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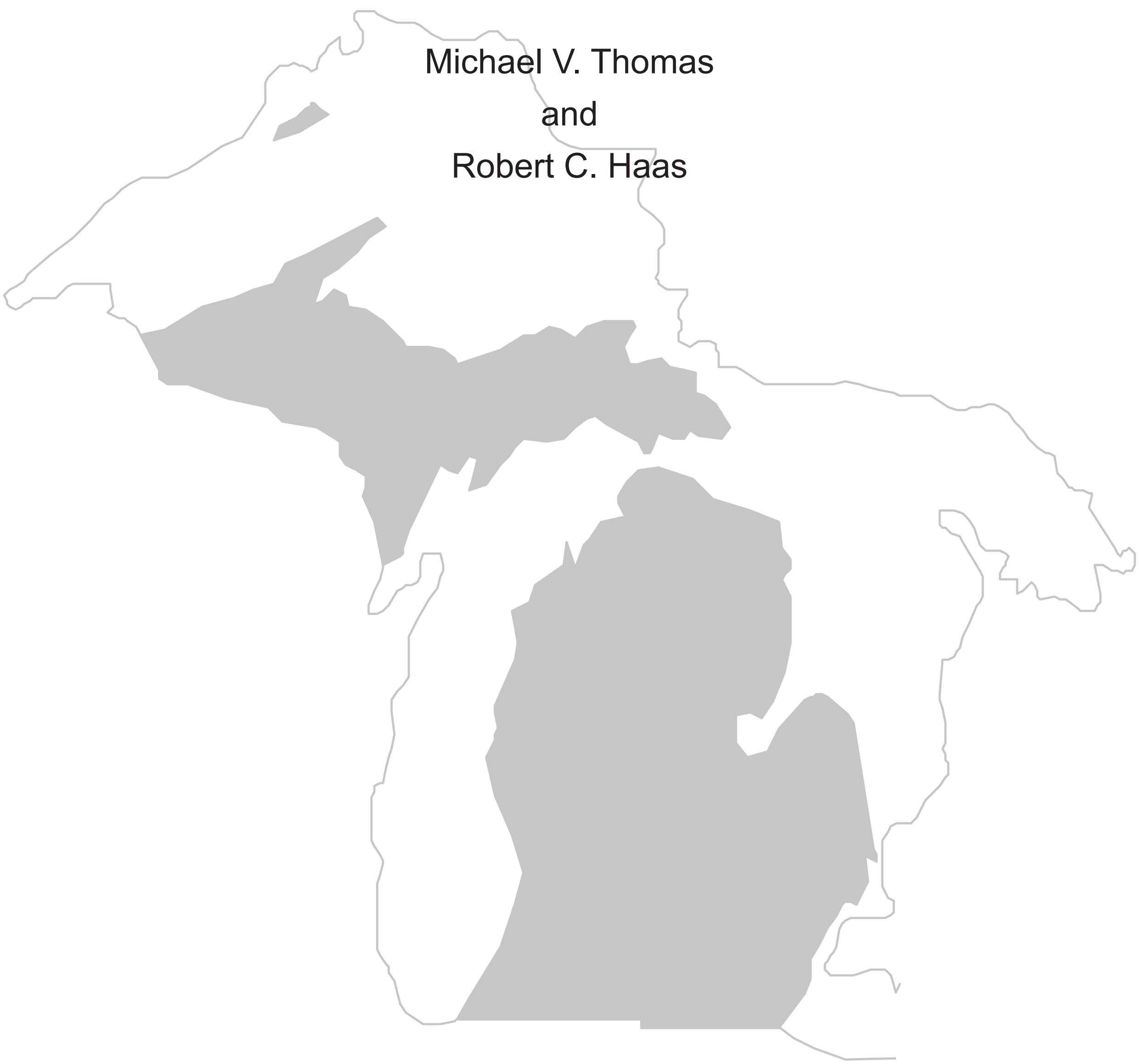

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Status of Yellow Perch and Walleye in Michigan Waters of Lake Erie, 1999–2003

Michael V. Thomas and Robert C. Haas

Michigan Department of Natural Resources
Lake St. Clair Fisheries Research Station
33135 S. River Road
Harrison Township, MI 48045

Abstract.–We investigated population dynamics of yellow perch *Perca flavescens* and walleye *Sander vitreus* in Michigan waters of Lake Erie. This study was conducted from 1999 to 2003, but information from previous years is considered in the analyses. Results of index trap-net and gill-net surveys, catch-at-age analysis of survey and sport fishery data, and walleye tag-recapture data were examined. For yellow perch, index trap-net data suggested an increase in abundance. Similarly, catch-at-age analysis indicated yellow perch abundance increased markedly after 1995. Catch-at-age analysis produced mean estimates for survival (0.57), instantaneous fishing mortality (0.16), and annual exploitation (0.14) for yellow perch in Michigan waters of Lake Erie. For walleye, index trap-net data revealed no trend in walleye abundance during the period. However, index gill-net data suggested a steady decline in walleye abundance from 2000 to 2003. Catch-at-age analysis for walleye indicated a general decline in the abundance of age-2 and older fish after 1996, with abundances of less than 20 million fish estimated for 1997, 1999, 2000, and 2002. Catch-at-age analysis produced mean estimates of survival (0.55), instantaneous fishing mortality (0.29), and annual exploitation (0.16). Analysis of Michigan, Ohio, and Ontario walleye tag-recapture data for 1999–2003 also produced mean estimates of walleye survival (0.59), instantaneous fishing mortality (0.16), annual exploitation rate (0.13), as well as natural mortality (0.36). A possible factor in the differences between the two sets of parameter estimates for walleye was the wider geographic area included in the tag recovery analysis. Maps of walleye tag recovery data showed strong northward and eastward movement patterns. Walleyes tagged near Monroe showed very similar movement patterns compared to tagging sites in Ohio and Ontario. Based on the results of this study, management actions recommended for Lake Erie percids included: no change in existing Michigan sport fishing regulations for yellow perch, continued restrictive sport fishing regulations for walleye until recruitment improves, and repeat an interagency reward tag study of walleye on a regular 5-year cycle.

Introduction

Walleye *Sander vitreus* and yellow perch *Perca flavescens* have been the highest valued sport and commercial species in Lake Erie over the last 50 years. In Michigan waters of Lake Erie, walleye and yellow perch routinely account for over 80% of the total number of fish harvested by the sport fishery. Sport angling pressure in Michigan waters of Lake Erie ranged from 2 to 4 million hours annually from 1986 to 1990 (Rakoczy 1992; Rakoczy and Rogers 1987, 1988, 1990, 1991), but declined to about 1 million angler hours annually from 1991 to 1994

(Rakoczy and Svoboda 1997). These percid fisheries clearly represent a resource of great importance to Michigan anglers, with significant socioeconomic benefits for all of southeast Michigan.

Since the mid-1970s, both species have been managed lakewide under an interagency quota system. Under the auspices of the Great Lakes Fisheries Commission's Lake Erie Committee, biologists and administrators from Michigan, New York, Ohio, Ontario, and Pennsylvania work together to set annual harvest quotas for yellow perch and walleye that will ensure continued viability of both fisheries into the future. The annual harvest allocations are largely based on stock assessment efforts of the Walleye Task Group and Yellow Perch Task Group. Success of this management system depends on accurate assessment of harvest and effort, abundance trends, and survival rates by each agency for fish stocks in its waters of Lake Erie.

The Michigan Department of Natural Resources (MDNR) began an annual assessment of walleye and yellow perch populations in Lake Erie in 1978. Ultimately the goal of the Michigan assessment efforts on Lake Erie is to support science-based management of the shared fishery resources. Bryant (1984), Haas et al. (1988), Thomas and Haas (1994), and Thomas and Haas (2000) have previously reported on results of this assessment program for various time periods. While this report focuses on the assessment program from 1999 to 2003, we found it both relevant and necessary to present the results in the context of the longer historical data series whenever possible. Our purpose was to examine trends in abundance, growth, and survival rates for yellow perch and walleye in Michigan's waters of Lake Erie. Movement patterns of walleye based on tag-recovery data were also examined.

Methods

Net Samples

Trap nets set in the spring provided abundance data on age-2 and older walleye and yellow perch. Gill nets, set in the fall, provided data on the abundance of yearling and older walleye. Standardized gill net sets can also provide indices of relative year-class strength (Willis 1987). Impoundment gear (trap net) is generally considered to be superior for studying relative abundance of species (Yeh 1977; Craig 1980); however, traps must be fished for extended time periods, which is expensive. We examined the relative year-class strength indices for walleye from both gear types because gear selectivity influences the size distribution of the sample.

Trap nets were used to capture walleye for tagging and to provide an index of walleye and yellow perch relative abundance (catch-per-unit effort, CPUE, as number of fish caught per 24 hours or trap day). This method assumes that CPUE is linearly related to fish abundance, and that a percent change in abundance will be reflected in the same percent change in CPUE (Bannerot and Austin 1983). We captured walleye and yellow perch with trap nets fished each year at the same locations off Monroe, Michigan (Figure 1). GPS was used to locate the same sampling locations each year. The trap nets had 1.8-m deep pots of 5.1-cm stretch mesh, 7.6-cm stretch mesh hearts and wings, and 91.4-m long leads of 10.2-cm stretch mesh. Five nets were fished throughout each sample period and were normally tended four or five times each week. The nets were typically set in early April and fished through the end of the month. We tried to obtain a minimum of 50 net lifts each year. However, due to vessel repairs, spring sampling in 1995, 2001, and 2003 was delayed 4–6 weeks and the number of net lifts was reduced. As a result, trap net catches during these years were not strictly comparable with the rest of the time series.

The entire catch from each trap net was identified and enumerated. Size data and scales (for age interpretation) were collected from walleye and yellow perch. Trap nets fished an average of 52 hours between lifts. Catch-per-net-lift data for yellow perch and walleye were standardized to catch per 24-hour period by dividing the catch per net lift by the hours fished, then multiplying by 24.

We fished multifilament, graded-mesh gill nets at two to four stations (Figure 1) in October in 1978–2003 as part of the Great Lakes Fishery Commission interagency yearling walleye index program. Replicate sets were made each year with gangs of nets, 1.83-m deep, each consisting of seven 30.48-m long panels that ranged from 51 to 127-mm stretched-mesh measure by 13-mm intervals. The gill nets were canned (suspended from the surface) on strings 0.91-m long. All walleye captured in gill nets each year were measured and aged using scale samples.

We also developed a ranking system for the 1974–2002 walleye year classes. Each year class was ranked using three criteria: cumulative Michigan survey trap-net CPUE, cumulative Michigan survey gill-net CPUE, and cumulative harvest, including all sport and commercial harvests for the western and central basins. The ranks for the three criteria were equally weighted. For a given year class, ranks for the three criteria were averaged to arrive at a mean rank.

Catch-Age Analysis

Abundance, instantaneous fishing mortality rate, and annual survival rate were estimated for yellow perch and walleye with catch-age modeling by the Walleye Task Group and Yellow Perch Task Group of the Lake Erie Committee. Custom catch-age models were developed by the task groups with AD Model Builder (ADMB, Otter Research Ltd. 1999). For yellow perch, Michigan recreational harvest and effort data were included in a model for the western basin yellow perch population, along with harvest, effort, and survey data for Ontario and Ohio (Belore et al. 2004). For walleye, the model incorporated harvest, effort, and survey data for Michigan, Ontario, and Ohio (Haas et al. 2004). Both models combined recreational and commercial catch-age data with survey catch-age data to arrive at stable and reliable estimates of historical and current stock size. This was an improvement over the traditional virtual population analysis because multiple gear types (including assessment, sport, and commercial fishing gear) and auxiliary information on fishing effort are explicitly considered in the model. Deriso et al. (1985) found that bias was substantially reduced when auxiliary information, such as effort data and survey catches, was included in the analysis. We estimated total annual exploitation by dividing the observed annual harvest by the estimated abundance.

