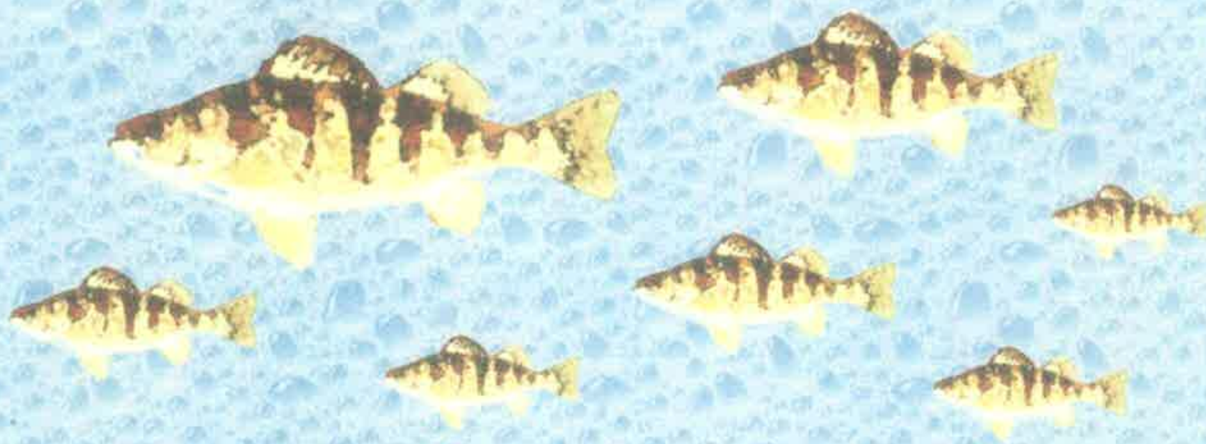
Report of the Lake Erie Yellow Perch Task Group

March 1999



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Presented to:

Standing Technical Committee
Lake Erie Committee
Great Lakes Fishery Commission

Introduction

In 1998, the Lake Erie Committee assigned the Yellow Perch Task Group (YPTG) five charges. As in previous years, the task group was charged with producing a lake-wide Recommended Allowable Harvest (RAH) partitioned by Lake Erie management unit, and to maintain and update the centralized time-series data set of harvest, effort, growth and maturity and agency or interagency abundance indices of yellow perch. Another continuing charge undertaken by the YPTG involves using interagency field data in a regression or other predictive model to estimate the relative strength of the age 2 cohort in each management unit as it recruits into the fishery in the subsequent year. Another charge assigned to the YPTG, a determination of a minimum spawning stock biomass necessary for sustaining fishable yellow perch stocks in Lake Erie, was examined in greater detail this year. The fifth charge on which we will report examines the potential for genetic research on Lake Erie yellow perch stocks.

1998 Fisheries Review

The reported harvest of yellow perch from Lake Erie in 1998 totaled 5.864 million pounds (2,660 metric tonnes or 2.66 million kgs), which was a 7% decrease over the 1997 harvest (Table 1). As in recent years, the YPTG partitioned Lake Erie into four Management Units (Units, or MUs; Figure 1) for harvest, effort, age and population analyses. Yellow perch harvest increased over 1997 levels for Ontario (+1%), Pennsylvania (+10%), Michigan (+18%) and New York (+33%), but declined for Ohio (-21%).

In comparison with 1997, each agency's proportion of the lakewide harvest changed only slightly. Ontario's proportion increased from 60% to 65% of the lakewide harvest, Ohio's proportion decreased from 38% to 32%, Michigan's remained at 2%, while New York's and Pennsylvania's shares remained at less than one percent of the total lakewide harvest.

Harvest, fishing effort, and catch rates are summarized for the time period 1988-1998 by management unit, year, agency, and gear type in Table 2, parts a through d. Trends over a longer time series (1975-1998) are depicted graphically for harvest (Figure 2), fishing effort (Figure 3), and catch rate (Figure 4) by management unit and gear type. Harvest summed by management unit showed minor increases in Units 1-3. Unit 4 (the eastern basin) exhibited a minor increase for the second consecutive year. Ontario experienced increases in Units 1 (+7%)

and 4 (34%) and slight declines in Units 2 (-2%) and 3 (-2%). Michigan's harvest (Unit 1) increased by 18% over 1997. Ohio's yellow perch harvest experienced a small decrease in Unit 1 (-9%), and a sizable decrease in Unit 2 (-42%). Ohio's Unit 3 harvest was up 25% compared to 1997 levels. Pennsylvania's fisheries, albeit small, showed a sizable increase in Unit 3 (up 22%); but a strong decline in Unit 4 (down 82%). New York's small fishery realized a harvest increase for the first time in nine years, up 33% over their 1997 harvest.

