high market value of the species and increasing interest of the angling fraternity in crappies. With the occasional exception in West and East Lakes, there have been few instances of commercial crappie quotas limiting commercial harvest. Habitat changes in the Bay of Quinte and adjoining waters may favour expansion of crappie populations and increase the importance of quota management for this species in the future.

Bullhead and Sunfish

Quota management of bullheads and sunfish was discontinued for the Lake Ontario and the Bay of Quinte in the early 1990s, as commercial harvest from large water bodies was not considered a major stress on these relatively low value commercial species. These species are not under quota management in the Ontario waters of other Great Lakes. Bullhead and sunfish remain under quota management in the enclosed embayments of Prince Edward County (e.g. East, West and Consecon Lakes, North and Pleasant Bay); this is consistent with the approach taken on other small inland waters in the province.

Other Fish Species

Other commercially harvested fish species, such as carp, channel catfish, white perch and freshwater drum have not been placed under quota management. In light of limited markets, low landed value and relatively modest harvest levels for these species, quota management has not been deemed necessary. However, some harvest restrictions (e.g. maximum size limit on channel catfish, closed season on carp in some Quota Areas) have been implemented as conditions of licence, where high contaminant levels have been documented.

Industry Cooperation

The importance of industry cooperation has been clearly conveyed to all licence holders, fish buyers and processors, and others associated with the Lake Ontario commercial fishery. Compliance with licence conditions and the importance of accurate record keeping are areas of special emphasis.

Daily Catch Reports (DCRs) were fully implemented on lake Ontario in 1995. Prior to that, most of the fishery used Monthly Harvest Reports (CF1s) to document their fishing activity. Section 61 Orders under the Fisheries Act have been widely used to require buyers and processors of Lake Ontario fish to report their transactions.

A commercial fish royalty was introduced across the province in 1993. The initial royalty of 2 per cent on the landed value of the catch generated annual revenues of about $25,000 from the Lake Ontario commercial fishery; this represented about 3 per cent of the total provincial royalties received from commercial fishing activity.

In 1998, OMNR and the Ontario Commercial Fisheries' Association (OCFA) negotiated a "New Business Relationship". Through this agreement, the OCFA took on responsibilities in the areas of royalty administration, data management, the Lake Erie port observer system and supplementary fisheries assessment. A portion of royalty revenues was returned to the OCFA to fund these new responsibilities.

The initiation of royalties and negotiation of a new business relationship reflect improved communications and cooperation between OMNR and the commercial fishing industry at the provincial level. However, declines in the Lake Ontario fishery through the late 1990s have resulted in continuing tensions at the local level, between fishers and OMNR fishery managers.

Future Challenges in Managing the Lake Ontario Commercial Fishery

Throughout its history, the Lake Ontario commercial fishery has been characterized by its instability as the fishery has constantly changed in response to ecological, economic and social pressures. While there have been dramatic shifts in fish species abundance and the scale and scope of commercial activity, the types of issues facing fisheries managers in the next few years will be similar in many ways to those of the last two decades.

Ecosystem change will continue to have a significant impact on the fishery. The invasion of exotic species (e.g. zebra mussel), the long-term effects of climate change (e.g. on water temperatures, water levels) and the physical alteration of fish habitat (e.g. land use, development) will result in further shifts in fish species composition and abundance. Human health concerns relating to elevated contaminant levels in some Lake Ontario fish species may well limit future management options.

Managing the Lake Ontario fishery for sustainability will require a careful balancing of conservation needs and the important economic and social benefits derived from fishing activity. This is evident in the ongoing discussions about the most appropriate management strategies for lake whitefish and American eel, both of which have experienced serious declines in abundance in recent years.

Conflicts among user groups (i.e. commercial, aboriginal, recreational and tourism interests) will be a major challenge. Allocation of those fish species of special interest to more than one user group, such as walleye, will be particularly controversial. Incidental catch (by-catch) associated with commercial fishing activity will continue to attract the attention of the recreational fishing fraternity and outdoor media.

Regulation and licensing of commercial fishing activity must consider a broad range of factors, including resource conservation requirements, enforceability, and the business needs of the commercial industry and individual licence holders. Commercial fishing licence conditions have become more complex over the years, as managers have attempted to address various conservation and enforcement concerns. The proliferation of licence conditions is seen by commercial fishermen as an unnecessary infringement on their ability to succeed as independent small businesses. The industry and OMNR managers agree in principle with the streamlining of commercial fishing licences on Lake Ontario; negotiating the simplification of licensing and associated restrictions will require constructive participation by both OMNR and industry representatives.

Ensuring compliance with licence conditions, regulations and reporting requirements will continue to be a priority for commercial fisheries enforcement activity on Lake Ontario. Strong industry support and the commitment of licence holders to adhere to “the rules of the game” will help ensure an effective compliance program.

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11

Genetic Origins of Walleye from New York Waters of Eastern Lake Ontario

Chris Wilson[1] and Alastair Mathers

Summary

This study used mitochondrial DNA (mtDNA) and microsatellite DNA to assess whether walleye collected from New York waters of eastern Lake Ontario originated from the Bay of Quinte or a separate spawning stock. Samples were collected by the Lake Ontario Management Unit (LOMU) and New York State Department of Environmental Conservation (NYSDEC) in 1999 from six sites and compared against Bay of Quinte and West Lake spawning stocks.

Both mtDNA and microsatellite analyses indicated that the walleye samples from New York originated from the Bay of Quinte stock. Sequence analysis of a 610-base segment of the mtDNA control region (D-loop) detected 14 haplotypes among the New York samples, all of which also occur within the Bay of Quinte. Analysis of microsatellite DNA loci showed comparable allelic diversity and allele frequencies between the New York and Bay of Quinte collections, with both being significantly different from the comparison population (West Lake).

Individual assignment tests showed that walleye collected in New York waters probably originated from the Bay of Quinte. By contrast, West Lake walleye were recognizably distinct, indicating that the close similarity between New York and Bay of Quinte walleye is not an artifact of low resolution of the genetic data.

In summary, no evidence of a separate stock was detected among the walleye sampled from New York, and the genetic data supports the hypothesis of their originating from the Bay of Quinte. Management decisions by NYSDEC and OMNR should factor in the movement of these fish and the potential effects of dual jurisdictional management.

Introduction

Concerns over the decline of walleye stocks in the lower Great Lakes transcend political borders. Eastern Lake Ontario walleye are harvested by fisheries in both Ontario waters (chapters 6 and 8 of this report) and New York waters (Eckert 2003). The sharp decline of walleye in eastern Lake Ontario has greatly impacted long-term commercial and recreational fisheries that help sustain local and regional economies. Although walleye stocks in Lake Ontario have undergone major fluctuations in the past (Schneider and Leach 1979), there is considerable concern over their current status and chances for recovery (Mills et al. 2003).