Michigan sport fishery harvest and effort data for both species were available through an on-site creel survey conducted annually under another study. Biological data including length, weight, and scale samples for age analysis were collected from a representative subsample of the observed harvest by on-site creel clerks during all years except 1990. The age composition of Michigan's sport fishery harvest in 1990 was assumed to be the same as that estimated for Ohio's 1990 sport fishery based on creel survey data. The Michigan sport fishery harvest and targeted effort data used in the yellow perch and walleye ADMB catch-age analysis are shown in Appendices 3 and 4.

Tag-Recapture Study

Walleye were tagged by MDNR personnel during spring trap-net surveys from 1978 to 2003 in Lake Erie near Monroe. During some years spawning walleye were also collected by electrofishing in the lower Huron River near Flat Rock, Michigan. Upon capture, walleye were immediately placed in an on-board live tank equipped with continuously circulating lake water. Fish were removed individually from the live tank and tagged. Total length measurements were made on all tagged fish, while total weight measurements were taken from 36% to 100% of the total number tagged. Scale samples were taken from all walleye tagged. All fish under 600 mm were tagged with size 10 or 12 monel metal strap tags affixed by overlapping the tag snugly around the dentary bone of the lower jaw. Fish over 600 mm were tagged with size 12 monel metal strap tags affixed by overlapping the tag snugly around both the maxillary and premaxillary bones of the upper jaw. All tags were inscribed with the Lake St. Clair Fisheries Research Station address (MDNR, Mt. C., 48045) and an individual tag number. We tagged 7,067 walleyes at the Monroe site and 1,073 at the Huron River site from 1999 to 2003. Tag-recapture data were solicited from anglers and commercial fishermen on a voluntary basis.

Tag recovery data were summarized by location and calendar day and mapped using ArcView© geographic information system software. Dates of tagging and tag recovery for recaptured walleye were summarized by calendar day and thus were independent of the calendar year.

A generalized stochastic model, referred to as the ESTIMATE model (Brownie et al. 1985), was used to analyze the results of the tag-recapture study. This model provided unbiased maximum likelihood estimates of recovery and survival rates. Since the tag-recovery rate is a product of the exploitation rate and the reporting rate (Krementz et al. 1987), total mortality (natural logarithm of survival rate) may be partitioned into fishing and natural mortality rates if an estimate of the tag reporting rate is available (Horsted 1963). The z-statistic (Brownie et al. 1985) was used to compare annual tag recovery rate estimates.

In many studies the reporting rate is assumed to be 100%, that is, all tags recovered by the fisheries are seen and subsequently reported. If 100% reporting is assumed, then the recovery rate is an estimate of the exploitation rate. More likely, reporting rate is less than 100% and may vary over time (Rawstron 1971), space (Chadwick 1968; Henny and Burnham 1976; Reeves 1979; Green et al. 1983), or other factors (Rawstron 1971; Green et al. 1983).

If an independent estimate of the exploitation rate is available, the fishing mortality rate may be computed. However, fishing mortality rate is underestimated whenever the assumption of complete reporting is violated. Estimation of the exploitation and fishing mortality rates will be most reliable when reporting rates are high. Unfortunately, high reporting rates are difficult to ensure. Presumably, monetary rewards or prizes are incentives for anglers and commercial fishermen to report their tagged catch. A reward tag study, funded by the Ontario Ministry of Natural Resources, was begun in 1990 to provide an estimate of the non-reporting rate for traditional non-reward tags for Lake Erie walleye. Reward tags, carrying a reward inscription of $100 US, were randomly applied to 10% of the walleye tagged by Ontario, Ohio, and Michigan in 1990. The return rate of reward versus non-reward tags provided an estimate of the reporting rate for non-reward tags assuming that 100% of reward tags were reported. In 1999, the 1990–99 cumulative non-reporting rate based on the 1990 tagging was 2.73 non-reward tags for every reward tag reported.

The reward tag program was replicated in 2000 to provide an updated non-reporting rate. Funding for the $100 US tags was provided by the U.S. agencies (New York, Pennsylvania, Ohio, and Michigan). Reward tags were applied to 10% of the walleyes tagged at the Chicken and Hen Island site in Ontario, the Lackawanna and Van Buren Bay sites in New York, the Grand River and Sandusky Bay sites in Ohio, and the Raisin River site in Michigan (Table 13). Anglers reported catching 240 non-reward and 75 reward tags from the 2000 tagged population during the 2000, 2001, 2002, and 2003 fishing seasons combined. The non-reporting ratio for anglers was 2.80 which was nearly identical to the 2.73 value calculated from the long-term recovery data from the 1990 reward study. However, commercial operators reported 88 reward tags and only 50 non-reward tags, resulting in a non-reporting ratio of 15.76. This was much higher than any non-reporting ratios encountered during the 1990–99 period, suggesting that the commercial operators, during 2000, 2001, 2002, and 2003, dramatically altered how frequently they reported non-reward tags. These data were not used to calculate a new non-reporting ratio because they need to be adjusted for this change in reporting behavior. The reporting pattern for the reward tags may provide a basis for adjusting the non-reward tag numbers.

Results

Net Samples

Forty-four species of fish were identified from trap-net and gill-net catches in Lake Erie since the assessment program began in the late 1970s. Appendix 1 lists fish species collected with both types of nets since 1978.

Yellow perch relative abundance, as indicated by trap-net CPUE, declined sharply after 1989 and remained low through 1998 (Table 1). A slight improvement in yellow perch relative abundance was evident in 2002, with the highest total trap-net CPUE (40.2) since 1989. This recovery was largely a result of strong recruitment in 1996–98, as evidenced by elevated catch rates for ages 4–6 in 2002. The mean yellow perch CPUE during the 1990s was about 6 times lower than the mean from 1978 to 1989 (Appendix 2). Based on catch per net lift, the five years from 1994 to 1998 ranked among the seven lowest for perch abundance since 1978. During 1999, 2000, and 2002, yellow perch CPUE increased, with the 2002 CPUE of 74.5 the highest annual mean value since 1991. Length-at-age for scale-sampled yellow perch caught in trap nets during 1995–2002 is shown in Table 2. In general, no trend in length-at-age is obvious over this time period.

Walleye abundance as indicated by catch per 24-hour trap-net set varied over the study period, with the highest abundance in 2002 (Table 3). The lowest abundance value for the period was in 1995 and probably was a result of the delayed sampling period that year. Age-specific CPUE values throughout the study period demonstrated the annual variability in recruitment experienced by Lake Erie walleye. Year-classes characterized by low abundance such as the 1992 and 1995 year classes resulted in consistently low CPUE for the corresponding age groups in each subsequent year. Alternatively, strong year classes such as 1986 and 1996 were characterized by high CPUE each year for the corresponding age group. Mean age of walleye captured in trap nets increased from 4.2 years in 1989 to 5.4 years in 1993 as the abundant 1986 year class matured. Since 1997, mean age has remained below 5.0, as proportionally fewer old fish remained in the population. Overall, sex-specific length-at-age (Table 4) for trap-net caught walleye exhibited no apparent change over the study period.

Walleye abundance as indicated by total catch per multifilament gill-net lift declined from 2000 to 2003 (Table 5), reaching the lowest level for the study period at 42.1 fish per net lift. Yearling walleye catch rates indicated very poor recruitment in 2002, 2000, and 1995 and these have resulted in lower overall population abundance.

Sex-specific length-at-age (Table 6) for gill-net-caught walleye exhibited no apparent trends over the study period. Mean length-at-age for the 1996 year class as age-1 fish in 1997 was quite low. In fact, the 1996 year class exhibited the lowest mean length-at-age for yearlings of any year class in the 1978–2003 study period (Table 7).

Mean ranks were assigned to the 1974–2002 year classes (Table 8), although the latter were not completely recruited to the trap nets or fishery harvests. The top 10 year classes were 1982, 1986, 1985, 1991, 1984, 1996, 1993, 1994, 1987, 1977, and 1990. It is noteworthy that 4 of the top 5 year classes produced during this study period fell within the 5-year span from 1982 to 1986.

Catch-at-Age Analysis

Estimates of mean instantaneous fishing mortality (*F*), annual survival, and total abundance were derived with ADMB catch-age models for yellow perch and walleye. The estimates for western basin yellow perch, along with the observed combined catch and total exploitation, are presented in Table 9. Fishing mortality was high and survival was low from 1989 through 1993, but survival increased (as *F* declined) and remained above 0.50 from 1994 through 2003. Annual exploitation was highest at 0.619 in 1990, but declined after 1994, and reached a low point of 0.088 in 2001. Over the study period, the population abundance declined drastically from 1989 to 1990, and remained below 20 million fish through 1994. Since 1994, the population has increased with estimates of abundance exceeding 50 million fish each year from 2000 to 2003. Average parameter values during the study period (1999–2003) were: survival, 0.57; instantaneous fishing mortality, 0.16; annual exploitation, 0.14; abundance, 63,093,200 fish; and harvest, 8,206,266 fish.

Estimates of lakewide walleye mean instantaneous fishing mortality, annual survival, exploitation by gear type, total abundance, and catch are presented in Table 10. Estimated numerical abundance declined 70% between 1989 and 1997, but harvest only declined 33%. As a result, exploitation peaked at 0.31 in 1997 and remained above 0.20 through 2000. Quota reductions greatly restricted harvest from 2001 to 2003, and consequently, exploitation declined. However, despite decreased exploitation and increased survival, estimated abundance remained under 30 million fish. Average parameter values during the study period (1999–2003) were: survival, 0.55; instantaneous fishing mortality, 0.29; annual exploitation, 0.16; abundance, 21,290,492 fish; and harvest, 3,301,744 fish.

Tag-Recapture Study

Commercial and sport fishermen caught and reported a total of 509 tagged walleye from the Monroe site from 1999 through 2003. Low numbers of walleye had been tagged at Monroe in 2001 (94 fish) due to mechanical problems with our survey boat and in 2003 (438 fish) due to low fish abundance. Additional tag data for 1999 through 2003 were available from Ohio and Ontario tag sites through the cooperative interagency tagging study. A total of 4,080 tagged fish from Ohio and Ontario sites were caught and reported through 2003. The majority of the tag recoveries reported came from anglers. There appears to be ample angling harvest throughout the area to provide enough voluntary tag recoveries to adequately monitor exploitation and movements of the tagged stocks.

The geographical distribution of Michigan, Ohio, and Ontario tag recaptures varied slightly during the study period from 1999 to 2003 and remained very similar to the Monroe tag site for 1994–98 (Table 11). The percentage of recoveries reported from Lake Erie waters stayed above 70%, with modest switches between the Central and Eastern basins from year to year. Recoveries were reported from all months, with 70% reported during the months of April (13.4%), May (13.4%), June (25.1%), and July (18.2%). The spatial distribution of Monroe tag recaptures from 1999 to 2003 by season is shown in Figure 2.

Comparison of the spatial distribution of tag recoveries from the Monroe and the combined Ohio and Ontario Lake Erie tag sites is made in Figure 3. The geographical centers (centroids) for these comparisons are similar, with recapture centroid for Monroe walleyes (longitude 82.8191 degrees; latitude 42.0195 degrees) slightly north and west of the combined Ohio and Ontario fish (longitude 82.2101 degrees; latitude 41.9103 degrees).