Commercial gill net harvest (by weight) for 1998 increased in management units 1 and 4, and decreased in management units 2 and 3 compared to 1997 levels. Ontario has the only gill net fishery remaining on Lake Erie for yellow perch. Harvest from commercial trap nets decreased in Units 1 and 2, down 13% and 39%, respectively, but increased in Units 3 and 4, up 53% and 8%, respectively. Sport harvest decreased in Units 1, 2 and 4: -7% in Unit 1, -9% in Unit 2, and -44% in Unit 4. Sport harvest increased by 15% in Unit 3. *Note: Ontario's Lake Erie sport, trap net and large mesh gill net catches and effort are not calculated in Yellow Perch Task Group reporting procedures and analyses. Complete data for these fisheries is unavailable. The task group uses Ontario commercial small mesh gill net fishery data obtained in OMNR fish processor reports (known as processor weight) instead of landed estimates.*

Commercial small mesh gill net effort for 1998 increased in Management Units 1, 2 and 4 over 1997 levels: up 39% in Unit 1, 15% in Unit 3 and 1% in Unit 4. Reported gill net effort declined in Unit 2 by 5%. Trap net effort for 1998 decreased lakewide: Unit 1, down 2%; Unit 2, down 9%; Unit 3, down 3%; and Unit 4, down 39%. Compared to 1997, sport fishing effort for 1998 increased by 2% in Unit 1, but decreased by 27% in Unit 2, 16% in Unit 3, and 52% in Unit 4.

Catch rates (catch per unit of effort, or CPE) for the 1998 commercial gill net fishery decreased in Units 1 and 3: down 23% in Unit 1 and 15% in Unit 3. Small to moderate increases in CPE were realized in Units 2 and 4: up 3% in Unit 2 and 37% in Unit 4. Trap net catch rates for 1998 declined in Unit 1, down 10%, and Unit 2, down 33%; but increased markedly in Units 3 and 4, up 57% and 79%, respectively. Catch rates for anglers targeting yellow perch increased in Unit 1 by 3% and in Unit 3 by 24%, but decreased by 7% in Unit 2 and 18% in Unit 4.

The lakewide RAH range recommended by the YPTG for 1998 was 5.9 to 7.5 million pounds lakewide. The Lake Erie Committee supported a total allowable catch (TAC) lakewide allocation of 7.44 million pounds. Partitioned by YPTG Management Unit, TAC values for 1998 were: Unit 1, 2.6 million pounds; Unit 2, 3.3 million pounds; Unit 3, 1.4 million pounds; Unit 4, 0.14 million pounds. The YPTG RAH mean values from CAGEAN and age-2 regression estimates by Unit from west to east were 2.2, 2.6, 1.1 and 0.1 million pounds, respectively. Using the alternate scenario presented last year that re-evaluated the 1995 year class, the RAH mean value estimates by Unit from west to east were 2.6, 3.3, 1.2 and 0.1 million pounds, respectively. The 1998 harvest of Lake Erie yellow perch in each management unit did not exceed total allowable catch set by the Lake Erie Committee. The 1998 harvest in millions of pounds by MU was: 2.3, 2.4, 1.1, and 0.052. The 1998 Lake Erie yellow perch fisheries attained 88% of TAC in Unit 1, 74% of TAC in Unit 2, 93% of TAC in Unit 3 and 37% of TAC in Unit 4.

Stock Assessment

Age and Growth

After years of inconsistent recruitment in the late 1980's and early 1990's, the 1993 and 1994 year classes were strong and helped turn around the declining yellow perch population. These two year classes entered the fisheries strong in 1996, dominated the fisheries in Management Units 1 through 3 during 1997, and remained in the fisheries in 1998. In Units 1, 2, and 3, the 1995 year class came in at age 3 stronger than expected. Its poor growth in prior years led to the underestimation of year class strength in 1997. The 1996 year class, still strong by current measures, entered the fishery weaker than expected in all Units except Unit 2 (Table 3). Again, reduced growth of these fish and selectivity of fishery gear is the suspected cause. Trawl and gill net surveys still show this is a very strong year class, especially in the west central and east central basins. In Unit 1, the 1994 year class, then the 1995 and 1996 year classes were strong contributors in the harvest. In Unit 2, the 1996 year class was the greatest contributor, primarily due to the high percentage of age 2 fish caught by gill nets and sport anglers. The 1994 and 1995 year classes were also well represented. In Unit 3, the 1995 was the strongest contributor followed by the 1994 then the 1996 year class. In Unit 4, where the fishery has been dominated by older fish, the 1994 year class made up the greatest proportion of harvest, followed by the 1995 and 1993 year classes. In all Units, we can point to the contribution of three moderate to strong year classes as a sign that recovery of the yellow perch population continues.