To determine whether walleye collected from eastern New York waters of Lake Ontario originated from the Bay of Quinte or a separate source, we used molecular genetic markers (mitochondrial DNA and microsatellite DNA) to characterize their genetic origins. These complementary sets of neutral genetic markers are highly effective in resolving the stock structure and diversity of fish populations, and are widely used to evaluate stock structure and dispersal (Carvalho and Hauser 1994). By comparing the genetic profiles of individual fish against population-level baseline data, it is possible to establish the genetic probability of individuals originating from a particular source with statistical certainty (Cornuet et al. 1999, Pritchard et al. 2000). To assess the origin of walleye captured in New York waters of eastern Lake Ontario, we tested the null hypothesis that walleye sampled from New York waters constituted a separate

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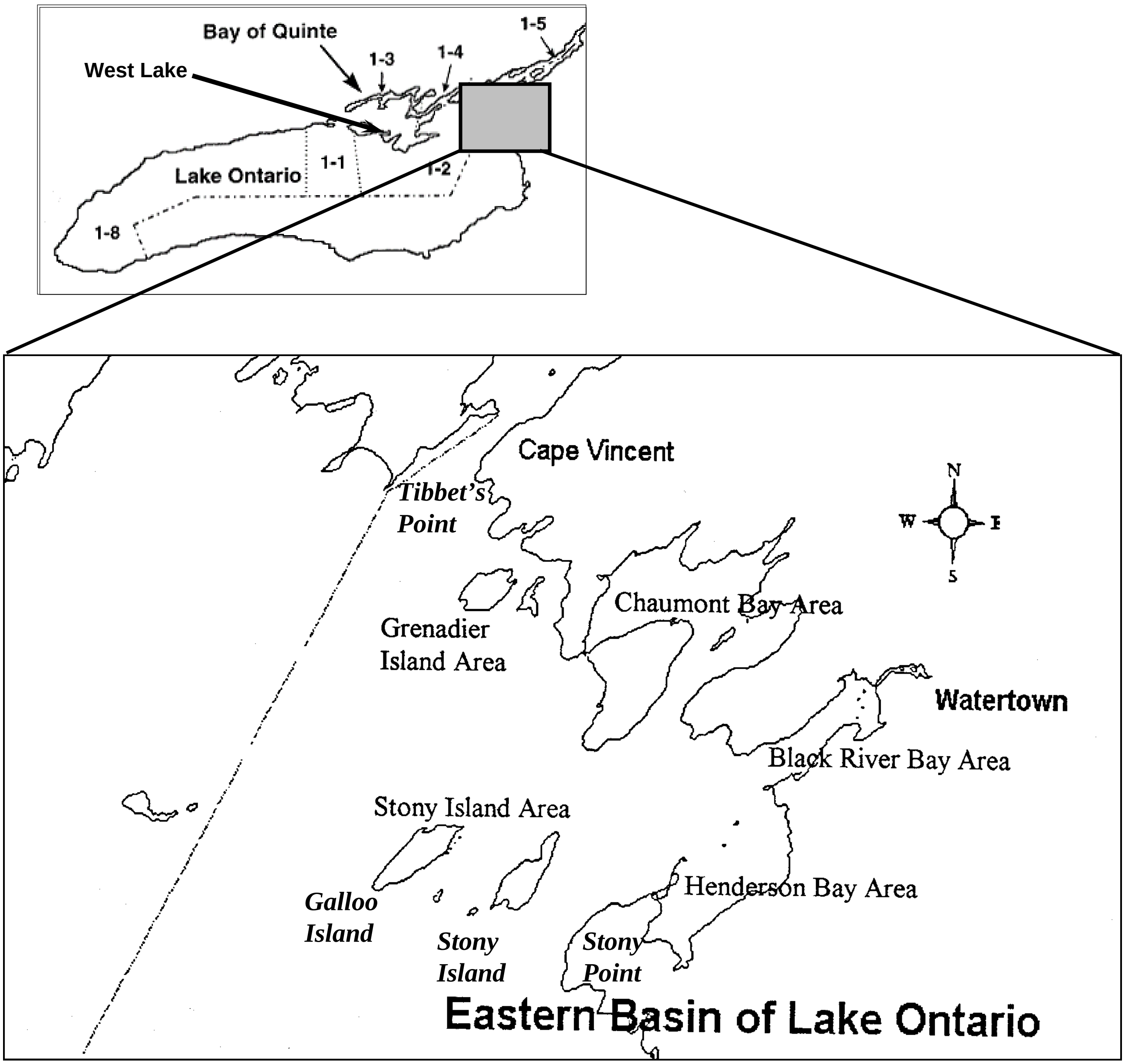

FIG. 1. Map of New York walleye sampling locations, showing their relative positions within Lake Ontario with respect to the Bay of Quinte.

stock that was genetically distinct from walleye from the Bay of Quinte. In order to provide a comparison, data from West Lake near the Bay of Quinte were also considered, as this population has been recognized as being closely related but recognizably distinct from the Bay of Quinte using mtDNA and microsatellite DNA markers (Wilson and Gatt 2001).

Methods

Tissue samples were obtained from walleye populations in New York waters of the eastern basin of Lake Ontario (Figure 1) by the New York State Department of Environmental Conservation (NYSDEC). Sample collections and sites are summarized in Table 1 and Figure 1. Walleye were captured in monofilament gillnet gangs during the first two weeks of August 1999 as part of the NYSDEC annual warm water assessment program (Eckert 2001). Finclip samples were take from adult fish and preserved individually in 80%

***TABLE 1.** Collection sites for walleye from eastern New York waters, showing numbers of walleye caught by sex.*

	No. males	No. females
Black River Bay / Henderson Bay	2	3
Chaumount Bay	1	3
Galloo Island.	6	5
Stony Island / Galloo Island	5	9
Stony Point	1	4
Tibbet's Point	0	6

ethanol and sent to the OMNR Fisheries Genetics laboratory in Peterborough for DNA extraction and analysis.

Genomic DNA was extracted and amplified from 20 mg of preserved fin tissue as described by Wilson and Gatt (2001). After regular organic extraction, genomic DNA was quantified and standardized to a working concentration of 8 ng/ ul. A 715-base portion of the mitochondrial DNA (mtDNA) control region or D-loop was amplified from walleye mtDNA via the polymerase chain reaction (PCR), using primers LN20 (Bernatchez et al. 1992) and HW1 (Gatt et al. 2000). This region is highly variable in walleye, and has been effective in identifying walleye stock structure in the Great Lakes (Faber and Stepien 1997, Stepien and Faber 1998, Gatt et al. 2000, 2002, Wilson and Gatt 2001). Each 25-L PCR contained sterile deionized water, 1X manufacturer buffer, 1.8 mM $MgCl_2$, 0.40 M of each primer, 0.30 mM dNTP's, 1.5 units *Taq* polymerase, and 8 ng of genomic DNA. Thermal cycling conditions were comprised of an initial denaturation step at 94C for 1 minute, followed by 30 cycles of 92C for 1 minute, 1 minute at 52C, and 1 minute at 72C, with a final extension time of 2 minutes at 72C. Amplified products were purified using the Qiagen QiaQuick PCR Purification Kit and verified via horizontal gel electrophoresis prior to being sequenced. Purified PCR product was sequenced using the HW1 primer with the Big Dye dye-terminator cycle sequencing kit (Applied BioSystems Inc.), using conditions recommended by the manufacturer. The thermal program for cycle sequencing was 2 minutes at 96C, followed by 25 cycles of 30 seconds at 96C, 15 seconds at 50C, and 4 minute at 60C. The resulting DNA sequences were electrophoresed in an ABI Prism 377 DNA Sequencer using 5% Long Ranger polyacrylamide gels. By using HW1 in the sequencing reaction we were able to resolve up to 630 bp near the 5' end in each of the walleye processed. Each electropherogram displayed heavy strand sequence that was then translated into the light strand sequence in BioEdit (Hall 1999) for analysis. Haplotypes were compared against known sequence variants (Faber and Stepien 1997, Stepien and Faber 1998, Gatt et al. 2000, 2002, Wilson and Gatt 2001) by local BLAST searches (Altschul et al. 1997) in BioEdit and visual alignment.