Walleye tag-recovery data from Michigan, Ohio, and Ontario were analyzed to estimate annual rates for tag recovery and survival during the period from 1999 to 2003. Michigan, Ohio, and Ontario non-reward tag recovery data for that period are shown in Appendix 5. All parameter estimates were taken from Model 1 of the computer program ESTIMATE (Brownie et al. 1985) under the assumption that survival and reporting rates were year-specific. Model 1 was more compatible with all data sets than three alternative models and probably produced the least biased estimates. Another assumption was made that all tag recoveries attributable to the 2003 fishing year had been received so that the recovery rate estimates for 2003 were comparable to those for prior years (occasionally some tags are reported a year or two after the fish were caught). Analysis of the tag recovery data produced an estimate for mean annual survival of 59.35% and mean recovery rate of 4.50% (Table 12).

The reward tag study conducted in year 2000 produced an estimate of reward/non-reward tag recovery ratio of 2.798 for walleyes tagged at Michigan, Ohio, and Ontario sites (Table 13).

Instantaneous natural mortality (*M*) was estimated according to the relationship:

$$M = Z - uZ/A$$

where Z is the instantaneous total mortality, u is the exploitation rate, A is the total mortality rate, and F is the instantaneous fishing mortality rate which is equal to uZ/A for Type II Fisheries (Ricker 1975).

A value for u of 12.6% was generated by multiplying the mean recovery rate (4.503) by the reward/non-reward ratio (2.80). The resulting values were 0.36 for M and 0.16 for F. It is important to note that survival rate estimates from the program "ESTIMATE" are independent of recovery rates; thus, expansion of the tag recovery rate by reward/non-reward ratios would not alter survival rate estimates in any way. The estimated annual tag recovery rate (and exploitation) varied without trend from 1999 to 2003 (Table 12). The z-statistics were significantly different for 5 of 10 comparisons (Table 14).

Discussion

Yellow Perch

Trap-net CPUE for yellow perch suggested that yellow perch abundance in Michigan's waters of Lake Erie was high in the late 1970s and early 1980s, then declined to a low period from 1994 to 1998. Abundance then increased from 1999 to 2002. These trends in yellow perch abundance appear roughly synchronized with the colonization of the lake by several exotic species. White perch invaded Lake Erie in the 1970s, but their abundance exploded in the mid-1980s (Boileau 1985), possibly as a result of warmer climatic conditions (Johnson and Evans 1990). As white perch abundance increased through the 1980s, yellow perch abundance declined. Zebra mussels colonized the lake by 1989 (Griffiths et al. 1991) and increased in abundance through the early 1990s. Yellow perch abundance declined further and white perch abundance appeared to level-off and begin oscillating at a lower level. Round gobies invaded the lake around 1994, and became widely established across the central and western basins by 1998 (Johnson et al. 2001). This invasion was accompanied by increased yellow perch CPUE in trap nets from 1999 to 2002. While these fluctuations in yellow perch abundance seem related to exotic species introductions, another factor may have been equally important. Ludsin et al. (2001) identified oligotrophication, due to phosphorous abatement program successes, as the key factor in fish community changes in Lake Erie between 1969 and 1996. In the case of yellow perch, we suggest that oligotrophication and trophic shifts due to zebra mussel filtering and round goby predation on zebra mussels have played a role in changing yellow perch abundance in western Lake Erie.

Results of catch-age modeling indicate that exploitation was also a major factor in declining population abundance for yellow perch from 1989 to 1993. Exploitation was greater than 50% in 1989 and 1990, and remained above 25% through 1994, while abundance declined. After 1994, yellow perch abundance gradually recovered, while harvest quotas were held low enough to keep mean exploitation from 1999 to 2003 at 0.14. The peak abundance was estimated at 87.9 million fish for the year 2003. However, as Hilborn and Walters (1992) point out, estimation of abundance for the most recent cohorts with catch-at-age analysis is risky, because the regression methods are not able to determine if a given cohort is small and being fished hard or is large and being subjected to lower fishing rates. Therefore, it remains uncertain if yellow perch abundance truly increased during 2003. However, we are certain that if the high exploitation rates of the early 1990s had continued beyond 1994, yellow perch population recovery would have been impaired. Thus, the recovery of yellow perch in Lake Erie from the low abundance levels of the early 1990s represents an interagency fisheries management success story.

The estimate of mean annual survival for yellow perch from 1999 to 2003, 0.57, produced by catch-at-age analysis was within the range of those recently reported from other areas of the Great Lakes. Annual survival for yellow perch in southern Lake Michigan ranged from 0.40 to 0.44 (Rybicki 1985), while Les Cheneaux Island perch (northern Lake Huron) experienced a survival rate of 0.45 (Lucchesi 1988) during the 1980s and 0.55 in 1995 (Schneeberger and Scott 1997). Schneeberger (2000) estimated mean annual survival for Little Bay De Noc yellow perch at 0.42 for 1996.

Sport fishing regulations for yellow perch in the Michigan waters of Lake Erie were consistent from 1999 to 2003. The regulations included no closed season, no minimum size limit, and a daily bag limit of 50 fish. Under this regulation, Michigan sport harvest remained under the quota each year (Appendix 3). Thus, there was no apparent need for any adjustment in yellow perch regulations for Michigan's Lake Erie fishery.

Walleye

Although trap-net CPUE in 2002 was within the range of values recorded during the 1990s, gill-net CPUE in 2003 was the lowest recorded since 1981. The low gill-net CPUE in 2003 was largely a result of extremely weak year-classes produced in 2000 and 2002. Based on catch-age analysis, walleye population abundance was less than 25 million fish from 1999 to 2002. This represents a decrease in abundance of more than 50% from 1989, when four strong year-classes were present in the population. The catch-age analysis indicated an increase in abundance in 2003, but again, it is important to recognize that the estimates for the most recent year in the catch-age analysis are the most prone to error.

In any case, walleye abundance over the 5-year period from 1999 to 2003 was low compared with the period from 1989 to 1998.

Declining abundance after 1993 was not accompanied by lower harvests. In fact, harvest remained fairly steady and exploitation increased, peaking at 0.31 and 0.28 in 1997 and 1998, respectively. These levels of exploitation exceeded target exploitation levels, largely as a result of the limitations inherent in the previous catch-age model format (CAGEAN) and socio-political issues. Quotas were greatly reduced in 2001 by interagency agreement. This resulted in substantial declines in exploitation during 2001, 2002, and 2003. However, weak 2000 and 2002 cohorts impeded recovery of abundance to pre-1994 levels.

Zebra mussel colonization of Lake Erie may have been another factor in declining walleye abundance. Rutherford et al. (1999) found that simulations of zebra mussel effects induced shifts in energy from pelagic to benthic pathways and resulted in a 30% reduction in adult walleye abundance for Oneida Lake. This reduction was largely a result of the elimination of high-recruitment years. Our study indicates that a similar pattern may be emerging for Lake Erie walleye recruitment. The mean ranking system used for walleye year classes illustrated the dominance of the 1982, 1986, 1985, 1984, and 1991 year classes in the time series. Conversely, the period from 1997 to 2003 failed to produce a single year class ranking among the 10 strongest.

Michigan sport fishing regulations for Lake Erie walleye have been more variable than for yellow perch. Michigan sport harvest exceeded the walleye quota in 1987, 1988, and 1989 (Appendix 4). During those years, the minimum size limit was 13 inches, with a daily bag limit of 10 fish and no closed season. In an attempt to keep annual harvest within the quota, the daily creel limit for walleye was reduced to 6 fish in 1990. From 1990 to 1998, the Michigan harvest averaged less than 50% of the annual quotas. This decline appeared to be primarily a function of greatly reduced effort after 1990. In 1999, the daily bag limit was again increased from 6 fish to 10 fish to allow Michigan Lake Erie anglers to harvest a larger portion of the annual quota. Even though catch rate remained relatively high, angler effort and harvest did not increase. By 2001, it was apparent that walleye abundance was low and likely to decline further due to the low abundance of the 2000 year class. Consequently, the daily bag limit was reduced from 10 fish to 6 fish. A Coordinated Percid Management Strategy was adopted by the Lake Erie Committee and greatly reduced quotas were instituted for 2001, 2002, and 2003. The Michigan sport fishery stayed below the quota in 2001 and 2003, but exceeded the quota in 2002 (Appendix 4). Anticipating further reductions in quota due to poor recruitment in 2002, MDNR fisheries managers implemented a closed season for walleye fishing in Michigan's waters of Lake Erie from April 1 to May 31, 2004. In addition, the daily bag limit was reduced to 5 fish and the minimum size limit was increased to 15 inches. These regulation changes will expire March 31, 2009, unless FO 215.04 is amended prior to that date. Until walleye recruitment improves, conservative regulations will be needed to keep Michigan's recreational harvest of Lake Erie walleye at or under the quota.

Tag-Recapture Study

Haas et al. (1988) and Thomas and Haas (1994, 2000) reported that tag-recovery data from the period 1978–98 for the Monroe and Huron River tag sites demonstrated a strong tendency for upstream movement after spawning, with substantial movement of Lake Erie walleye into the Detroit River, Lake St. Clair, and the St. Clair River. They found that 29% and 23% of all Monroe tags recovered, during their respective time periods, came from the Detroit River or further north. Michigan, Ohio, and Ontario tag-recovery data from the study period 1999–2003 continued to show a strong tendency for upstream movement with 20% of all tags again recovered from the Detroit River or further north even though many of these tags were applied at locations much further east in Lake Erie. The spatial distribution of tag recoveries from the Monroe site by season (Figure 2), further illustrated the northward movement of fish into the connecting waters. An eastward movement pattern was also evident. There appeared to have been greater movement north out of Lake Erie during the spring period than eastward within Lake Erie. However, by summer, a number of Monroe-tagged fish were recovered in the Central and Eastern basins. The spatial distribution of tag recoveries is a function of the movement of tagged fish and the spatial distribution of fishing effort. In the case of these seasonal tag recovery patterns, differences in fishing effort could be a major factor. For example, fishing effort is intense in the Detroit River in April and May, but quite low in the Central and Eastern basins during this time. Thus, an apparently strong northward movement during the spring could be primarily a function of fishing effort differences between geographic areas. We suggest that the potential influence of fishing effort should always be considered when evaluating tag recovery spatial distributions.

Although sample sizes were quite different, tag recoveries from walleye tagged at the Monroe site did not appear to differ much from the Ohio and Ontario tag sites (Figure 3). Thomas and Haas (2000) had shown that walleye tagged in the Huron River were recovered significantly north of the Monroe tagged fish. This difference suggests that the walleye tagged at Monroe are more similar to, or from the same stocks, as the Ohio and Ontario fish. This is further evidence that the Huron River spawning walleye may represent a separate stock. Separate stocks may exhibit different movement patterns, experience different growth, mortality, and exploitation rates, and respond differently to environmental perturbations. Although the Maumee River spawning stock was likely the single largest walleye stock in Lake Erie, inclusion of as many separate stocks as possible in the interagency tag-recapture study, including comparatively small stocks, should provide a broader understanding of walleye population dynamics in the lake.

The estimates of mean annual survival and exploitation produced by the program ESTIMATE, on Michigan, Ohio, and Ontario data were similar to the estimates derived from the catch-age analysis. Considering the differences in the geographical areas included in the two analyses, it is somewhat surprising that the differences were not greater. It should be noted that the estimate of natural mortality from ESTIMATE was 0.36 and included tag recovery data from fisheries outside of Lake Erie. However, a value of 0.32 was used as the input value for M in the ADMB catch-age analyses, based on Lake Erie tag recoveries.

Reward tag studies carried out by Ontario, Ohio, and Michigan in 1990 and 2000 have provided critical information on non-reporting of tagged Lake Erie walleyes. This information has greatly increased our confidence in the estimates of walleye survival and natural mortality derived from the tag-recovery data. Recent declines in the cooperation in reporting recoveries of non-reward tags by the Ontario commercial fishery, especially evident from year 2000 study, highlights the importance of these reward studies. It also illustrates well the unpredictable role that human dimensions can play in the assessment and management of fisheries.