In examination of the growth of both the 1995 and 1996 year classes, we observed that length and weight across ages was substantially below the mean value or recent trend since about 1988 (Appendix A). In concern that overall lake productivity might be affecting yellow perch growth, condition, maturity and ultimately recruitment into the fishery, we investigated this issue further. There was no apparent decreasing trend in condition for Lake Erie yellow perch. This variation may be attributed to abiotic and/or biotic factors associated with the lake and their effects on the food web. The 1997 and 1998 year classes are showing improved growth rates-lengths and weights that are at the ten-year mean or higher. Specific age-growth data and the relationship of summer climatic factors to growth of yellow perch at age 0 and age 1 are also presented in Appendix A.

The task group continues to update yellow perch growth in: (1) weight-at-age values recorded annually in the harvest and (2) weight-at-age values taken from interagency trawl and gill net surveys. These values are important in our calculation of available biomass and for calculating harvest in the next year. The task group reviewed yellow perch von Bertalanffy growth model data and F_{opt} values according to methods previously described (YPTG 1996, 1998), but no changes were made to last year's F_{opt} values.

Catch-at-Age Analysis (CAGEAN) and the 1999 Population Estimate

CAGEAN 1998/1999

As discussed in a previous report (YPTG 1996), only data from 1988 to present were incorporated in the CAGEAN model. The accuracy and credibility of the model was improved by reducing the number of parameters used by the model (e.g. selectivity or catchability groups, gear types, age groups), according to the pattern of residual variables, which decreased variability in the shortened data series (T. Quinn - personal communication). Lack of sufficient biological data from Unit 4 has caused analyses for that management unit to be less precise. However, given the current reduced state of the yellow perch population and the small size of the fishery (and low exploitation rates), our CAGEAN results and conservative recommendations for low harvest in Unit 4 are still valid.

The effort lambda, λ_E , was adjusted for each gear type to equal the ratio of the variance of catch observations to the variance of effort observations. The 1998-99 CAGEAN model ran efficiently as model iterations were low (usually 4 to 8), no apparent trends were depicted in the residuals, and 40 bootstraps were easily completed. A three-gear (gill net, trap net and sport: harvest-by-age, effort, and weight-at-age) version of the CAGEAN model was used to estimate the 1998 population size in numerical abundance and biomass in each management unit. The three-gear version allows factors such as catchabilities and selectivities to be gear specific. Population size estimates were based on a natural mortality rate of 0.4 (M=0.4). A surface response rate exercise to determine the sensitivity of population estimates to variability or error in estimating M showed little variation compared to the overall coefficient of variation (CV) of the population estimate. Growth and recruitment of the slower growing 1995 and 1996 year classes were addressed by blocking selectivity groups for several of the most recent years used in the CAGEAN command files.

Population size and population parameters such as survival and exploitation rates are presented for a stock size estimate that consists of 1999 age 2 abundance estimates derived from a refined recruitment-regression model (Tables 4 and 5 and Appendix B). Numbers and biomass by management unit are presented for age 2 and older. Population estimates using the regression model are depicted in Figure 5, and biomass estimates are presented in Figure 6.

Backcasting population estimates for 1998, and comparing to YPTG (1998) CAGEAN, stock size estimates of age 3 and older fish are higher than predicted (i.e., they were underestimated last year) in Units 1 (+112%), 3 (+19%), and 4 (94%). Estimates of age 3 and older yellow perch in Unit 2 were close to that value reported last year (-2%). The source of the variation was traced to the inability to estimate the 1995 year class strength. As previously discussed, growth declines for Age 2 fish and specific gear selectivity (Appendix A) may have led to their reduced recruitment, which in turn could give an underestimate to CAGEAN's first estimate of the 1995 year class as it entered the fishery in Units 1-3. In an effort to address this perceived underestimate, we used OMNR Partnership gill net regression values to give another estimate of the strength of the 1995 year class. These estimators gave a closer result in Unit 1, but overestimated the age 3 cohort for 1998 in Unit 3 by 22% and severely overestimated the age 3 population in Unit 2 by 176%.