DNA from microsatellite loci was amplified in a multiplex PCR reaction using dye-labeled primers from five variable walleye-specific loci (*Svi* 2, 4, 6, 7, and 14; Borer et al. 1999). Each 10-L PCR contained sterile deionized water, 1X manufacturer buffer, 1.5 mM $MgCl_2$, 0.06 M *Svi* 2, 0.05 M *Svi* 4, 0.20 M *Svi* 6, 0.17 M *Svi* 7, 0.30 M *Svi* 14, 0.20 mM dNTP's, 0.75 units *Taq* polymerase, and 32 ng of genomic DNA. The thermal program was 2 minutes denaturation at 94C, followed by 30 cycles of 30 seconds at 94C, 1 minute at 60C, 2 minutes at 72C. A final extension time of 40 minutes at 72C was necessary to ensure clean PCR product. The amplified products were diluted to a volume of 80 L with sterile deionized water; 0.8 L of the diluted PCR product was then combined with 0.8 L of an internal lane standard composed of formamide, loading buffer, and ROX 500 size standard (Applied Biosystems Inc.). Microsatellite products were denatured at 96C for 2 minutes and then loaded (0.3-L) into a 5% Long Ranger gel and electrophoresed with an ABIPrism 377 DNA Sequencer. Alleles were scored using GenoTyper 2.0 (Applied Biosystems Inc.) and proofreading / confirmation using GeneScan3.1 (Applied Biosystems Inc.).

Statistical analysis

Differences in mitochondrial DNA haplotype composition (presence / absence and frequency differences) between New York samples and Ontario data (Bay of Quinte and West Bay; Wilson and Gatt 2001) were assessed with pairwise contingency X^2 tests (Roff and Bentzen 1989). Microsatellite DNA data from New York walleye was tested for conformity to Hardy-Weinberg equilibrium expectations using GenePop (Raymond and Rousset 1995). Pairwise genetic distances as well as genic and genotypic differentiation among the three putative populations were also assessed using GenePop.

In addition to using population data for assessing stock structure, individual assignment tests were run to match multilocus genotypes of individual walleye to the different sampling sites, based on within-population allele frequencies at the five microsatellite loci examined. Simulations and resampling statistics were calculated using the GeneClass program (Cornuet et al. 1999). Log-likelihood probabilities of source origin for individual samples were calculated for all putative sources (New York, Bay of Quinte and West Lake) using Bayesian resampling statistics of pooled data frequencies within each potential source (Cornuet et al. 1999). In addition, the significance of individual log-likelihood probabilities for walleye collected from New York waters were evaluated using a t-test of a single observation against a sample mean and variance (Sokal and Rohlf 1981), using the Bay of Quinte as the putative source. Under the null hypothesis that New York fish represent a distinct genetic population from Bay of Quinte walleye, walleye originating from a separate stock should show significantly different assignment probabilities.

Potential stock differences among sample sets were further evaluated using 'blind' clustering of multilocus microsatellite genotypes, independent of their sampling origin. The number of major cluster groups detected were used as analogs for stocks, and used as the input number of stocks / populations for the genetic assignment program Structure (Pritchard et al. 2000). Under the null hypothesis of separate stocks, walleye from each of the three sample sets should be recognizably distinct from fish from the other collections.

Results

A total of 45 walleye captured between August 9 and 17, 1999 at 6 sites in eastern New York waters of Lake Ontario were provided by NYSDEC personnel for analysis (Table 1, Figure 1). These fish tended to be large (average total length 623mm, standard deviation 86) and have a similar length distribution (Fig. 2) to walleye observed in MNR gillnets set in the Ontario waters of the Outlet Basin (Jim Hoyle, OMNR, pers. comm.). Comparative analysis of a 610 base control region sequence fragment detected 14 haplotypes among the 15 male and 30 female walleye provided, with no significant difference in haplotype composition by sex. All 14 haplotypes were previously detected among spawning walleye from the Bay of Quinte (Wilson and Gatt 2001). No statistical difference in haplotype composition was detected between New York walleye and the Bay of Quinte stock based on chi-square tests (Roff and Bentzen 1989).

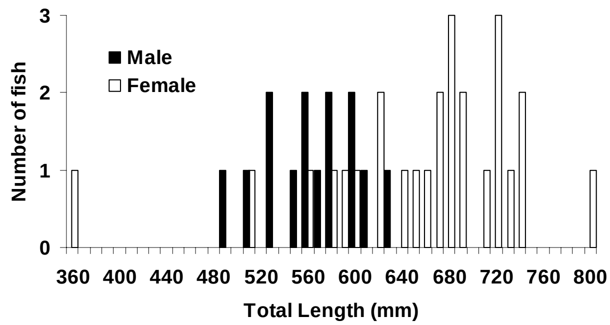

FIG. 2. *Frequency distribution of total lengths of walleye sampled from New York waters of eastern Lake Ontario.*

Results from the five microsatellite loci similarly failed to detect differences between New York and Bay of Quinte walleye (Figure 3). Although the pooled New York samples showed marginally significant genotypic differentiation from the Bay of Quinte stock, genic differentiation, which is based on allele frequencies, was not significant between the two sets. Walleye from West Lake, however, showed significant genic and genotypic differentiation from both New York and Bay of Quinte fish.

Log-likelihood probabilities of stock origin were calculated for all sampled walleye, using baseline data for the Bay of Quinte (Wilson and Gatt 2001) as a putative source. Walleye originating from a different source should show lower membership probabilities than individuals from the Bay of Quinte itself, indicating their separate origin. This was observed for walleye from West Lake (Figure 3), which had previously been shown to be closely related to but recognizably distinct from the Bay of Quinte stock (Wilson and Gatt 2001). By contrast, walleye from New York showed similar membership of likelihood probabilities for originating from the Bay of Quinte as walleye sampled from within the Bay. Pairwise t-tests of probability distributions for each population (one-tailed tests assuming unequal variances) showed no significant difference between New York and Bay of Quinte groups ($t = 0.79$; $p = 0.21$), whereas West Lake walleye showed a significantly different probability distribution ($t = 3.85$; $p < 0.0001$). Cluster analysis of multilocus genotypes also showed no difference between New York and Bay of Quinte walleye. Two major groups of genotypes were detected using UPGMA clustering (data not shown). When analysed with the Structure program (Pritchard et al. 2000), New York and Bay of Quinte walleye showed comparable membership probabilities, whereas the West Lake control walleye were largely separate.

Discussion

The genetic results strongly reject the null hypothesis of a separate stock origin for walleye collected in New York waters of eastern Lake Ontario. No evidence was observed to support the presence of a genetically distinct source for New York walleye; rather, all available evidence suggests that they originate from the spawning stock within the Bay of Quinte. Walleye from West Lake showed much clearer genetic differentiation.

It is unlikely that New York walleye originated from a New York-based stock that is genetically indistinguishable from the Bay of Quinte stock. Mitochondrial DNA has been widely used as a tool to detect stock structure in Great Lakes walleye (Billington et al. 1992, Stepien and Faber 1998, Gatt et al. 2000, 2002), however, in this study no genetic differentiation was detected between New York and Bay of Quinte walleye. Walleye stocks in other Great Lakes are recognizably distinct in the absence of continuous spawning or nursery habitat (Merker and Woodruff 1996, Stepien and Faber 1998, Gatt et al. 2002, Wilson et al. unpubl. data). This refutation is further supported by the distinctiveness of the West Lake population, despite its close relatedness and geographic proximity to the Bay of Quinte (Figure 3).