Recommendations

(1) Yellow perch are a critically important sport and commercial species in the Lake Erie fishery. While yellow perch abundance has recovered in recent years from the low levels of the early 1990s, abiotic changes in Lake Erie during the past decade confound the assessment of their status. All management agencies around the lake should be strongly encouraged to closely monitor the status of yellow perch stocks and fisheries. This study indicates that current Michigan sport fishing regulations (no closed season, no size limit, 50 fish creel limit) are not resulting in over-exploitation of yellow perch in Michigan waters of Lake Erie at this time. Thus, we find no biological basis for changing yellow perch regulations for Michigan sport anglers.

(2) Poor recruitment for walleye resulted in lower abundance and the implementation of reduced quotas in 2001. In 2004, Michigan implemented more restrictive sport fishing regulations for walleye in Lake Erie in an effort to stay within allotted quotas. If recruitment improves and the adult walleye population recovers, managers will need to carefully evaluate options for increasing sport harvest levels in Michigan waters.

(3) The interagency reward tag studies initiated in 1990 and continued in 2000 with a $100.00 US tag applied to 10% of the walleyes was crucial to interagency walleye management during 1990–2003. Walleye tagged in 1990

have passed completely through the population and the 2000 tags have passed through more than half of their lifetime contribution. Managers, therefore, have reduced ability to estimate important walleye population parameters. We recommend that the interagency reward tag study be repeated on a 5-year rotation for as long as the external tagging program for Lake Erie walleye continues.

(4) Walleye and yellow perch have both experienced periods of low abundance in Lake Erie during the last 20 years. Clearly, the combined fishing effort of commercial and sport fisheries could potentially overexploit and suppress recovery of the populations without adequately conservative harvest policies. Michigan managers should continue to pursue wise interagency management of these valuable shared fisheries resources through the Great Lakes Fisheries Commission's Lake Erie Committee and its various task groups.

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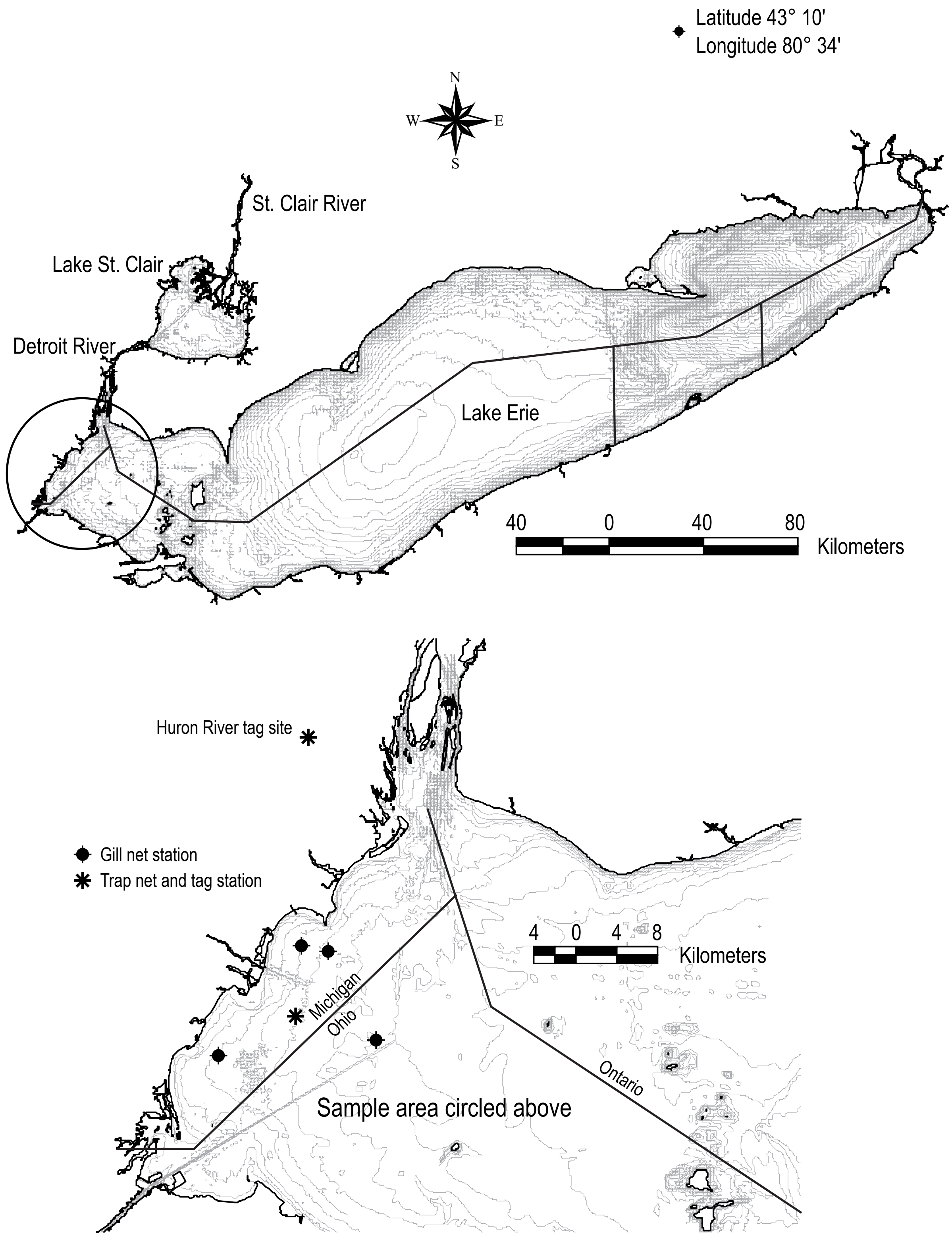

Figure 1.–Map of Lake Erie, Lake St. Clair, and the Detroit and St. Clair rivers showing net stations and the Huron River and Monroe (Raisin River) walleye tag sites. The Huron River site is the farther north location and the Monroe site is also the spring trap-net location.

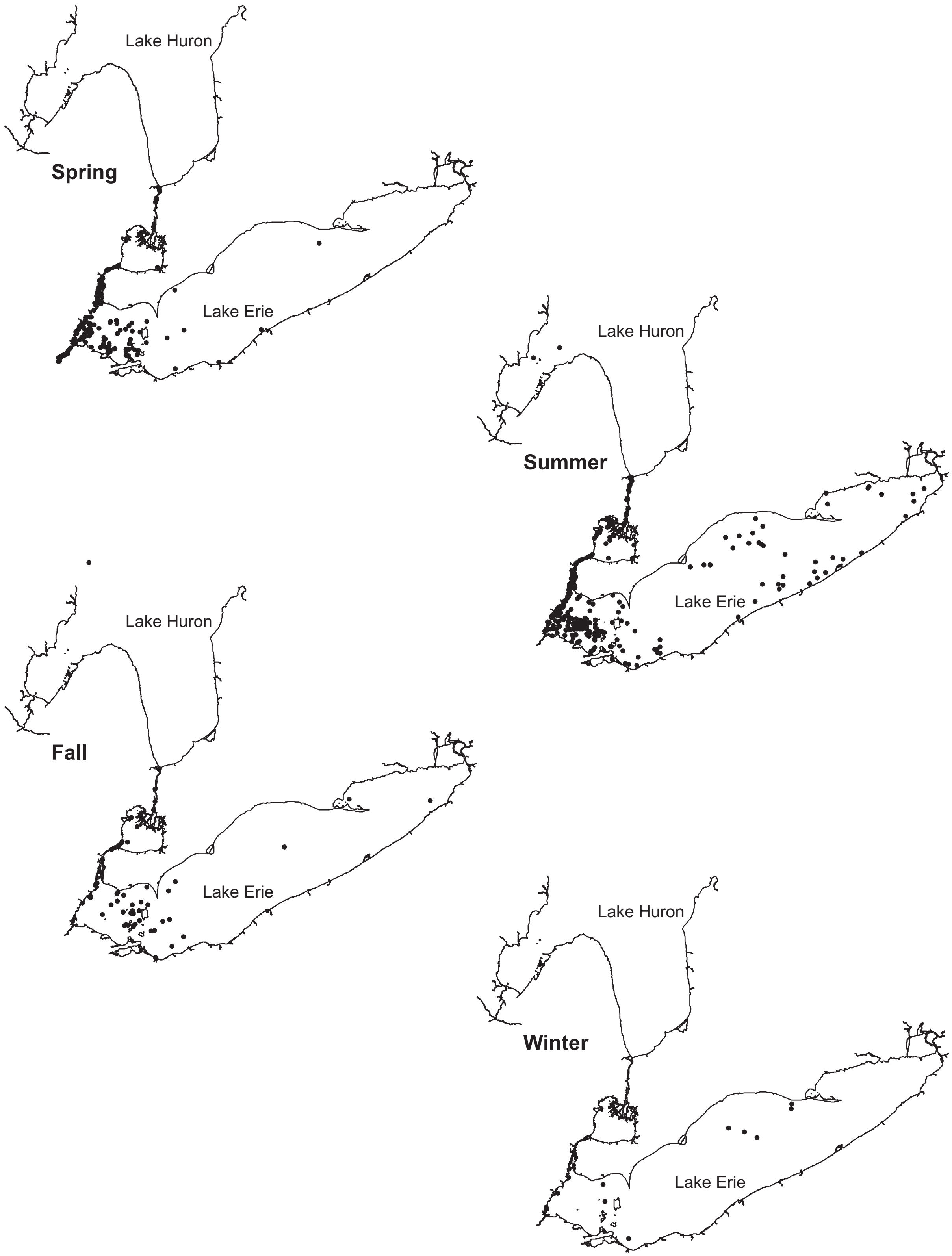

Figure 2.−Maps of the spatial distribution by season of 632 tag recoveries from walleyes caught by anglers and commercial fishermen in lakes Huron, St. Clair, Erie, and connecting waters during 1999-2003. All walleyes were tagged at Monroe trap-net station during spring.