In examining backcast estimates of ages 2 and older, last year's CAGEAN and recruitment regression values overestimated the population in Units 1-3, but underestimated Unit 4. Much of the error was attributed to overestimates of the age 2 cohort. Our original regression estimates were 79.3 million in Unit 1, 71.7 million in unit 2 and 32.4 million in Unit 3. CAGEAN's first read on the 1996 year class estimated 41.7 million in Unit 1, 54.7 million in Unit 2 and 12.1 million in Unit 3. The 1996 year class has also exhibited reduced growth; therefore, it is possible that this cohort had reduced recruitment during this year (and subsequently lower selectivity). If this were the case, then we would expect these estimates to rise again next year when we perform the next permutation of CAGEAN. There are some cautionary notes regarding the strength of the 1996 year class that are also evident. Recent OMNR Partnership surveys show that the 1996 year class may not be as strong as expected in Ontario waters of Units 1-3. Ohio Division of Wildlife trawl surveys in Unit 1 during 1998 also validate this position.

CAGEAN estimates have generally followed a pattern of increasing abundance of the year class represented by the age 2 cohort for the first few years after successive annual CAGEAN runs. This process improves precision of the cohort estimate with time. Even the 1994 year class exhibited substantial gains (similar to the 1995 year class), again due to the reduced growth factor and now that cohort had full recruitment into all fishery gears. After that year class though, and further back into past years, no increasing trends were apparent.

With the overestimates of the 1996 year class and the underestimates of the 1995 year class, the age 2 and older estimates for 1998 in this year's report were generally at the lowest end of the given range from our YPTG 1998 reported population estimates. Unit 4's age 2 and older estimate for 1998 in this year's report was higher due to improved precision of the 1993 through 1995 year classes.

Backcast estimates of biomass for ages 2+ at the start of 1998 were slightly higher than projected in the YPTG 1998 report for Units 1 and 2, somewhat lower than projected in Unit 3, and much higher in Unit 4 (using the standard CAGEAN and regression estimators). This is primarily due to the difference in abundance estimates but may also be due to reduction in growth and weight-at-age values. Age 2+ backcast values of biomass were higher than YPTG 1998 projections by 3% in Unit 1 and 2% in Unit 2, but lower than YPTG 1998 projections by 11% in Unit 3. The biomass estimate was increased by 98% in Unit 4. Backcast estimates increased the biomass of age 3+ yellow perch in Units 1, 3, and 4, up 59%, 33%, and 120%, respectively. Backcast estimates reduced age 3+ biomass in Unit 2 by 6%. Again most of this imprecision was due to changes in the abundance estimates of the 1995 year class, but Unit 4 imprecision was likely due to the paucity of experimental samples provided for the model.

Recruitment Estimator for Incoming Age 2 Yellow Perch

The Yellow Perch Task Group continues to refine the recruitment module and has improved the trawl data series that goes into calculating the least-squares regression values against calculated CAGEAN age 2 values. Trawl values were also pooled across season and agency where available to gather additional index series. Greater precision was gained by compiling data in arithmetic and geometric mean catch per hour tow. The YPTG presents the most significant regression equations used in calculating age 2 yellow perch from the 1997 year class entering the fishery in 1999 in Appendix B, Table B-1. Raw data from trawl index series for the time period examined are presented in Appendix B, Tables B-2 (geometric means) and B-3 (arithmetic means), while a key summarizing abbreviations used for the trawl series is presented as a Legend in Appendix B. Due to the variability in significant regression indices, the YPTG chose a mean estimator to describe age 2 yellow perch available to the fishery beginning in 1999. Regressions that produced negative slopes or did not have index values for 1998 were also omitted from the analyses.

In general, the 1997 year class is moderately weak compared to the last four years, but still may be a factor compared to the poor year classes of the late 1980's and early 1990's.

1999 Population Size Projection

Stock size estimates for 1999 (age 3 and older) were projected from the CAGEAN 1998 population size estimates and age-specific survival rates in 1998 (Tables 5 and 6). Age 2 recruitment values for the 1997 year class in 1999 (methods described above) were then added into the age 3 and older population size estimates in each unit to give a 1999 population of yellow perch ages 2 and older (Table 6). The YPTG continued to calculate and report standard errors and ranges about our mean estimates for each age as in the last two years (YPTG 1997). This method calculates the coefficient of variation (CV, Table 6), using the mean and standard deviation from the last year in the time series of CAGEAN in each management unit, instead of the bootstrap mean of means that was used in the past. This method was again employed to calculate the CV and the population ranges.

For 1999, stock size estimates of age 2 and older yellow perch compared to 1998 show a sizable decrease of 23% in Unit 1, 28% in Unit 2, 16% in Unit 3, and 13% in Unit 4 (Tables 4 and 5, Figure 5). Stock size estimates of age 3 and older fish show a sizable increase in all management units in 1999 except Unit 4: up 58% in Unit 1, 171% in Unit 2, 33% in Unit 3, but down 23% in Unit 4. The estimates changed so drastically because of a relatively weak year class entering at age 2 and a strong year class progressing into age 3.