The genetic results concur with tagging and

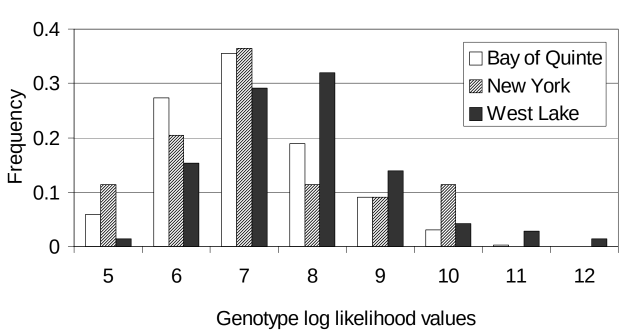

FIG. 3. *Log-likelihood probability distributions for multilocus microsatellite genotypes of walleye from the Bay of Quinte, West Lake, and New York waters, assuming the Bay of Quinte stock as the putative source.*

age class composition data that indicate the movement of larger walleye from the Bay of Quinte into eastern New York waters (J. Casselman, OMNR, pers. comm., Bowlby et al. 1991, Payne 1963). The good fit between the genetic results and tagging data supports the suggestion of Mills et al. (2003) that the presence of large walleye in New York waters and the upper St. Lawrence River results from their dispersion from the Bay of Quinte. Similar congruence between genetic and tagging data for quantifying walleye movement has been shown elsewhere (Todd and Haas 1993).

Based on these results, it appears that walleye from eastern New York waters originate from the Bay of Quinte, or put another way, that the same population (Bay of Quinte stock) is being harvested in two different jurisdictions. Harvest regulations on both sides of the border should take this into consideration. Furthermore, if walleye being caught in New York are primarily large adults, this fishing mortality should be recognized and quantified. As well as leading to improved predictive power for management models, recognition of joint harvesting and joint dependency on recruitment from the same source stock should encourage both MNR and NYSDEC to work closely together to help ensure the viability of the stock and its ability to support sustainable fisheries.

Acknowledgements

The OMNR Lake Ontario Management Unit funded this study. Brian Lantry (NYSDEC) coordinated the collection of the walleye samples. Mike Lavender was instrumental in collecting the genetic data and keeping the project running smoothly. John Casselman and Phil Ryan (OMNR) and Steve LaPan (NYSDEC) provided valuable input in several discussions.

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12

Atlantic Salmon Restoration in Lake Ontario

M. E. Daniels

Introduction

The Atlantic salmon was an important member of the original fish community in Lake Ontario. Habitat changes in the watershed during European settlement, most notably the construction of dams across spawning streams, led to the decline and eventual extirpation of Atlantic salmon by the late-1800s (Dymond 1965, Dunfield 1985).

Initial efforts by OMNR and NYSDEC to restore Atlantic salmon to selected Lake Ontario streams, through stocking of fall fingerlings and yearlings (Fig. 1), resulted in lower than expected returns of adults and few signs of natural reproduction (Abraham 1986 and 1987, OMNR 1995a). A long-term program to restore self-sustaining populations of Atlantic salmon to Lake Ontario was renewed by OMNR in 1995 (OMNR 1995b). Benchmarks were established to measure progress towards restoration.

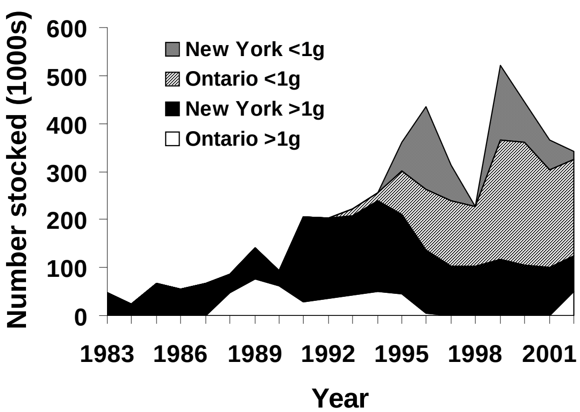

FIG. 1. Number of Atlantic salmon stocked in Ontario and New York State tributaries of Lake Ontario. Fish that are <1g are usually called fry.

Research

Research, to date, has been focused on evaluating the suitability of Lake Ontario streams for Atlantic salmon. Studies have been conducted by MNR and its partners to assess:

- Atlantic salmon spawning behavior,
- interactions between Atlantic salmon spawners and other salmonids,
- spawning substrate suitability,
- juvenile habitat suitability,
- embryo incubation,
- juvenile survival, and
- interspecific competition amongst juveniles.

Results from these studies were encouraging, and will be used to help assess the amount (and distribution) of suitable habitat for juvenile Atlantic salmon in Lake Ontario streams.

Some highlights from three of these studies are listed below.

Survival of stocked fry/interspecific competition (Stanfield and Jones, in press):

- densities of fall fingerlings exceeded the benchmark of 5 fish/100 m^2 at over half of the sites surveyed,
- parr or advanced fry (fish fed prior to release) had a higher survival rate to fall fingerling stage than those fish stocked as fry (fish released at swim-up, prior to feeding),
- amount of rock cover was the best predictor of densities of fall fingerlings for the parr-stocking strategy and was an important factor in the fry-stocking strategy,

- high numbers of rainbow trout juveniles reduced the survival of Atlantic salmon fry, suggesting competitive interactions,
- high quality habitat (good cover, low amounts of fine materials in the substrate) supported high densities of both Atlantic salmon and rainbow trout juveniles,

Spawning behaviour of hatchery-reared fish/ substrate suitability/embryo incubation (J. Fitzsimons, unpubl. data):

- redds containing viable eggs were built in several areas of the Credit and Humber Rivers, often in areas of low gradient (<1%); this may increase potential for sediment to accumulate in redds,
- most redds occurred in relatively close proximity to the release pools in pool-riffle or run-riffle transitional zones; eggs were deposited in shallow pockets (<15 cm), which increases potential for washout during high flows,
- over-winter survival of embryos decreased with increased time spent in the redd,
- preliminary results suggested that the amount of fine material, substrate permeability and oxygen levels in the redd environment were important factors governing successful incubation,
- while emergence was lower than in other streams with self-sustaining populations of Atlantic salmon, habitat conditions in parts of the Credit River were suitable for the production of Atlantic salmon, and
- stream-resident brown trout and hatchery-reared Atlantic salmon spawned about a month apart in the Credit River (late October and late November, respectively); genetic analyses did not show any superimposition of redds by these two species.

Spawner interactions (Scott et al 2003):

- A study of adult chinook salmon and Atlantic salmon interactions in small enclosures in Wilmot Creek suggested that Atlantic salmon activity was elevated, nest establishment was delayed and mortality was higher when chinook were present.

One of the greatest challenges to restoring Atlantic salmon may be a thiamine deficiency that results from a diet rich in alewife or smelt (Fitzsimons and Brown 1998, Honeyfield et al. 1998). Both of these non-native prey fish contain thiaminase, an enzyme that breaks down thiamine (vitamin B-1). Thiamine deficiency results in low reproductive success in salmonines, particularly Atlantic salmon, due to early mortality syndrome (Fisher et al. 1996). It also reduces prey avoidance and foraging ability of affected fry (Fitzsimons et al. 2002; Carvalho et al 2002), and may reduce migratory potential of adults (G. Ketola, unpubl. data) and increase mortality of adult fish (J. Fitzsimons, unpubl. data).

Fisheries

Atlantic salmon have not contributed significantly to the boat angling fishery, and harvest rates have declined in recent years (Fig. 2). No Atlantic salmon were observed in the boat fishery in 2002 (Bowlby 2003). Fewer Atlantic salmon were harvested than other salmonines due, at least in part, to relatively low stocking levels (Fig. 1). As well, sport fishing regulations restrict the harvest of Atlantic salmon in the lake to one fish over 63 cm (25 in) per day. Since Atlantic salmon were not encountered as frequently as other salmon and trout, they were also, at times, misidentified by anglers and technical personnel. Therefore, trends in harvest rates may not have reflected the true abundance of Atlantic salmon in Lake Ontario.