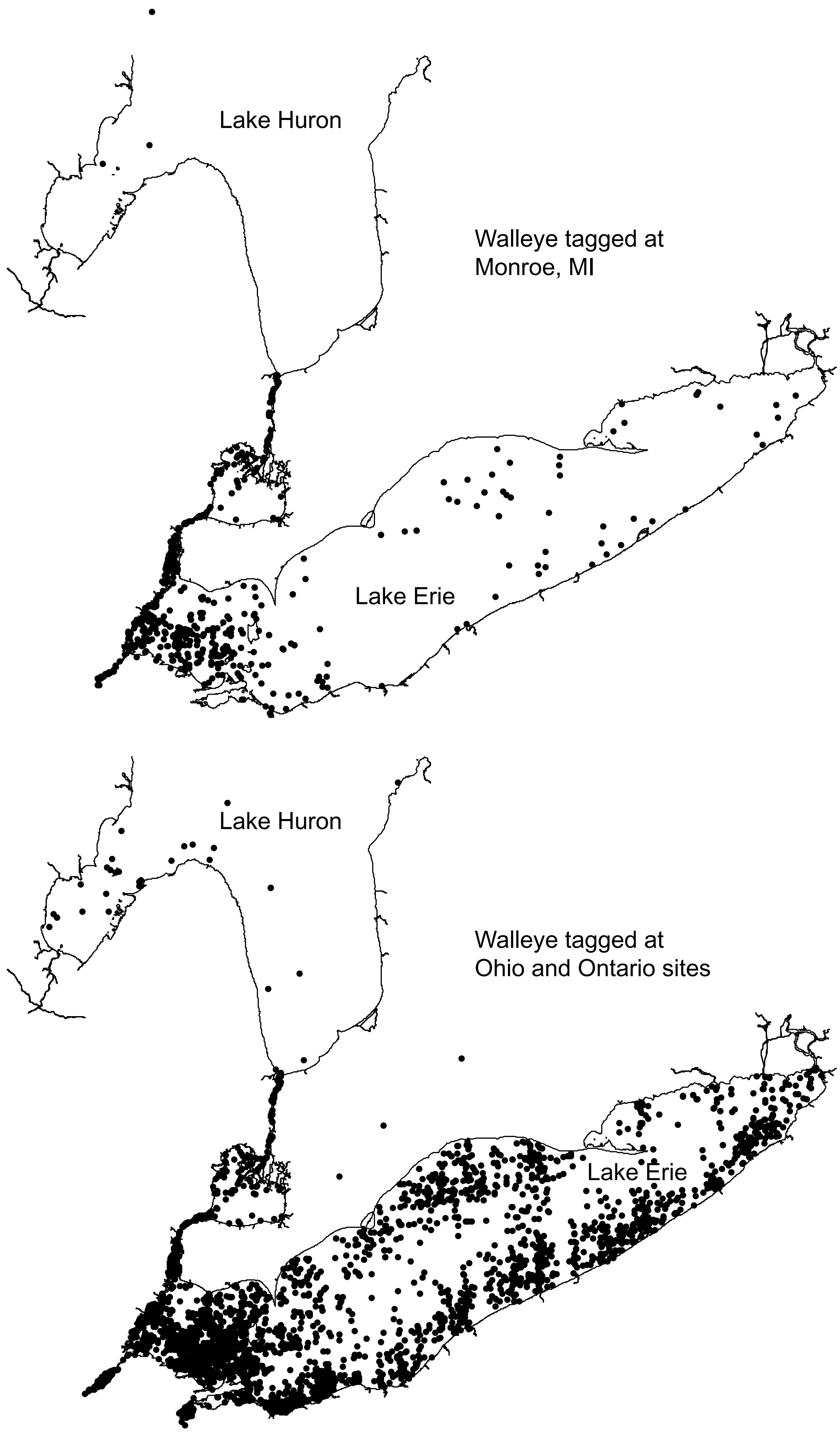

Figure 3.–Maps of Lake Erie, Lake St. Clair, southern Lake Huron, and the Detroit and St. Clair rivers comparing the distribution of walleye tag recoveries from the Monroe versus the Ohio and Ontario tag sites. Tagged walleye were caught and voluntarily reported by sport and commercial fishermen during 1999–2003. All walleyes were tagged during spring.

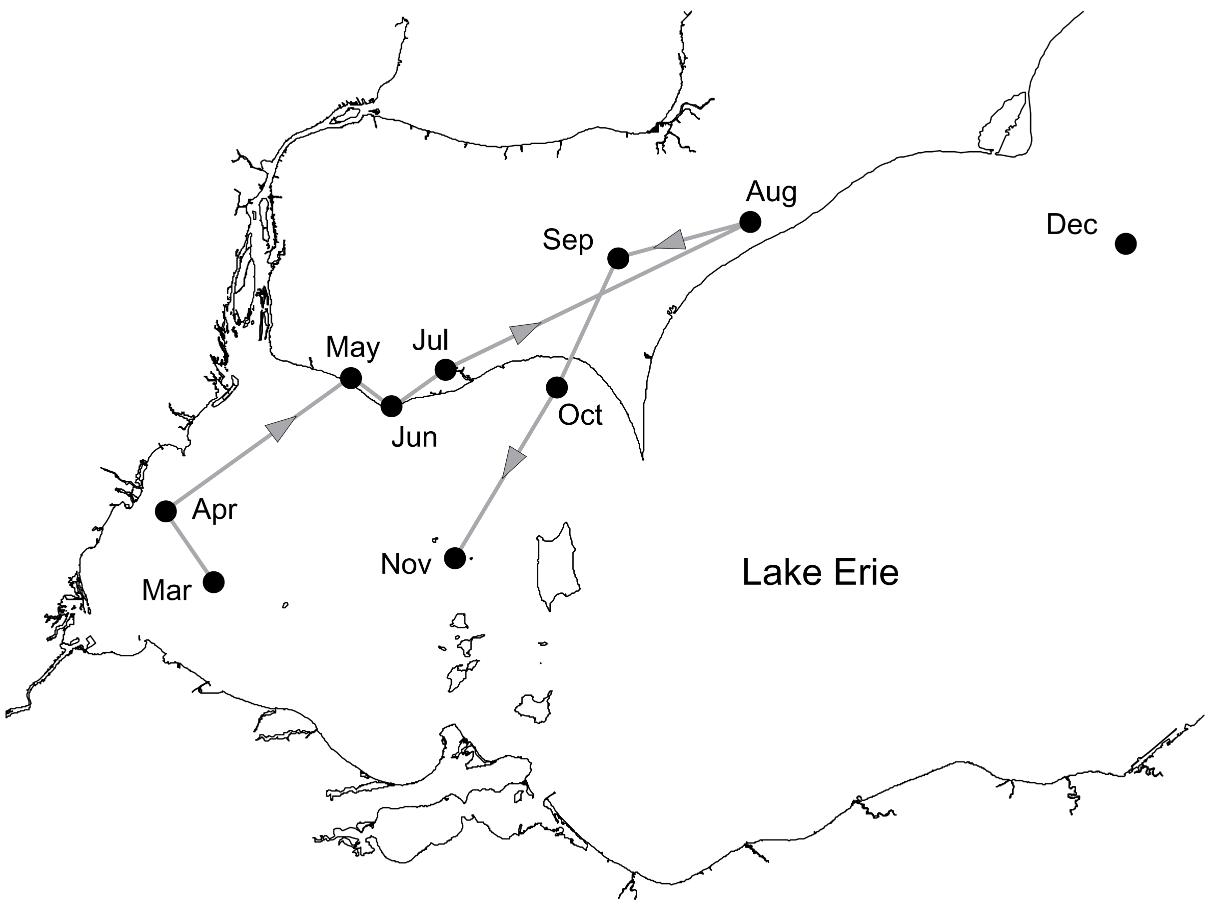

Figure 4.−Map of portions of Lake Erie, Lake St. Clair, and the Detroit rivers showing the monthly position of the centroid (black dots) of recoveries of walleye tagged at Monroe, MI. Tagged walleye were caught and voluntarily reported by sport and commercial fishermen during 1999–2003. All walleyes were tagged during spring. The gray line indicates the most probable (hypothetical) movement path of the center of Monroe tagged population from March through November. The December centroid was based on only a few fish.

Table 1.–Yellow perch CPUE (expressed as number caught per net in 24 hours) by age for trap-net surveys in Michigan waters of Lake Erie during 1989–2002.

		Age							Total
Year	Days	2	3	4	5	6	7	8+	CPUE
1989	96	0.02	26.64	50.02	39.27	24.63	2.89	1.28	144.83
1990	139	0.04	0.35	4.20	8.72	5.82	2.90	1.73	24.58
1991	86	0.03	2.74	2.41	9.29	7.99	6.29	1.79	31.91
1992	99	0.22	2.31	2.47	1.68	5.04	4.47	2.41	19.50
1993	99	0.25	6.28	5.34	2.31	1.58	2.51	0.81	20.24
1994	95	0.20	1.70	4.39	2.20	1.29	0.52	0.65	10.95
1995	89	0.01	0.09	1.39	1.60	0.84	0.15	0.09	4.16
1996	101	0.20	2.42	2.87	4.38	2.82	2.24	0.67	15.60
1997	93	0.00	4.87	6.11	2.82	2.67	1.66	0.68	18.82
1998	88	0.42	6.30	4.70	2.39	1.68	0.65	0.38	16.51
1999	105	0.39	6.57	6.38	10.69	2.42	0.26	0.17	26.88
2000	129	0.55	1.24	6.71	6.04	3.66	1.39	0.25	19.84
2002	153	0.10	1.23	8.84	9.41	17.13	2.09	1.39	40.20

Table 2.–Mean length (mm) of yellow perch caught in trap nets during spring surveys in Michigan waters of Lake Erie. Sample size is in parentheses; SE is the standard error of the mean.

	1995		1996		1997		1998		1999		2000		2002	
Age	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
							Males							
2	187 (1)	–	173 (8)	2.2	–	–	–	–	175 (5)	4.5	183 (6)	4.9	201 (1)	
3	194 (4)	0.7	191 (33)	1.9	191 (30)	1.9	206 (7)	12.6	185 (32)	3.4	207 (7)	8.9	199 (4)	7.0
4	243 (11)	4.6	216 (21)	4.5	212 (25)	3.1	207 (72)	2.3	212 (26)	4.8	213 (35)	3.8	219 (18)	7.5
5	250 (12)	2.4	244 (26)	4.0	231 (16)	5.6	226 (26)	3.9	230 (42)	3.6	238 (37)	3.6	242 (27)	4.4
6	256 (7)	5.0	258 (22)	3.8	257 (17)	4.8	250 (8)	7.8	248 (10)	5.5	251 (15)	3.7	245 (41)	3.9
7	265 (2)	13.5	258 (10)	6.4	255 (18)	1.8	268 (12)	5.0	–	–	252 (4)	12.4	271 (9)	5.5
8	273 (1)	–	277 (4)	12.8	266 (2)	2.0	290 (1)	–	–	–	–	–	295 (2)	31.5
9	286 (2)	7.0	284 (3)	12.4	–	–	–	–	–	–	307 (1)	–	–	–
10	–	–	–	–	–	–	–	–	–	–	–	–	–	–
							Females							
3	251 (1)	–	223 (8)	6.7	215 (14)	3.7	199 (5)	14.4	224 (22)	4.8	220 (9)	7.8	227 (4)	7.2
4	278 (31)	4.2	243 (21)	3.3	238 (48)	3.0	240 (53)	3.8	249 (23)	5.8	249 (36)	4.3	263 (33)	5.1
5	287 (39)	3.0	282 (33)	4.2	261 (23)	5.8	254 (38)	4.9	275 (58)	3.9	264 (19)	5.6	263 (15)	9.4
6	288 (20)	5.6	287 (17)	4.2	295 (27)	3.7	279 (15)	5.6	278 (16)	6.7	286 (23)	4.0	282 (51)	4.6
7	290 (3)	4.2	302 (23)	3.5	305 (10)	6.2	308 (9)	5.8	308 (4)	7.4	289 (10)	6.8	315 (6)	12.4
8	–	–	351 (1)	–	317 (10)	6.3	305 (4)	10.2	327 (4)	7.9	314 (2)	2.0	307 (8)	8.5
9	–	–	316 (2)	30.0	–	–	320 (1)	–	334 (1)	–	324 (2)	16.5	309 (3)	5.6
10	–	–	344 (1)	–	–	–	–	–	–	–	–	–	–	–

Table 3.–Walleye CPUE (expressed as number caught per net in 24 hours) by age for trap-net surveys in Michigan waters of Lake Erie during 1989–2002.