Biomass estimates for age 2 and older fish for 1999 decrease over 1998 levels in all Units except Unit 4 (Table 4, Figure 6) due to the weaker incoming 1997 year class. Ages 2+ biomass estimates are down 34% in Unit 1, 31% in Unit 2, 29% in Unit 3 and up 2% in Unit 4. Biomass estimates of age 3 and older yellow perch available at the start of 1999 are higher than 1998 in all management units: Unit 1, +36%; Unit 2, +115%; Unit 3, +10%; and Unit 4, +6%. Yellow perch populations in all units will be dominated by fish from the 1996 year class, but the 1995 and 1994 year classes and to a smaller extent the 1993 year class are persisting in all management units. It is expected that the 1997 year class will contribute less than the 1995 year class when it entered the fishery at age 2 a couple of years ago.

Survival rates for ages 2 and older perch in 1998 increased in Units 1-3, and declined slightly in Unit 4 (Figure 7). This trend was also exhibited for survival of ages 3 and older yellow perch in Units 2 and 3 (Table 4, Figure 7), but Units 1 and 4 exhibited small declines. Overall survival trends since 1988 show a general (slow) increase in survival across all management units until 1996 when trends show a leveling off (Unit 1) or a decline (Units 2-4). Exploitation rates for ages 2 and older fish in 1998 decreased substantially in all management units except unit 4 (Figure 8). This trend is probably due to lower selectivity of the slower-growing strong 1996 year class. Exploitation of age 3 and older yellow perch increased in Units 1 and 4 but decreased in Units 2 and 3 (Figure 8). Overall trends for exploitation showed a slight decreasing trend up until 1996, but are influenced in each management unit independently by periodic spikes that coincide with the entry of strong year classes into the fishery. There is a concern by the task group that exploitation rates are still above target levels (as specified by mean RAH values calculated under F_{opt} over years of YPTG reports). Exploitation rates must remain under control to sustain recovery in all Units.

Yield per Recruit; F_{opt} and F_{age}

The yield per recruit model used to calculate a recommended harvest in 1999 is similar to that used in 1998. The basic assumption of the yield per recruit model is that the desired harvest strategy is to optimize the return in weight per recruit. The optimum harvest rate, F_{opt}, is determined by growth rate versus natural mortality rate. For temperate waters, F_{opt} is modified to $F_{0.1}$, which corresponds to 10% of the rate of increase in yield per recruit, which can be obtained by increasing F (fishing mortality) at low levels of fishing. A full description of the model inputs, as well as the steps required to determine a scaled $F_{0.1}$, is given in previous reports (YPTG 1991, 1995). Since we have updated our growth information, the YPTG determined updates to von Bertalanffy inputs and F_{opt} calculations and outputs were also necessary. For Management Units 1, 2 and 4, knife-edge full recruitment in the F-OPTMAXX model (YPTG 1995, 1996) was set at age equal to 3.5 years, whereas in unit 3 it was set to 3.0 years based on recent selectivity and CAGEAN information. Updated F_{opt} values are presented in Table 7. F_{opt} values in general decreased slightly for Management Units 2 through 4, but increased in Unit 1.

The second factor in determining yield per recruit is calculating fishing mortality by age (F_{age}). In previous years (see YPTG 1996 or 1997, for example), a method of calculating F_{age} was employed that resulted in values of F for specific ages being greater than F_{opt} for that age. The YPTG again employed the method described in last year's report. F_{age} is equal to F_{opt} (not greater) and for those ages where full recruitment is not attained F_{age} is calculated by the equation: $F_{age} = F_{opt} * s_{(age)}$, where $s_{(age)}$ is the selectivity for that age. Selectivity at a specific age is calculated from the last year of the CAGEAN run (or a similar year's conditions in CAGEAN runs if the new year is expected to differ significantly from the previous year's fishery), based on the ratio of F for that age to F for the age of full recruitment (see "F" column from Table 6 and "s(age)" column from Table 7). This method produces a more conservative estimate of F_{age}, more akin to a Ricker method, and will result in a lower estimate of harvest (and RAH) than the previous method. This is also a more desirable calculation in that at no time do we recommend an F value for any age group that is higher than F_{opt}. This is the same method of calculating F_{opt} that has been adopted by the WTG.