Conservation Status

A status report for Atlantic salmon is nearing completion and will be submitted to the Committee on the Status of Species at Risk in Ontario (COSSARO) in 2003, recommending a designation of “extirpated” for the Lake Ontario

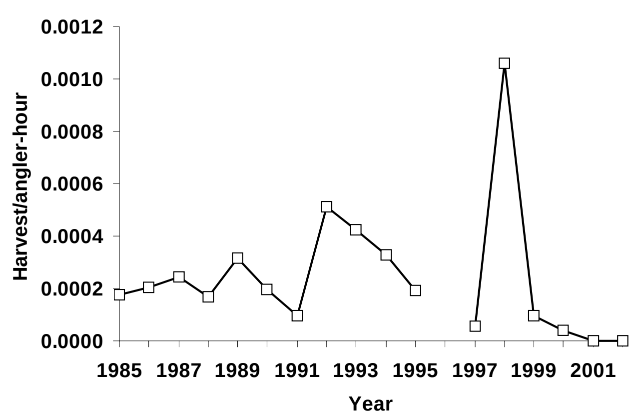

FIG. 2. Harvest rate of Atlantic salmon by Ontario boat anglers in Lake Ontario from April to September.

population. Having an official conservation status may broaden support for the program and provide access to additional resources that could be directed towards restoration.

Next steps

OMNR hosted a workshop in February 2003 to review the results of Atlantic salmon research to date and identify the challenges still facing us with respect to restoring self-sustaining populations of Atlantic salmon to Lake Ontario. The results of the workshop will provide the basis for revising the Atlantic salmon restoration plan and setting future directions for the program. Public input will be sought during an upcoming review of salmon and trout management.

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Appendix A

Fish stocked in the Province of Ontario in 2002

Atlantic salmon stocked in the province of Ontario in 2002.

SITE NAME	MONTH STOCKED	YEAR SPAWNED	HATCHERY/ SOURCE	STRAIN/ EGG SOURCE	AGE (MONTHS)	MEAN WT (G)	MARKS	NUMBER STOCKED
			ATLANTIC SALMON - EGGS					
SHELTER VALLEY CREEK								
Doig Property	11	2002	Partnership	LaHave/Normandale			None	17,000
	12	2002	Partnership	LaHave/Normandale			None	27,000
								44,000
			ATLANTIC SALMON - DELAYED FRY					
CREDIT RIVER								
Snows Creek - Gorge	5	2001	Partnership	LaHave/Normandale	2		None	50
W Credit - Belfountain	3	2001	Partnership	LaHave/Normandale	1	0.1	None	500
	4	2001	Partnership	LaHave/Normandale	2	0.2	None	4,961
								5,511
			ATLANTIC SALMON - ADVANCED FRY					
COBOURG BROOK								
Cobourg Lower	5	2001	Ringwood	LaHave/Normandale	6	0.8	None	24,000
Cobourg Middle	5	2001	Ringwood	LaHave/Normandale	6	0.8	None	17,239
Cobourg Top	5	2001	Ringwood	LaHave/Normandale	6	0.8	None	54,800
Lower Main	5	2001	Ringwood	LaHave/Normandale	6	0.8	None	12,300
Middle Main	5	2001	Ringwood	LaHave/Normandale	6	0.8	None	60,396
Top Main	5	2001	Ringwood	LaHave/Normandale	6	0.8	None	26,000
								194,735
			ATLANTIC SALMON - SPRING FINGERLINGS					
CREDIT RIVER								
Black Creek	5	2001	Partnership	LaHave/Normandale	4	1.9	None	**34,190**
			ATLANTIC SALMON - FALL FINGERLINGS					
CREDIT RIVER								
Inglewood	12	2001	Normandale	LaHave/Normandale	12	22.4	Ad	1,299
Forks of the Credit	9	2001	Ringwood	LaHave/Normandale	8	2.7	None	13,314
								14,613
			ATLANTIC SALMON - ADULTS					
BRONTE CREEK								
Lowville Park	10	1996	Codrington	LaHave/Normandale	72	3853	Floy Tag	32
Lowville Park	12	1999	Normandale	LaHave/Normandale	37		Floy Tag	8
								40
CREDIT RIVER								
Dr. Kauk Property	10	1996	Codrington	LaHave/Normandale	72	3151	Floy Tag	33
McLaughlin Rd Bridge	10	1996	Codrington	LaHave/Normandale	72	3310	Floy Tag	92
Trout Unlimited Area	10	1996	Codrington	LaHave/Normandale	72	3280	Floy Tag	56
Inglewood	12	1999	Normandale	LaHave/Normandale	37	947	None	99
Inglewood	12	1998	Normandale	LaHave/Normandale	49	1888	None	28
								308
LAKE ONTARIO								
Plaus Park	5	1998	Normandale	LaHave/Normandale	42	943	Floy Tag	**230**

TOTAL - ATLANTIC SALMON EGGS	**44,000**
TOTAL - ATLANTIC SALMON DELAYED FRY	**5,511**
TOTAL - ATLANTIC SALMON DELAYED FRY	**194,735**
TOTAL - ATLANTIC SALMON SPRING FINGERLINGS	**34,190**
TOTAL - ATLANTIC SALMON FALL FINGERLINGS	**14,613**
TOTAL - ATLANTIC SALMON ADULTS	**578**
TOTAL - ATLANTIC SALMON	**293,627**

Brown trout stocked in the province of Ontario in 2002.

SITE NAME	MONTH STOCKED	YEAR SPAWNED	HATCHERY/ SOURCE	STRAIN/ EGG SOURCE	AGE (MONTHS)	MEAN WT (G)	MARKS	NUMBER STOCKED
				BROWN TROUT - SPRING YEARLINGS				
DUFFIN CREEK								
401 Bridge	5	2000	Harwood	Ganaraska/ Normandale	18	68.1	Ad	**10,421**
LAKE ONTARIO								
Ashbridge's Bay Ramp	3	2000	Harwood	Ganaraska/ Normandale	16	49.5	Ad	6,752
	5	2000	Harwood	Ganaraska/ Normandale	18	70.6	Ad	9,416
Bluffer's Park	3	2000	Harwood	Ganaraska/ Normandale	16	51.4	Ad	6,750
	5	2000	Harwood	Ganaraska/ Normandale	18	65.7	Ad	9,796
Burlington Canal	2	2000	Normandale	Ganaraska/ Normandale	15	49.7	Ad	15,040
Fifty Point CA	2	2000	Normandale	Ganaraska/ Normandale	15	51.0	Ad	14,849
	4	2000	Normandale	Ganaraska/ Normandale	17	65.0	Ad	34,614
Finkle's Shore Ramp	5	2000	Harwood	Ganaraska/ Normandale	18	67.7	Ad	3,963
Humber Bay Park	5	2000	Normandale	Ganaraska/ Normandale	18	64.0	Ad	7,973
Lakeport	3	2000	Harwood	Ganaraska/ Normandale	16	56.7	Ad	6,761
	5	2000	Harwood	Ganaraska/ Normandale	18	69.1	Ad	3,732
Millhaven Wharf	3	2000	Harwood	Ganaraska/ Normandale	16	57.4	Ad	6,751
	5	2000	Harwood	Ganaraska/ Normandale	18	67.7	Ad	3,944
Oshawa Harbour	5	2000	Harwood	Ganaraska/ Normandale	18	64.9	Ad	10,041
Port Dalhousie East	5	2000	Normandale	Ganaraska/ Normandale	18	64.9	Ad	11,943
								152,325
TOTAL - BROWN TROUT								**162,746**

Chinook salmon stocked in the province of Ontario in 2002.