Survey year	24 hr. sets	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11+	All Ages	Mean age
1989	96	0.01	1.10	9.90	2.90	1.88	0.85	3.37	0.35	0.01	0.12	0.03	20.69	4.2
1990	139	0.00	0.59	1.06	5.90	1.78	2.11	0.37	1.92	0.13	0.01	0.01	14.05	4.9
1991	86	0.00	1.87	4.90	3.91	13.37	2.52	3.60	1.19	0.89	0.00	0.00	32.35	4.9
1992	99	0.00	2.32	1.42	2.38	2.58	7.00	2.11	2.16	0.46	0.56	0.00	21.03	5.5
1993	99	0.00	0.52	5.01	0.72	1.46	1.75	3.66	1.23	0.63	0.26	0.31	15.57	5.4
1994	95	0.00	0.21	8.37	6.33	1.14	1.75	3.79	3.15	1.43	0.59	0.33	27.14	5.0
1995	89	0.00	7.33	0.01	1.52	0.56	0.18	0.57	0.76	0.29	0.17	0.00	11.53	3.3
1996	101	0.00	1.29	5.90	0.36	4.61	3.63	1.25	2.18	1.97	1.36	0.69	23.28	5.5
1997	93	0.00	0.18	6.06	4.19	0.37	2.84	1.54	1.08	0.98	0.92	0.42	18.74	4.8
1998	88	0.00	5.50	0.59	4.04	2.39	0.47	1.80	0.76	0.61	0.73	0.46	17.44	4.3
1999	105	0.00	3.87	8.11	0.15	1.05	0.91	0.38	0.66	0.31	0.40	0.45	16.29	3.9
2000	129	0.01	3.76	11.09	14.53	0.71	3.52	2.15	1.67	1.58	1.10	1.29	41.41	4.3
2002	153	0.00	0.91	10.46	1.67	1.83	1.78	0.36	0.82	0.30	0.34	0.33	18.80	4.2
Mean	105	0.00	2.26	5.61	3.74	2.59	2.26	1.92	1.38	0.74	0.50	0.33	21.41	4.6

Table 4.–Mean length (mm) of walleye caught in trap nets during spring surveys in Michigan waters of Lake Erie. Sample size is in parentheses; SE is the standard error of the mean.

	1996		1997		1998		1999		2000		2002	
Age	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
							Males					
2	346 (75)	2.5	354 (13)	6.0	337 (301)	0.9	343 (171)	1.8	358 (159)	1.4	358 (122)	1.4
3	410 (500)	1.0	411 (513)	0.9	408 (49)	3.5	407 (711)	0.8	418 (533)	1.0	418 (1410)	0.6
4	459 (26)	5.4	456 (307)	1.4	446 (323)	1.4	466 (11)	7.3	455 (609)	1.0	460 (215)	1.9
5	482 (408)	1.4	491 (30)	5.8	478 (198)	2.1	483 (95)	2.5	486 (28)	3.1	489 (241)	1.8
6	510 (304)	1.6	508 (241)	1.8	512 (37)	5.3	498 (78)	3.1	512 (150)	2.3	511 (217)	2.8
7	534 (113)	3.0	533 (127)	2.6	521 (147)	2.3	508 (33)	5.9	532 (89)	3.0	537 (44)	5.4
8	551 (194)	2.3	558 (94)	3.4	549 (58)	4.3	544 (60)	5.2	556 (77)	3.4	558 (107)	3.1
9	568 (165)	2.8	579 (86)	3.7	575 (46)	5.6	572 (24)	7.3	567 (61)	4.1	588 (40)	5.1
10	577 (107)	3.7	580 (71)	4.8	585 (45)	5.4	594 (33)	5.7	583 (44)	5.8	595 (45)	4.4
11	609 (31)	6.2	581 (29)	7.8	593 (13)	9.0	594 (15)	8.7	596 (18)	7.8	617 (23)	7.6
							Females					
2	–	–	–	–	332 (1)	–	–	–	345 (2)	20.5	–	–
3	453 (5)	17.5	443 (14)	3.7	518 (1)	–	451 (1)	–	431 (1)	–	452 (25)	4.1
4	517 (8)	14.0	497 (41)	3.7	488 (29)	4.8	528 (2)	37.5	505 (78)	3.3	513 (16)	8.6
5	539 (37)	4.6	511 (3)	20.4	532 (7)	12.3	549 (7)	12.1	546 (5)	14.1	538 (24)	6.1
6	572 (55)	4.8	517 (16)	11.0	588 (4)	16.2	579 (5)	4.6	601 (20)	6.9	575 (32)	5.0
7	593 (12)	12.7	586 (13)	11.6	605 (11)	10.1	615 (2)	5.0	616 (14)	6.8	628 (7)	6.2
8	637 (22)	10.4	614 (2)	9.0	636 (9)	11.7	641 (7)	12.0	614 (7)	14.4	638 (12)	11.6
9	652 (29)	9.6	645 (3)	25.9	648 (8)	7.8	634 (3)	10.4	654 (18)	5.0	656 (5)	10.3
10	662 (29)	6.5	667 (12)	16.6	677 (18)	8.2	658 (7)	19.5	693 (11)	9.1	693 (6)	10.7
11	685 (15)	8.3	687 (7)	17.3	688 (6)	17.3	646 (2)	85.0	690 (8)	12.6	697 (6)	14.5
12	720 (9)	15.4	709 (3)	25.9	726 (8)	10.4	722 (3)	14.3	705 (13)	13.1	728 (10)	11.8

Table 5.–Walleye CPUE (expressed as number caught per net lift) in multifilament gill-net gangs during fall surveys on Michigan waters of Lake Erie.

Year class	Total CPUE	Survey year																					
		1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1972	1.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1973	1.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1974	13.6	1.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1975	42.8	2.0	0.5	0.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1976	18.4	1.0	1.5	0.3	0.0	0.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1977	171.0	9.0	5.0	2.5	3.0	0.5	0.3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1978	61.6	6.0	5.5	2.5	1.8	0.5	1.3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1979	72.4	13.5	5.0	4.3	2.3	2.0	0.5	0.5	0.3	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1980	92.7	43.0	21.5	14.5	5.0	5.3	2.3	0.5	0.3	0.0	0.3	–	–	–	–	–	–	–	–	–	–	–	–
1981	72.3	–	33.5	21.3	7.8	3.8	2.8	2.3	0.5	0.3	0.0	–	–	–	–	–	–	–	–	–	–	–	–
1982	306.2	–	–	29.0	91.8	95.8	44.3	28.5	5.3	7.5	3.5	0.5	–	–	–	–	–	–	–	–	–	–	–
1983	34.6	–	–	–	4.5	12.0	4.0	5.0	3.5	1.8	1.8	2.0	–	–	–	–	–	–	–	–	–	–	–
1984	147.7	–	–	–	–	69.8	34.3	20.5	3.5	8.0	8.3	2.0	0.3	0.5	–	–	–	–	–	–	–	–	–
1985	177.2	–	–	–	–	–	98.0	42.5	9.3	14.3	8.5	1.5	0.8	1.0	–	–	–	–	–	–	–	–	–
1986	297.5	–	–	–	–	–	–	96.8	30.3	90.3	43.5	19.5	3.8	2.0	0.3	–	–	–	–	–	–	–	–
1987	127.8	–	–	–	–	–	–	–	4.5	53.8	26.8	20.0	2.5	3.8	1.0	0.5	0.8	–	0.3				
1988	125.0	–	–	–	–	–	–	–	–	61.5	35.8	9.3	4.5	4.5	0.5	0.8	0.8	–	–	–	–	–	–
1989	52.6	–	–	–	–	–	–	–	–	–	16.0	17.0	2.8	3.3	1.3	0.8	0.8	0.3	0.3	–	–	–	–
1990	136.4	–	–	–	–	–	–	–	–	–	–	54.5	13.0	16.5	1.5	1.3	1.3	0.0	0.3	–	–	–	–
1991	194.3	–	–	–	–	–	–	–	–	–	–	–	47.3	61.5	11.3	6.8	2.8	1.3	0.3	–	–	–	–
1992	16.7	–	–	–	–	–	–	–	–	–	–	–	2.0	7.3	2.0	0.3	1.5	2.3	1.0	0.3	–	–	–
1993	169.7	–	–	–	–	–	–	–	–	–	–	–	–	73.3	71.0	11.8	8.08	3.3	1.5	0.3	0.5	–	–
1994	130.5	–	–	–	–	–	–	–	–	–	–	–	–	–	63.3	43.0	14.0	4.8	2.8	1.8	0.8	–	–
1995	8.3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3.3	1.3	0.8	1.0	0.8	0.8	0.3	
1996	178.2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	37.5	84.3	30.5	13.3	9.8	1.8	1.0
1997	128.2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	54.3	34.3	20.3	15.3	3.0	1.0
1998	77.6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	26.0	29.5	14.8	6.3	1.0
1999	157.6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	57.0	73.3	21.5	5.8
2000	13.6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6.5	6.3	0.8
2001	75.3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	42.8	32.5
2002	0.8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.8
Total		76.0	72.5	74.9	116.2	190.2	187.8	196.6	57.5	237.5	144.5	126.3	77.0	173.7	152.2	68.6	68.8	151.4	98.3	123.3	121.8	82.0	42.1
Net lifts		2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4

Table 6.–Mean total length (mm) at age for walleye caught during fall in survey gill nets in Michigan waters of Lake Erie (standard error in parentheses).

	Survey year									
Age	1999		2000		2001		2002		2003	
					Sexes combined					
1	339	(233)	327	(228)	345	(26)	338	(316)	337	(8)
2	416	(301)	410	(118)	418	(293)	420	(51)	412	(253)
3	462	(218)	447	(81)	460	(59)	464	(244)	472	(11)
4	514	(5)	484	(53)	493	(61)	487	(48)	494	(55)
5	515	(16)	513	(3)	521	(39)	502	(33)	529	(8)
6	535	(10)	525	(7)	540	(3)	528	(15)	533	(10)
7	554	(6)	492	(1)	565	(3)	–	–	529	(9)
8	562	(2)	530	(1)	558	(2)	530	(2)	–	–
9	569	(1)	–	–	–	–	580	(1)	602	(1)
10	648	(2)	–	–	–	–	–	–	–	–
Mean	412	(795)	388	(492)	439	(486)	409	(710)	434	(356)
					Males					
1	337	(87)	326	(91)	342	(17)	335	(140)	343	(1)
2	406	(154)	401	(81)	412	(181)	413	(35)	407	(186)
3	444	(133)	441	(63)	443	(40)	451	(170)	469	(10)
4	480	(3)	467	(40)	480	(46)	477	(34)	477	(39)
5	492	(10)	494	(2)	493	(22)	490	(26)	472	(2)
6	511	(7)	498	(5)	540	(3)	501	(11)	527	(5)
7	544	(4)	492	(1)	528	(2)	–	–	526	(7)
8	562	(2)	530	(1)	499	(1)	538	(1)	–	–
9	569	(1)	–	–	–	–	–	–	602	(1)
10	–	–	–	–	–	–	–	–	–	–
Mean	411	(402)	398	(492)	430	(312)	415	(417)	426	(252)
					Females					
1	340	(146)	328	(136)	350	(9)	339	(176)	337	(7)
2	426	(147)	428	(37)	429	(112)	435	(16)	427	(67)
3	489	(85)	471	(17)	497	(19)	492	(74)		
4	564	(2)	535	(13)	533	(15)	511	(14)	548	(8)
5	553	(6)	550	(1)	556	(17)	546	(7)	564	(4)
6	592	(3)	594	(2)	638	(1)	604	(4)	574	(2)
7	572	(2)	–	–	618	(1)	–	–	–	–
8	–	–	–	–	–	–	522	(1)	–	–
9	–	–	–	–	–	–	580	(1)	–	–
Mean	414	(393)	374	(206)	456	(174)	401	(293)	–	–

Table 7.–Mean total length (mm) for yearling walleye caught in Michigan fall gill-net surveys in Michigan waters of Lake Erie (sample size in parentheses).