The third and fourth factors updated in the yield per recruit calculations are calculating mean weight-at-age in the population (Table 6) and mean weight-at-age in harvest (Table 7). In both cases, a two-year time series average was used in each management unit for these calculations. Because of the recent changes and variability seen in growth, the YPTG determined that shortening the time series used in calculating these averages to just two years would be more appropriate in reflecting current conditions seen across the lake and would be more responsive to changes in each unit. These values are based on a high number of samples taken from interagency surveys by all agencies.

The 1999 harvest estimates for age 2 and older fish are summarized by management unit in Table 7. These values are the sum of the estimates of the harvest in numbers of each age group. The harvest estimates are derived (as described above) by scaling the F_{opt} value by the selectivity for that age, s(age), and applying the resulting F and exploitation (u) to the 1999 population projection for that age. The harvest in weight is then calculated by multiplying the age specific catch (millions of fish) by mean weight in the harvest (2 year average, 1997-1998).

The 1999 harvest estimates are somewhat lower than those calculated for 1998 and similar to or slightly higher than the observed 1998 harvest. Two dominant factors that will affect the accuracy of the 1999 harvest estimates are: the full recruitment of the 1996 year class (which from our initial indications was very strong, and may be underestimated in this year's CAGEAN due to poor growth) and the entry of the weak 1997 year class, one of the smallest seen in our interagency trawl and gill net surveys for at least a decade.

Recommended Allowable Harvests

In 1998, the Lake Erie Committee adopted a lakewide harvest of 7.44 million pounds of yellow perch. The lakewide RAH range recommended by the YPTG for 1998 was 5.9 to 7.5 million pounds lakewide. The 1998 lakewide harvest was 5.864 million pounds. The YPTG and the LEC presented TAC (Total Allowable Catch) for 1998 by management unit. Allocation for Unit 1 was 2.6 million pounds, and harvest was 2.271 million pounds. Allocation for Unit 2 was 3.3 million pounds, and harvest was 2.425 million pounds. Allocation for Unit 3 was 1.4 million pounds, and harvest was 1.115 million pounds. Allocation for Unit 4 was 0.14 million pounds, and harvest was 0.052 million pounds.

The Yellow Perch Task Group is aware that recovery of yellow perch stocks in all management units may hinge on the progression of the 1996 year class to reproductive age and size. Recovery signs (increased abundance and biomass and survival, reduced exploitation and production of good year classes) were evident until 1996 in Units 1, 2 and 3, but may have been handed a setback in 1997 and 1998 with increased exploitation well above F_{opt}. Recovery and strong to moderate year classes are not apparent in Unit 4. The YPTG is concerned about the delay (or inability) of the 1995 and 1996 year classes to recruit into the fishery during 1997 and 1998. The YPTG is urging caution in setting allowable catch levels too high based on the potential strength of the 1996 year class completely entering the fishery or the perceived strength of the 1997 year class. Independent estimators point to their weakness. Until we get a better read on the strength of the 1996 year class, which is just really beginning to fully contribute to the fishery, the task group would prefer that TAC's are somewhat conservative. The task group is aware of the problems of ultraconservative TAC estimates that could be generated by under-representing the age 2 cohort and compounding the problem in yield per recruit calculations for the subsequent year.

At the request of the Standing Technical Committee (STC), we examined the use of Partnership trawl estimates of the 1996 year class at age 2. In general, they showed a much weaker 1996 year class (about half or less than the CAGEAN estimates). This translated into a 26% lower estimated mean RAH. These values aren't completely substantiated by other trawl values or index trawl values used to initially estimate the 1996 year class.

Also at the request of the STC, we examined patterns of selectivity to note if they would significantly change our recommended RAH range. With this exercise we could determine changes in selectivity for the upcoming year based on selection of a prior year that had gone through CAGEAN with a similar age structure. In this exercise, the age structure most similar was 1997 for Units 1-3 and 1995 for Unit 4. These years showed very similar selectivity patterns. In fact, the RAH ranges based on the selectivity patterns of the prior years differed by plus or minus five percent or less in each Unit. There were no trends or significant differences in this year's exercise that would alter our course for the RAH range, but this will be examined in the future.

The Yellow Perch Task Group recommends adopting a 1999 harvest distribution by Management Unit in the range of values found in Table 8. Presented by management unit these suggested 1999 RAH values would be: Unit 1, 1.7-2.9 million pounds; Unit 2, 2.1-3.8 million pounds; Unit 3, 0.7-1.5 million pounds; Unit 4, 0.07-0.17 million pounds. Given that other indicators like partnership and trawl indices point to weaker 1996 and 1997 year class estimates, and the need for reduced exploitation to meet F_{opt} and rehabilitation targets, the Yellow Perch Task Group recommends that the LEC choose a TAC for each Unit that is near or below the mean RAH value given in Table 8. Those values are 2.3, 3.0, 1.1, and 0.1 million pounds for Units 1 though 4, respectively, for a lakewide total of 6.5 million pounds.