SITE NAME	MONTH STOCKED	YEAR SPAWNED	HATCHERY/ SOURCE	STRAIN/ EGG SOURCE	AGE (MONTHS)	MEAN WT (G)	MARKS	NUMBER STOCKED
				CHINOOK - SPRING FINGERLINGS				
COBOURG BROOK								
South of King St	1	2001	Partnership	Wild - Cobourg Br.	4	2.1	None	3,521
	4	2001	Partnership	Wild - Cobourg Br.	7	7.4	AdRP	2,237
								5,758
CREDIT RIVER								
Eldorado Park	4	2001	Ringwood	Wild - Credit R.	5	4.1	None	51,137
Huttonville	4	2001	Ringwood	Wild - Credit R.	5	4.0	None	50,855
Norval	4	2001	Ringwood	Wild - Credit R.	5	3.7	None	50,833
								152,825
LAKE ONTARIO								
Ashbridge's Bay Ramp	4	2001	Ringwood	Wild - Credit R.	5	3.5	None	11,044
	5	2001	Ringwood	Wild - Credit R.	6	4.7	None	29,273
Bluffer's Park	4	2001	Ringwood	Wild - Credit R.	5	3.5	None	37,149
	5	2001	Ringwood	Wild - Credit R.	6	4.6	None	51,395
Consecon	5	2001	Ringwood	Wild - Credit R.	6	5.0	None	26,581
Humber Bay Park	4	2001	Ringwood	Wild - Credit R.	5	4.7	None	50,964
Oshawa Harbour	4	2001	Ringwood	Wild - Credit R.	5	4.6	None	51,152
Port Dalhousie East	5	2001	Ringwood	Wild - Credit R.	6	4.8	None	107,504
Wellington Channel	5	2001	Ringwood	Wild - Credit R.	6	5.0	None	26,580
Whitby Harbour	4	2001	Ringwood	Wild - Credit R.	5	3.5	None	25,001
								416,643
TOTAL - CHINOOK SALMON								**575,226**

Coho salmon stocked in the province of Ontario in 2002.

SITE NAME	MONTH STOCKED	YEAR SPAWNED	HATCHERY/ SOURCE	STRAIN/ EGG SOURCE	AGE (MONTHS)	MEAN WT (G)	MARKS	NUMBER STOCKED
				COHO - FALL FINGERLINGS				
CREDIT RIVER								
Eldorado Park	10	2001	Ringwood	Wild - Salmon R.	10	19.0	AdRV	30,785
Huttonville	10	2001	Ringwood	Wild - Salmon R.	10	17.4	AdRV	30,785
Norval	10	2001	Ringwood	Wild - Salmon R.	10	18.8	AdRV	30,784
								92,354
				COHO - SPRING YEARLINGS				
CREDIT RIVER								
Eldorado Park	2	2000	Ringwood	Wild - Credit R.	13	18.8	Ad	14,506
	3	2000	Ringwood	Wild - Salmon R.	15	20.1	RV	13,879
Huttonville	1	2000	Ringwood	Wild - Credit R.	12	14.6	Ad	14,463
	2	2000	Ringwood	Wild - Credit R.	13	19.8	Ad	14,500
Norval	3	2000	Ringwood	Wild - Salmon R.	15	19.6	RV	28,179
								85,527
TOTAL - COHO FALL FINGERLINGS								**92,354**
TOTAL - COHO SPRING YEARLINGS								**85,527**
TOTAL - COHO SALMON								**177,881**

Lake trout stocked in the province of Ontario in 2002.

SITE NAME	MONTH STOCKED	YEAR SPAWNED	HATCHERY/ SOURCE	STRAIN/ EGG SOURCE	AGE (MONTHS)	MEAN WT (G)	MARKS	NUMBER STOCKED
LAKE TROUT - SPRING YEARLINGS								
LAKE ONTARIO								
Cobourg Harbour Pier	4	2000	Harwood	Michipicoten Island/Dorion	18	35.3	AdLV	32,662
	4	2000	Harwood	Seneca Lake/ Harwood	15	29.3	AdLV	65,477
	4	2000	Harwood	Slate Islands/ Dorion	17	27.3	AdLV	37,720
	5	2000	Harwood	Seneca Lake/ Harwood	15	32.7	AdLV	18,593
Fifty Point CA	3	2000	Harwood	Seneca Lake/ Harwood	14	35.6	AdLV	17,269
	5	2000	Harwood	Mishibishu Lakes/ Tarentorus	18	39.9	AdLV	16,430
	5	2000	Harwood	Seneca Lake/ Harwood	16	30.2	AdLV	20,037
Lakeport	4	2000	Harwood	Michipicoten Island/Dorion	18	37.5	AdLV	32,530
	4	2000	Harwood	Seneca Lake/ Harwood	15	29.4	AdLV	76,788
	4	2000	Harwood	Slate Islands/ Dorion	17	29.2	AdLV	21,446
	5	2000	Harwood	Seneca Lake/ Harwood	16	30.9	AdLV	19,668
Loyalist Cove Marina	5	2000	Harwood	Seneca Lake/ Harwood	16	33.5	AdLV	18,050
Millhaven Wharf	5	2000	Harwood	Seneca Lake/ Harwood	16	30.8	AdLV	19,581
Napanee Water Station	5	2000	Harwood	Mishibishu Lakes/ Tarentorus	18	36.9	AdLV	43,571
	5	2000	Harwood	Seneca Lake/ Harwood	16	35.2	AdLV	4,758
TOTAL - LAKE TROUT								**444,580**

Rainbow trout stocked in the province of Ontario in 2002.

SITE NAME	MONTH STOCKED	YEAR SPAWNED	HATCHERY/ SOURCE	STRAIN/ EGG SOURCE	AGE (MONTHS)	MEAN WT (G)	MARKS	NUMBER STOCKED
				RAINBOW TROUT - FRY				
CREDIT RIVER								
Black Creek	6	2002	Partnership	Wild - Credit R.	1		None	25,000
Papermill Dam	6	2002	Partnership	Wild - Credit R.	1		None	124,100
Silver Creek	6	2002	Partnership	Wild - Credit R.	1		None	80,000
								229,100
ROUGE RIVER								
Berczy Creek	6	2002	Partnership	Wild - Rouge R.			None	6,000
Little Rouge River	6	2002	Partnership	Wild - Rouge R.			None	8,000
Robinson Creek	6	2002	Partnership	Wild - Rouge R.			None	3,500
Silver Spring Farms	6	2002	Partnership	Wild - Rouge R.			None	2,500
								20,000
				RAINBOW TROUT - SPRING YEARLINGS				
HUMBER RIVER								
E Branch Islington Ave	5	2001	Normandale	Ganaraska/ Normandale	14	18.6	RV	15,136
E Branch Mill Rd	5	2001	Normandale	Ganaraska/ Normandale	14	19.5	RV	6,399
								21,535
LAKE ONTARIO								
Fifty Point CA	4	2001	Normandale	Ganaraska/ Normandale	13	16.0	RV	100,625
Glenora	5	2001	Harwood	Ganaraska/ Normandale	14	30.2	RV	8,908
Long Pt - P.E. Bay	5	2001	Harwood	Ganaraska/ Normandale	14	29.7	RV	5,882
Millhaven Wharf	5	2001	Harwood	Ganaraska/ Normandale	14	31.1	RV	6,877
								122,292
TOTAL - RAINBOW TROUT FRY								**249,100**
TOTAL - RAINBOW TROUT SPRING YEARLINGS								**143,827**
TOTAL - RAINBOW TROUT								**392,927**

Walleye stocked in the province of Ontario in 2002.