Survey year	Year class	Mean length		Standard error
1978	1977	343	(410)	1.0
1979	1978	330	(115)	1.9
1980	1979	344	(222)	1.3
1981	1980	336	(86)	2.0
1982	1981	333	(143)	1.9
1983	1982	308	(116)	1.7
1984	1983	311	(18)	4.7
1985	1984	329	(279)	1.2
1986	1985	339	(392)	1.0
1987	1986	332	(387)	1.1
1988	1987	347	(18)	4.2
1989	1988	336	(246)	1.2
1990	1989	352	(64)	2.4
1991	1990	345	(218)	1.3
1992	1991	309	(252)	1.4
1993	1992	331	(13)	6.5
1994	1993	328	(415)	1.0
1995	1994	318	(444)	1.1
1996	1995	326	(18)	4.0
1997	1996	306	(210)	1.3
1998	1997	319	(357)	1.0
1999	1998	339	(233)	1.1
2000	1999	327	(228)	1.0
2001	2000	345	(26)	2.0
2002	2001	338	(316)	1.0
2003	2002	337	(8)	6.9

Table 8.–Mean rank of Michigan's Lake Erie walleye year classes based on measured harvest and survey catch per effort.

Year class	Total harvest[a]	Harvest rank	Trap CPUE	Trap rank	Gill-net CPUE	Gill-net rank	Mean rank
1974	2,727,989	18	0.4	26	13.6	27	23.7
1975	3,356,110	16	1.3	24	42.8	22	20.7
1976	812,855	26	0.8	25	18.4	24	25.0
1977	6,837,878	7	10.2	16	171.0	6	9.7
1978	3,578,926	15	8.9	19	61.6	19	17.7
1979	2,535,057	21	8.7	20	72.4	17	19.3
1980	5,426,616	11	21.5	7	92.7	15	11.0
1981	3,093,746	17	16.9	12	72.3	18	15.7
1982	21,305,596	1	98.6	1	306.2	1	1.0
1983	2,572,846	20	21.4	8	34.6	23	17.0
1984	6,639,741	8	28.1	3	147.7	9	6.7
1985	7,518,595	4	27.0	5	177.2	5	4.7
1986	13,469,004	2	56.6	2	297.5	2	2.0
1987	4,081,685	12	27.5	4	127.8	13	9.7
1988	3,941,361	13	15.9	13	125.0	14	13.3
1989	2,688,970	19	8.9	18	52.6	20	19.0
1990	6,106,960	10	20.9	11	136.4	10	10.3
1991	7,163,771	5	21.1	9	194.3	3	5.7
1992	1,579,416	24	2.8	22	16.7	25	23.7
1993	6,356,968	9	21.8	6	169.7	7	7.3
1994	7,803,377	3	14.6	14	130.5	11	9.3
1995	851,533	25	1.5	23	8.3	28	25.3
1996	7,080,274	6	21.1	10	178.2	4	6.7
1997	2,224,000	22	10.1	17	128.2	12	17.0
1998	1,984,308	23	3.2	21	51.6	21	21.7
1999	3,680,524	14	10.5	15	157.6	8	12.3
2000	297,483	28	0.1	27	13.6	26	27.0
2001	658,517	27			75.3	16	21.5
2002	2,905	29			0.8	29	29.0
Mean	4,702,656		17.8		106.0		

[a] Total harvest determined by summing each agencies sport and commercial age specific harvest estimates.

Table 9.–Population statistics for yellow perch in Lake Erie's Western Basin, 1989–2003. Instantaneous fishing mortality (*F*), annual survival (*S*), and numerical abundance are from the ADMB CSI Catch-age model (Belore et al. 2004). Observed numerical harvest is the sum of all recorded harvest for the western basin perch fishery for each fishing year. Total exploitation rate is the observed numerical harvest divided by the estimated numerical abundance within a fishing year.

Fishing year	Instantaneous fishing mortality rate (*F*)	Annual survival rate (*S*)	Estimated numerical abundance	Observed numerical harvest	Total exploitation rate
1989	0.776	0.308	34,406,000	19,565,273	0.569
1990	0.716	0.328	14,391,000	8,902,819	0.619
1991	0.437	0.433	13,796,000	5,171,528	0.375
1992	0.323	0.485	17,929,000	4,519,714	0.252
1993	0.753	0.316	12,949,000	5,679,937	0.439
1994	0.238	0.529	12,943,000	4,295,884	0.332
1995	0.162	0.570	28,489,000	5,733,007	0.201
1996	0.239	0.528	41,182,000	8,320,832	0.202
1997	0.242	0.526	42,458,000	9,276,830	0.218
1998	0.190	0.554	62,752,000	9,213,407	0.147
1999	0.198	0.550	45,852,000	8,626,656	0.188
2000	0.141	0.582	59,944,000	7,808,466	0.130
2001	0.090	0.613	70,205,000	6,149,537	0.088
2002	0.267	0.513	51,516,000	9,544,618	0.185
2003	0.112	0.599	87,949,000	8,902,054	0.101

Table 10.–Population statistics for age-2 and older walleyes in all waters of Lake Erie, 1989–2003. Instantaneous fishing mortality (*F*), annual survival (*S*), and numerical abundance are from the ADMB Catch-age model, $M = 0.32$ (Haas et al. 2004). Observed numerical harvest is the sum of all recorded harvest for the western basin walleye fishery for each fishing year. Total exploitation rate is the observed numerical harvest divided by the estimated numerical abundance within a fishing year.

Fishing year	Instantaneous fishing mortality rate (*F*)	Annual survival rate (*S*)	Estimated numerical abundance	Observed numerical harvest	Total exploitation rate
1989	0.239	0.573	56,891,546	8,205,629	0.144
1990	0.190	0.601	44,253,840	5,595,013	0.126
1991	0.157	0.621	33,071,570	4,010,448	0.121
1992	0.203	0.594	33,424,590	4,843,526	0.145
1993	0.277	0.552	40,663,250	6,800,478	0.167
1994	0.266	0.558	27,612,290	5,175,241	0.187
1995	0.296	0.542	28,141,680	5,383,588	0.191
1996	0.418	0.482	30,578,880	7,143,486	0.234
1997	0.335	0.522	17,946,269	5,562,102	0.310
1998	0.444	0.469	23,626,097	6,797,463	0.288
1999	0.368	0.505	19,675,578	4,827,423	0.245
2000	0.398	0.491	15,992,636	3,645,221	0.228
2001	0.305	0.537	24,844,484	2,922,879	0.118
2002	0.179	0.608	16,820,296	2,408,892	0.143
2003	0.209	0.590	29,119,466	2,704,307	0.093

Table 11.–Geographical distribution of tag recoveries from walleye tagged at Michigan, Ohio, and Ontario sites in Lake Erie (expressed as a percentage of the total number recovered each year).

	Recovery year						
Geographical area	1994–1998[a]	1999	2000	2001	2002	2003	1999–2003
Lake Huron – Saginaw Bay	1.5	1.2	0.6	0.0	0.6	0.6	0.6
St. Clair River	5.5	5.6	1.9	4.3	3.2	5.2	3.9
Lake St. Clair	4.0	3.1	2.6	3.9	3.8	4.2	3.6
Detroit River	10.2	6.2	12.0	11.7	13.1	13.2	11.9
Lake Erie-Total	77.0	83.8	82.8	80.0	79.2	76.1	79.8
Western Basin-Lake Erie	52.4	43.4	51.1	58.7	52.2	51.4	51.8
Central Basin-Lake Erie	21.4	29.2	20.4	15.2	21.2	21.8	21.1
Eastern Basin-Lake Erie	3.2	11.2	11.3	6.1	5.8	2.9	6.9

[a] Percentages were from Michigan tagged walleye only.

Table 12.–Estimates of annual survival and recovery rate (percent) produced by the program "ESTIMATE"[a] during 1999-2003 for Lake Erie walleyes tagged at Michigan, Ohio, and Ontario sites.

Fishing year	Tag recovery rate	Standard error	Survival rate	Standard error
1999	3.93	0.48	63.24	6.34
2000	5.74	0.33	64.56	5.73
2001	4.07	0.32	51.68	4.78
2002	4.27	0.25	57.92	5.49
2003	5.75	0.40	–[b]	–[b]
Mean	4.50	0.18	59.35	2.08

[a] Brownie et al. 1985
b Survival rate for last year is not estimable.

Table 13.–Results from the year-2000 $100 reward tagging effort in Michigan, Ohio, and Ontario through year 2003.

Tag location	Tags applied		Tags returned		Rate		Non-reporting
	Non-reward	Reward	Non-reward	Reward	Non-reward	Reward	ratio
	Angler tag returns						
Chicken and Hen Islands (ON)	1,091	115	26	5	0.024	0.043	1.824
Lackawanna Shoreline (NY)	239	29	21	4	0.088	0.138	1.570
Raisin River (MI)	1,874	208	122	40	0.065	0.192	2.954
Sandusky Bay (OH)	1,460	162	27	14	0.018	0.086	4.673
Van Buren Bay (NY)	761	92	44	12	0.058	0.130	2.256
Total angler	5,425	606	240	75	0.044	0.124	2.798
	Commercial tag returns						
Chicken and Hen Islands (ON)	1,091	115	25	39	0.023	0.339	14.800
Lackawanna Shoreline (NY)	239	29	0	1	0.000	0.034	–
Raisin River (MI)	1,874	208	17	38	0.009	0.183	20.139
Sandusky Bay (OH)	1,460	162	7	8	0.003	0.049	10.300
Van Buren Bay (NY)	761	92	1	2	0.001	0.022	–
Total commercial	5,425	606	50	88	0.009	0.145	15.756

Table 14.–Statistical comparisons between annual tag recovery rates for the Michigan, Ohio, and Ontario tag sites during 1999–2003 using the *z*-statistic.

Fishing year	Recovery rate	Standard error	*z*-statistic comparing 1999	2000	2001	2002
1999	3.936	0.481				
2000	5.744	0.331	3.10*			
2001	4.072	0.319	0.24	3.64*		
2002	4.271	0.253	0.62	3.54*	0.49	
2003	5.750	0.396	2.91*	0.01	3.30*	3.15*

* Significantly different at the 95% confidence level.

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Gary L. Towns, Reviewer
James C. Schneider, Editor
Alan D. Sutton, Graphics
Ellen S. G. Johnston, Desktop Publisher

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Appendix 1.–Fish species collected from Michigan waters of Lake Erie with survey trap nets and gill nets since 1978.

Common name	Scientific name
Lake sturgeon	*Acipenser fulvescens*
Alewife	*Alosa pseudoharengus*
Rock bass	*Ambloplites rupestris*
Black bullhead	*Ameiurus melas*
Yellow bullhead	*Ameiurus natalis*
Brown bullhead	*Ameiurus nebulosus*
Bowfin	*Amia calva*
Freshwater drum	*Aplodinotus grunniens*
Goldfish	*Carassius auratus*
Quillback	*Carpiodes cyprinus*
White sucker	*Catostomus commersonii*
Lake whitefish	*Coregonus clupeaformis*
Common carp	*Cyprinus carpio*
Gizzard shad	*Dorosoma cepedianum*
Northern pike	*Esox lucius*
Muskellunge	*Esox masquinongy*
Mooneye	*Hiodon tergisus*
Channel catfish	*Ictalurus punctatus*
Bigmouth buffalo	*Ictiobus cyprinellus*
Black buffalo	*Ictiobus niger*
Longnose gar	*Lepisosteus osseus*
Pumpkinseed	*Lepomis gibbosus*
Bluegill	*Lepomis macrochirus*
Burbot	*Lota lota*
Silver chub	*Macrhybopsis storeriana*
Smallmouth bass	*Micropterus dolomieu*
Largemouth bass	*Micropterus salmoides*
Spotted sucker	*Minytrema melanops*
White perch	*Morone americana*
White bass	*Morone chrysops*
Silver redhorse	*Moxostoma anisurum*
Golden redhorse	*Moxostoma erythrurum*
Shorthead redhorse	*Moxostoma macrolepidotum*
Round goby	*Neogobius melanostomus*
Stonecat	*Noturus flavus*
Coho salmon	*Oncorhynchus kisutch*
Rainbow trout	*Oncorhynchus mykiss*
Chinook salmon	*Oncorhynchus tshawytscha*
Rainbow smelt	*Osmerus mordax*
Yellow perch	*Perca flavescens*
White crappie	*Pomoxis annularis*
Black crappie	*Pomoxis nigromaculatus*
Brown trout	*Salmo trutta*
Sauger	*Sander canadensis*
Walleye	*Sander vitreus*

Appendix 2.–Mean catch per trap-net lift for all species taken during spring trap-net surveys in Michigan waters of Lake Erie, 1978–2002.