Additional Task Group Charges

Spawning Stock Biomass

The task group was also charged to "...continue the effort to establish a minimum stock size which management agencies should stay above to sustain perch stocks. Inherent in this charge is the development and documentation of indicators and methodology for determining stock size."

During 1998, we initiated contact with Dr. Ransom Myers (Dalhousie University, Halifax, Nova Scotia) who has been instrumental in developing similar biomass models and estimates for coastal fisheries (Hutchings and Myers 1994, Myers and Barrowman 1994, 1995 and 1996, Myers et al. 1995a, Myers et al. 1995b, Gilbert 1997, Myers 1997 and Francis 1997).

Some of the data that we employed in the spawning stock biomass analyses included yellow perch abundance and biomass estimates (by age) from our CAGEAN exercises for the time period 1975-1998, and measures of percent female by age and maturity-at-age from our experimental sample data. We also incorporated yellow perch fecundity-at-age from an estimate presented by Sztramko and Teleki (1977) taken in Long Point Bay. The fecundity-at-age-estimates were generated from average length-at-age information and the mean length-fecundity curve provided by Sztramko and Teleki. Newer fecundity data is forthcoming, and will allow us to update our datasets and provide more current analysis this summer. We will also continue to examine fecundity to see if interannual variation is significant.

From our data, we can gain considerable insight into the relationship between the number of females or spawning stock biomass and the total egg production in a given year (Figure 9). In this review, it was apparent that yellow perch four years old and older are the most important in determining production. Many yellow perch at age 2 are still not mature, and in many years a surprisingly high percentage of age-3 female yellow perch do not spawn. We also can gain insight into yellow perch population characteristics for each management unit from examination of frequency plots of stock abundance (Figure 10), spawning stock biomass (Figure 11) and Age 2 recruits (Figure 12) and stock-recruitment plots (Figure 13). We also provide egg production-recruit curves (Figure 14).

It is apparent from these datasets that large numbers of eggs do not necessarily translate into large recruitment numbers. In fact, the better year classes have come from an area to the left of the mean stock size. The distribution is not a normal curve; it is in fact skewed with a majority of the data points to the left of the mean value and a long tail to the right. Rather than presenting a line about the mean of data points on the x-axis (as in Ricker 1975), it may be better to describe a dome-shaped curve under which all the stock-recruitment points lie. This would represent the maximum amount of recruitment expected given stock and fecundity levels and current biotic and abiotic conditions (see the hypothetical R_{max} curve drawn in Figure 15). Although we do not have an exact equation calculated for R_{max} by management unit yet, we are looking at key components and a technique that can accurately describe it.

It is, however, important to note where yellow perch stock estimates reside under that R_{max} curve as a statement of potential for the population, as well as a statement of risk to the population. During the period of the late 1980s, Lake Erie yellow perch stocks were near the x (horizontal) axis out to the far right tail from the origin (high stock, little recruitment). Then in the early 1990's, several years were spent closer to the X-Y origin before the larger 1993, 1994 and 1996 year classes moved us back out and up. Note that in Unit 4 we are still close to the origin and recovery is not progressing well.

In 1999, we will expand on this analysis by incorporating more recent fecundity data and the next permutation of CAGEAN, and recruitment data. We will also incorporate abiotic and biotic factors that may be influencing recruitment, identify minimum spawning stock size for conservation purposes, and determine associated risk levels with various management strategies.

The Yellow Perch Task Group will also continue to pursue this topic with Dr. Myers. The YPTG will continue to evaluate this method of estimating populations, ever cautious that the minimum stock size does not become a target for the fishery to overexploit the population.

Yellow Perch Stock Genetics

A new charge for the Yellow Perch Task Group in 1997-1998 was to "explore the potential for genetic research on yellow perch stocks in Lake Erie." In addressing this charge, the Yellow Perch Task Group collected samples of five adult female yellow perch from several different locations around the lake (Sandusky Bay, Gibraltar Island (Bass Isl.), Fairport, Erie, Dunkirk, and Long Point Bay). These samples, taken during the post-spawn season, were collected for genetic analysis by Dr. Carol Stepien of Case Western Reserve University at Cleveland, Ohio. She has stated that she intends to do more work on our full sample of Lake Erie yellow perch at the mtDNA level and will also use new nuclear DNA region testing to determine if this technique is more expressive of local, rapid changes (Lansman et al. 1981), thereby determining if specific stock lineage can be ascertained. We will continue to assist and promote this important work in stock identification and delineation.