SITE NAME	MONTH STOCKED	YEAR SPAWNED	HATCHERY/ SOURCE	STRAIN/ EGG SOURCE	AGE (MONTHS)	MEAN WT (G)	MARKS	NUMBER STOCKED
			WALLEYE - FRY					
ST. LAWRENCE RIVER								
Gananoque River	5	2002	Partnership	Wild - Napanee R.	1	0.1	None	100,000
	7	2002	Partnership	Wild - Napanee R.	2	2.5	None	100
								100,100
			WALLEYE - FINGERLINGS					
ST. LAWRENCE RIVER								
Gananoque River	9	2002	Partnership	Wild - Napanee R.	5	50.0	None	**300**
TOTAL - WALLEYE FRY								**100,100**
TOTAL - WALLEYE FINGERLINGS								**300**
TOTAL - WALLEYE								**100,400**

Appendix B

Catches in the index netting program in eastern Lake Ontario and the Bay of Quinte in 2002

Species-specific catch-per-gillnet, northeastern Lake Ontario, 2002.

	Brighton					Middle Ground	Wellington				
Species/Site Depth (m)	08	13	18	23	28	05	08	13	18	23	28
Alewife	2,051.3	222.8	271.7	315.2	671.8	5.4	282.6	38.0	21.7	432.6	888.7
Black crappie	-	-	-	-	-	-	-	-	-	-	-
Bluegill	-	-	-	-	-	-	-	-	-	-	-
Brown bullhead	3.3	3.3	-	-	-	3.3	3.3	-	-	-	-
Brown trout	-	-	-	-	-	-	1.6	4.9	-	3.3	-
Burbot	-	-	-	-	-	-	-	-	-	4.9	3.3
Channel catfish	-	-	-	-	-	-	-	-	-	-	-
Chinook salmon	-	3.3	4.9	3.3	-	-	-	-	6.6	-	-
Freshwater drum	-	-	-	-	-	1.6	-	1.6	-	-	-
Gizzard shad	-	-	-	-	-	-	-	-	-	-	-
Lake chub	-	-	-	-	-	-	-	-	-	-	-
Lake herring	-	-	-	-	-	-	-	-	-	-	-
Lake trout	1.6	1.6	6.6	3.3	21.4	-	3.3	14.8	18.1	16.4	19.7
Lake whitefish	-	-	-	-	-	-	-	-	1.6	-	-
Longnose gar	-	-	-	-	-	-	-	-	-	-	-
Northern pike	-	-	-	-	-	-	-	-	-	-	-
Pumpkinseed	-	-	-	-	-	-	-	-	-	-	-
Rainbow smelt	-	-	-	-	-	-	-	-	-	-	-
Rock bass	10.4	-	-	-	-	1.6	-	-	-	-	-
Round goby	-	-	-	-	-	-	-	-	-	-	-
Round whitefish	-	-	-	6.6	1.6	-	-	-	-	-	-
Smallmouth bass	-	-	-	-	-	-	-	-	-	-	-
Stonecat	-	-	-	-	-	-	-	-	-	-	-
Walleye	4.9	-	-	-	-	3.3	3.3	-	-	-	-
White bass	-	-	-	-	-	-	-	-	-	-	-
White perch	-	-	-	-	-	-	-	-	-	-	-
White sucker	-	1.6	1.6	-	-	20.2	-	-	-	-	-
Yellow perch	16.3	-	-	-	-	400.7	191.0	12.0	-	1.6	-

Species-specific catch-per-gillnet, northeastern Lake Ontario, 2002 (continued).

	Rocky Point								
Species/Site Depth (m)	08	13	18	23	28	40	60	80	100
Alewife	164.7	639.2	1,219.0	1,110.3	1,525.0	-	6.6	-	3.3
Black crappie	-	-	-	-	-	-	-	-	-
Bluegill	-	-	-	-	-	-	-	-	-
Brown bullhead	-	-	-	-	-	-	-	-	-
Brown trout	1.6	28.0	3.3	4.9	1.6	-	-	-	-
Burbot	-	-	1.6	6.6	3.3	-	-	-	-
Channel catfish	-	-	-	-	-	-	-	-	-
Chinook salmon	-	-	-	-	3.3	-	-	-	-
Freshwater drum	1.6	-	-	-	-	-	-	-	-
Gizzard shad	-	-	-	-	-	-	-	-	-
Lake chub	-	-	5.4	-	-	-	-	-	-
Lake herring	-	-	-	-	-	3.3	-	-	-
Lake trout	-	1.6	1.6	6.6	16.4	-	92.1	44.4	28.0
Lake whitefish	-	-	-	-	-	-	-	-	-
Longnose gar	-	-	-	-	-	-	-	-	-
Northern pike	-	-	-	-	-	-	-	-	-
Pumpkinseed	-	-	-	-	-	-	-	-	-
Rainbow smelt	-	-	-	-	-	1.6	1.6	-	1.6
Rock bass	17.4	-	-	-	-	-	-	-	-
Round goby	-	-	-	-	-	-	-	-	-
Round whitefish	-	-	-	-	-	-	-	-	-
Smallmouth bass	13.2	8.2	-	-	-	-	-	-	-
Stonecat	5.4	-	-	-	-	-	-	-	-
Walleye	3.3	4.9	-	-	-	-	-	-	-
White bass	-	-	-	-	-	-	-	-	-
White perch	-	-	-	-	-	-	-	-	-
White sucker	-	-	-	-	-	-	-	-	-
Yellow perch	-	-	-	-	-	-	-	-	-

Species-specific catch-per-gillnet, Kingston Basin, Lake Ontario, 2002.

	Kingston Basin		Flatt Point				
Species/Site Depth (m)	30 (02)	30 (06)	08	13	18	23	28
Alewife	1.6	3.8	77.7	-	87.0	5.4	-
Black crappie	-	-	-	-	-	-	-
Bluegill	-	-	-	-	-	-	-
Brown bullhead	-	-	1.6	-	-	-	-
Brown trout	-	0.5	-	-	-	-	-
Burbot	-	0.5	-	-	-	-	-
Channel catfish	-	-	-	-	-	-	-
Chinook salmon	-	-	-	-	-	-	-
Freshwater drum	-	-	-	-	-	-	-
Gizzard shad	-	-	-	-	-	-	-
Lake chub	-	-	-	-	-	-	-
Lake herring	-	-	-	-	-	-	-
Lake trout	4.9	15.4	-	1.6	1.6	4.9	16.4
Lake whitefish	2.7	2.7	-	-	1.6	21.4	66.3
Longnose gar	-	-	-	-	-	-	-
Northern pike	-	-	-	-	-	-	-
Pumpkinseed	-	-	-	-	-	-	-
Rainbow smelt	-	-	-	-	-	-	-
Rock bass	-	-	-	-	1.6	-	-
Round goby	-	-	-	-	-	-	-
Round whitefish	-	-	-	-	-	-	-
Smallmouth bass	-	-	1.6	1.6	-	-	-
Stonecat	-	-	1.6	-	-	-	-
Walleye	-	-	-	-	-	-	-
White bass	-	-	-	-	-	-	-
White perch	-	-	-	-	-	-	-
White sucker	-	-	9.9	4.9	-	-	-
Yellow perch	1.8	-	129.2	27.2	8.7	-	-

Species-specific catch-per-gillnet, Kingston Basin, Lake Ontario, 2002 (continued).