	Survey year													
Species	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Walleye	28.1	49.0	18.1	20.6	38.8	26.1	36.6	75.5	61.7	33.9	83.1	35.9	23.8	95.9
Smallmouth bass	0.1	0.0	0.0	0.1	0.2	0.1	0.1	0.1	0.1	0.0	0.1	0.3	0.1	0.2
Yellow perch	377.0	320.0	669.0	512.0	146.0	257.0	129.0	156.0	40.3	174.0	22.9	251.5	41.7	94.6
Rock bass	1.2	0.8	1.9	0.9	1.5	1.3	1.0	1.5	0.7	1.5	0.9	0.8	0.3	0.8
White bass	1.5	1.5	3.7	1.4	10.5	4.9	2.5	2.8	7.6	0.4	5.3	4.7	0.9	1.6
White perch	0.0	0.1	0.3	0.5	24.6	35.0	10.9	38.9	30.3	43.5	63.1	233.0	40.5	56.8
Pumpkinseed	0.1	0.0	0.0	0.1	0.1	0.1	0.0	0.1	0.0	0.1	0.1	0.1	0.0	0.0
Bluegill	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.2
Black crappie	0.2	0.0	0.2	0.0	0.1	0.0	0.1	0.1	0.2	0.2	0.4	0.2	0.0	0.0
Channel catfish	3.5	9.7	5.4	5.8	4.9	10.6	4.6	5.5	5.4	2.7	3.5	4.1	9.0	6.0
Brown bullhead	0.2	1.1	1.6	1.9	1.7	4.2	2.5	1.5	4.1	0.9	9.2	3.9	13.1	4.3
White sucker	7.8	8.3	7.9	12.2	8.7	6.7	10.2	33.0	10.2	7.0	6.7	2.8	4.3	13.5
Redhorse sp.	2.4	1.2	0.6	1.0	0.8	1.5	1.7	1.4	1.3	1.7	1.8	0.6	0.4	0.6
Freshwater drum	37.4	66.8	14.0	42.9	13.4	23.5	25.1	30.6	25.3	9.1	15.6	6.4	5.1	25.6
Common carp	5.1	26.1	4.7	8.2	6.9	14.9	3.5	2.0	1.9	0.6	6.0	0.6	2.3	2.3
Goldfish	4.8	2.4	0.3	0.4	0.4	2.5	0.6	0.2	0.1	0.0	0.2	0.1	0.1	0.1
Gizzard shad	4.4	4.7	2.3	3.9	17.8	28.4	18.1	17.4	2.7	2.3	15.9	0.3	2.3	0.0
Longnose gar	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bowfin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Quillback	4.0	18.6	1.8	2.0	2.4	5.6	2.0	1.9	1.7	1.8	1.5	0.7	1.9	2.9
Stonecat	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.1
Total	477.9	510.3	731.8	613.9	278.8	422.4	248.7	368.5	193.6	279.7	236.4	546.2	145.8	305.5
% yellow perch	78.9	62.7	91.4	83.4	52.4	60.8	51.9	42.3	20.8	62.2	9.7	46.0	28.6	31.0
% white perch	0.0	0.0	0.0	0.1	8.8	8.3	4.4	10.6	15.7	15.6	26.7	42.7	27.8	18.6
Net lifts	50	46	48	36	37	53	57	51	49	55	51	55	82	29

Appendix 2.–Extended.

Species	Survey year										Mean		
	1992	1993	1994	1995[1]	1996	1997	1998	1999	2000	2002	1978–89	1990–99	1978–2002
Walleye	37.7	39.2	53.0	26.2	52.0	30.2	34.8	38.0	41.4	35.7	42.3	43.1	42.6
Smallmouth bass	0.1	0.2	0.8	2.2	2.1	1.2	1.9	1.9	2.2	1.2	0.1	1.1	0.6
Yellow perch	35.0	50.2	23.2	10.3	36.6	30.7	33.3	61.0	50.1	74.5	254.6	41.5	153.0
Rock bass	0.5	1.2	1.0	4.1	1.1	0.9	1.0	2.8	0.7	1.1	1.2	1.4	1.2
White bass	0.5	0.1	1.1	2.1	0.6	2.6	1.3	4.6	4.0	3.0	3.9	1.5	2.9
White perch	5.1	0.0	14.7	72.8	5.9	10.2	8.7	79.4	54.7	36.3	40.0	29.4	36.0
Pumpkinseed	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0
Bluegill	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Black crappie	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.1
Channel catfish	4.6	4.6	5.4	3.7	8.8	4.4	11.4	16.0	5.2	8.0	5.5	7.4	6.4
Brown bullhead	4.0	1.6	1.1	0.2	1.1	0.4	0.0	1.0	2.9	0.8	2.7	2.7	2.6
White sucker	14.6	9.0	5.8	7.4	14.0	4.7	15.0	6.0	5.8	6.3	10.1	9.4	9.5
Redhorse sp.	3.1	3.6	1.8	1.0	5.5	1.9	3.3	2.2	3.6	4.8	1.3	2.3	2.0
Freshwater drum	8.9	20.7	8.8	13.0	15.4	6.8	28.3	50.4	11.3	42.7	25.8	18.3	22.8
Common carp	1.3	1.4	3.7	2.9	8.2	0.6	3.1	8.0	12.2	1.6	6.7	3.4	5.3
Goldfish	0.1	0.0	4.4	0.1	0.5	0.1	0.0	0.1	0.0	0.0	1.0	0.5	0.7
Gizzard shad	0.6	0.3	0.3	1.7	0.3	0.0	0.0	0.2	2.4	0.1	9.9	0.6	5.3
Longnose gar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bowfin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Quillback	4.4	3.2	4.6	6.7	8.9	2.2	7.9	8.5	3.7	20.8	3.7	5.1	5.0
Stonecat	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	120.5	135.2	129.6	155.2	161.2	96.9	150.0	280.3	200.4	237.0	409.0	167.8	292.6
% yellow perch	29.0	37.1	17.9	6.2	22.7	31.7	22.2	21.8	25.0	31.4	55.2	24.8	40.3
% white perch	4.2	0.0	11.3	46.9	3.6	10.5	5.8	28.3	27.3	15.3	11.1	15.7	13.9
Net lifts	55	40	45	39	45	57	44	45	51	81	49	48	50

Appendix 3.–Sport fishing catch-at-age, targeted effort, catch rate, and quota allocation (in pounds) for yellow perch in Michigan's waters of Lake Erie, 1988–2003.

	Harvest by age (numbers)						Total harvest	Targeted effort[a]	Total CPUE	Total harvest	Quota
Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6+	(numbers)	(angler hours)	(fish/ang. hr.)	(pounds)	(pounds)
1988	0	97,739	362,137	295,914	25,994	62,511	844,294	494,158	1.71	167,580	
1989	0	7,332	447,243	605,612	316,736	90,915	1,467,838	696,973	2.11	332,955	
1990	5,653	51,409	79,769	320,153	180,686	145,241	782,911	634,255	1.23	231,525	
1991	695	31,602	130,295	94,645	62,865	58,552	378,654	164,517	2.30	94,815	
1992	1,202	69,477	52,931	22,894	26,381	81,932	254,817	120,979	2.11	66,150	49,000
1993	4,868	83,450	264,259	83,450	27,817	9,736	473,580	244,455	1.94	123,480	223,000
1994	11,461	103,546	41,186	61,830	20,097	8,208	246,327	224,699	1.10	66,150	92,000
1995	14,351	225,789	59,554	17,621	21,007	4,918	343,240	123,616	2.77	77,175	71,000
1996	7,455	301,487	283,797	28,223	7,872	6,398	635,233	193,733	3.27	134,810	77,000
1997	0	92,269	277,609	134,728	21,001	3,828	529,435	192,605	2.74	111,819	144,000
1998	761	183,936	234,283	142,877	22,087	2,334	586,277	183,882	3.18	132,051	164,000
1999	1,216	12,559	243,630	80,511	39,162	19,949	397,027	184,710	2.15	101,549	153,000
2000	510	34,941	49,113	105,231	57,330	16,187	263,313	122,447	2.15	67,010	154,000
2001	0	76,483	130,437	40,161	31,769	4,924	283,774	97,761	2.90	70,910	126,000
2002	10,815	14,542	136,193	207,107	60,061	55,978	484,696	190,573	2.54	147,065	196,000
2003	1,053	74,610	34,539	96,778	61,207	30,403	298,591	121,638	2.45	84,879	198,000

[a]Targeted effort estimated from monthly distribution of effort.

Appendix 4.–Sport fishing catch-at-age, targeted effort, catch rate, and quota allocation for walleye in Michigan's waters of Lake Erie, 1988–2003.

	Harvest by age (numbers)							Total harvest	Targeted effort[a]	Total CPUE	Quota
Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7+	(numbers)	(angler hours)	(fish/ang. hr.)	(numbers of fish)
1988	0	873,147	418,736	194,333	34,332	445,729	30,511	1,996,788	4,362,450	0.458	397,500
1989	0	146,149	599,508	101,409	62,635	29,826	152,114	1,091,641	3,794,000	0.288	383,000
1990	0	19,558	117,350	340,315	78,233	89,968	101,704	747,128	1,803,000	0.414	616,000
1991	530	21,243	25,043	20,878	32,483	10,368	21,584	132,129	440,393	0.300	440,000
1992	0	130,313	27,571	28,720	16,126	24,916	21,872	249,518	714,917	0.349	329,000
1993	0	58,138	95,962	10,507	16,811	19,613	69,345	270,376	690,797	0.391	556,500
1994	0	7,407	122,114	36,707	3,768	8,526	37,516	216,038	787,896	0.274	400,000
1995	0	48,800	5,848	34,317	7,904	1,609	9,431	107,909	276,852	0.390	477,000
1996	0	39,302	93,468	5,364	20,669	5,851	9,953	174,607	521,011	0.335	583,000
1997	0	1,494	56,365	43,466	4,546	7,291	9,238	122,400	374,437	0.327	514,000
1998	0	52,561	20,113	30,045	5,846	2,350	3,691	114,606	374,218	0.306	546,000
1999	0	38,578	66,988	24,308	6,110	904	3,381	140,269	411,002	0.341	477,000
2000	1,444	70,196	99,472	54,259	11,401	8,006	7,502	252,280	540,221	0.467	408,100
2001	0	79,361	37,953	22,274	11,160	3,486	5,380	159,614	362,047	0.441	180,200
2002	0	7,006	127,721	23,946	13,614	10,989	10,239	193,515	606,395	0.319	180,200
2003	0	21,664	7,013	73,324	10,781	4,577	11,459	128,818	326,231	0.395	180,200

[a]Targeted effort estimated from monthly distribution of effort.

Appendix 5.–Tag recovery data (non-reward) for walleye tagged at the Michigan, Ohio, and Ontario sites, Lake Erie, 1999–2003.

Year tagged	Number tagged	Year recovered				
		1999	2000	2001	2002	2003
1999	1,630	64	61	23	20	9
2000	4,469	–	255	128	70	36
2001	2,719	–	–	105	57	56
2002	5,291	–	–	–	218	185
2003	3,461	–	–	–	–	199