	Grape Island					Melville Shoal				
Species/Site Depth (m)	08	13	18	23	28	08	13	18	23	28
Alewife	244.6	173.9	70.7	5.4	-	447.3	113.6	260.9	375.0	92.4
Black crappie	-	-	-	-	-	-	-	-	-	-
Bluegill	-	-	-	-	-	-	-	-	-	-
Brown bullhead	-	-	-	-	-	-	-	-	-	-
Brown trout	-	-	-	-	-	-	-	-	-	-
Burbot	-	-	1.6	1.6	-	-	-	-	-	-
Channel catfish	-	-	-	-	-	-	-	-	-	-
Chinook salmon	-	-	-	-	-	-	-	-	-	-
Freshwater drum	-	-	-	-	-	-	-	-	-	-
Gizzard shad	-	-	-	-	-	-	-	-	-	-
Lake chub	-	-	-	-	-	-	-	-	-	-
Lake herring	-	-	-	-	-	-	-	-	-	-
Lake trout	-	-	-	8.7	9.9	-	-	1.6	-	-
Lake whitefish	-	-	3.3	-	3.3	-	-	-	3.3	3.3
Longnose gar	-	-	-	-	-	-	-	-	-	-
Northern pike	-	-	-	-	-	1.6	-	1.6	-	-
Pumpkinseed	-	-	-	-	-	-	-	-	-	-
Rainbow smelt	-	-	-	-	-	-	-	-	-	-
Rock bass	-	1.6	-	-	-	27.2	4.9	-	-	-
Round goby	-	-	-	-	-	-	-	-	-	-
Round whitefish	-	-	-	-	-	-	-	-	-	-
Smallmouth bass	7.1	8.7	-	-	-	1.6	4.9	1.6	-	-
Stonecat	-	5.4	-	-	-	-	14.2	-	-	-
Walleye	1.6	1.6	-	-	-	120.1	6.6	-	1.6	-
White bass	-	-	-	-	-	-	-	-	-	-
White perch	-	-	-	-	-	-	-	-	-	-
White sucker	-	-	-	-	-	-	-	-	-	-
Yellow perch	260.1	300.5	75.6	7.1	5.4	75.6	599.0	141.6	52.2	5.4

Species-specific catch-per-gillnet, Bay of Quinte, Lake Ontario, 2002.

	Big Bay	Hay Bay		Conway				
Species/Site Depth (m)	05	08	13	08	13	20	30	45
Alewife	5.8	31.3	75.7	19.7	51.0	23.0	-	1.6
Black crappie	2.5	-	-	-	-	-	-	-
Bluegill	24.7	-	-	-	-	-	-	-
Brown bullhead	36.2	1.6	-	-	-	-	-	-
Brown trout	-	-	-	-	-	-	1.6	-
Burbot	-	-	-	-	-	-	-	-
Channel catfish	0.8	-	-	-	1.6	-	-	-
Chinook salmon	-	-	-	-	-	-	-	-
Freshwater drum	48.5	41.1	-	3.3	-	-	-	-
Gizzard shad	43.6	3.3	-	-	-	-	-	-
Lake chub	-	-	-	-	-	-	-	-
Lake herring	-	-	1.6	-	-	-	-	-
Lake trout	-	-	-	-	-	3.3	42.8	29.6
Lake whitefish	-	-	-	-	-	1.6	3.3	3.3
Longnose gar	6.6	-	-	-	-	-	-	-
Northern pike	0.8	1.6	-	-	-	-	-	-
Pumpkinseed	54.3	13.2	-	1.6	-	-	-	-
Rainbow smelt	-	-	3.3	-	-	-	-	-
Rock bass	-	-	-	23.0	6.6	-	-	-
Round goby	-	-	3.3	-	24.7	8.2	-	-
Round whitefish	-	-	-	-	-	-	-	-
Smallmouth bass	-	1.6	-	-	-	-	-	-
Stonecat	-	-	-	-	1.6	-	-	-
Walleye	50.2	44.4	4.9	34.5	11.5	1.6	-	-
White bass	0.8	-	-	-	-	-	-	-
White perch	239.3	70.7	-	-	1.6	-	-	-
White sucker	60.9	18.1	19.7	14.8	28.0	39.5	3.3	-
Yellow perch	1,203.1	611.8	863.5	940.8	876.6	578.9	153.0	-

Species-specific catch-per-trawl, Lake Ontario (Kingston Basin and Rocky Point) and Bay of Quinte, 2002.

	Kingston Basin			Rocky Point	Bay of Quinte					
Species/Site	EB02	EB03	EB06	RP01	Trenton	Belleville	Big Bay	Deseronto	Hay Bay	Conway
Alewife	20.8	21.4	0.3	0.8	98.6	74.5	223.2	47.9	21.1	-
American eel	-	-	-	-	-	-	0.1	0.1	-	-
Black crappie	-	-	-	-	-	-	0.5	0.6	-	-
Bluegill	-	-	-	-	0.5	0.5	13.6	0.1	-	-
Brook silverside	-	-	-	-	-	0.5	-	-	-	-
Brown bullhead	-	-	-	-	3.5	10.9	32.6	10.6	15.8	-
Brown trout	-	-	-	-	-	-	-	-	-	0.1
Channel catfish	-	-	-	-	-	0.1	0.1	-	-	-
Common carp	-	-	-	-	0.3	0.1	-	-	-	-
Freshwater drum	-	-	-	-	3.6	58.3	24.4	1.9	4.9	-
Gizzard shad	-	-	-	-	6.4	234.6	52.3	20.9	0.1	-
Johnny darter	-	-	-	-	7.3	2.1	0.3	-	1.8	-
Lake herring	-	-	-	-	-	-	-	-	-	0.3
Lake trout	0.1	-	0.1	-	-	-	-	-	-	0.3
Lake whitefish	-	-	0.2	0.3	-	-	-	-	-	1.0
Largemouth bass	-	-	-	-	2.9	0.4	0.3	1.1	1.8	-
Lepomis sp.	-	-	-	-	64.6	88.4	67.9	-	-	-
Logperch	-	-	-	-	-	0.5	-	0.1	-	-
Northern pike	-	-	-	-	-	-	0.1	-	-	-
Pumpkinseed	-	-	-	-	32.3	5.1	64.1	17.5	11.9	-
Rainbow smelt	7.9	207.5	6.8	75.3	-	-	-	-	-	39.6
Rock bass	-	-	-	-	0.6	-	0.1	1.8	-	-
Round goby	-	-	-	-	-	1.6	0.1	11.5	1.3	0.5
Slimy sculpin	0.6	0.3	-	0.3	-	-	-	-	-	-
Smallmouth bass	-	-	-	-	0.3	0.1	0.3	0.1	1.3	-
Spottail shiner	-	-	-	-	60.9	21.5	63.6	25.0	54.0	-
Threespine stickleback	34.4	680.3	47.8	-	-	-	-	-	-	-
Trout-perch	-	592.2	-	-	0.5	5.5	9.1	7.5	2.8	58.2
Walleye	-	-	-	-	3.6	0.8	6.1	2.9	3.3	-
White bass	-	-	-	-	0.1	3.0	2.1	-	-	-
White perch	-	-	-	-	19.9	155.5	793.2	194.9	132.6	-
White sucker	-	-	-	-	1.6	0.4	2.9	0.4	0.1	28.8
Yellow perch	-	-	-	-	238.4	53.3	153.5	555.4	856.9	182.5