Conclusions

It is the view of the Yellow Perch Task Group that the long term time series monitoring of the yellow perch population and harvest continue, and that effort continue to be devoted to understanding the population changes which are occurring. The Task Group is continuing to monitor yellow perch growth rates and will serve as baseline comparisons of yellow perch condition throughout the lake.

The YPTG will also continue to address current charges regarding long term data sets, RAH, age 2 recruitment estimators. The YPTG will continue to explore age 2 growth, backcasting, and selectivities, all selectivity curves for each fishery, the F_{opt} procedure and fishing mortalities at specific ages for incorporation into following task group reports in order to better track how fisheries will perform in subsequent years with projected yellow perch populations. We will also look at other independent estimators of population abundance that could be used to complement and verify CAGEAN outputs and trends. We will continue to track the 1995 and 1996 year classes and CAGEAN estimates of them after another fishing year. The YPTG plans a renewed effort to examine abiotic and biotic factors influencing yellow perch growth and condition and their effect on yellow perch entering the fishery at age 2 and selectivity at all ages. We will also apply these findings to how we address projection of age 2 recruitment into the next year and our projected population abundance, biomass, and harvest estimates and recommendations.

Task group members are pleased to be working with Dr. Stepien addressing the genetics issues and with Dr. Myers investigating the spawning stock biomass and stock-recruitment issues and look forward to making substantial progress on these charges in the coming year.

Acknowledgments

The task group wishes to thank Tim Bader (ODW), Mike Bur (USGS-BRD), Andy Cook (OMNR), Don Einhouse (NYSDEC), Gene Emond (ODW) and Jeff Tyson (ODW) for providing data and/or comments for this year's report.

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Table 1. Lake Erie yellow perch harvest in pounds by management unit (Unit) and agency, 1988-1998.

		Ontario*		Ohio		Michigan		Pennsylvania		New York		Total
	Year	Catch	%	Catch	%	Catch	%	Catch	%	Catch	%	Catch
Unit 1	1988	3,186,225	61	1,865,430	36	167,580	3	--	--	--	--	5,219,235
	1989	3,157,560	59	1,900,710	35	332,955	6	--	--	--	--	5,391,225
	1990	1,781,640	67	652,680	24	231,525	9	--	--	--	--	2,665,845
	1991	648,270	46	681,345	48	94,815	7	--	--	--	--	1,424,430
	1992	687,960	59	405,720	35	66,150	6	--	--	--	--	1,159,830
	1993	1,139,985	62	577,710	31	123,480	7	--	--	--	--	1,841,175
	1994	710,010	59	434,385	36	66,150	5	--	--	--	--	1,210,545
	1995	524,790	38	784,980	57	77,175	6	--	--	--	--	1,386,945
	1996	704,167	36	1,125,716	57	134,810	7	--	--	--	--	1,964,693
	1997	1,091,844	48	1,071,025	47	111,819	5	--	--	--	--	2,274,688
	1998	1,170,533	52	968,842	43	132,051	6	--	--	--	--	2,271,426
Unit 2	1988	5,596,290	93	421,155	7	--	--	--	--	--	--	6,017,445
	1989	5,578,650	84	1,071,630	16	--	--	--	--	--	--	6,650,280
	1990	2,873,115	75	952,560	25	--	--	--	--	--	--	3,825,675
	1991	2,171,925	76	683,550	24	--	--	--	--	--	--	2,855,475
	1992	2,522,520	83	500,535	17	--	--	--	--	--	--	3,023,055
	1993	1,933,785	80	493,920	20	--	--	--	--	--	--	2,427,705
	1994	1,300,950	55	1,045,170	45	--	--	--	--	--	--	2,346,120
	1995	1,073,835	57	804,825	43	--	--	--	--	--	--	1,878,660
	1996	1,290,998	61	823,425	39	--	--	--	--	--	--	2,114,423
	1997	1,826,180	63	1,079,882	37	--	--	--	--	--	--	2,906,062
	1998	1,797,458	74	627,944	26	--	--	--	--	--	--	2,425,402
Unit 3	1988	2,487,240	78	526,995	17	--	--	178,605	6	--	--	3,192,840
	1989	2,414,475	63	1,199,520	31	--	--	211,680	6	--	--	3,825,675
	1990	2,127,825	76	504,945	18	--	--	185,220	7	--	--	2,817,990
	1991	1,212,750	75	253,575	16	--	--	152,145	9	--	--	1,618,470
	1992	1,190,700	82	185,220	13	--	--	77,175	5	--	--	1,453,095
	1993	606,375	78	145,530	19	--	--	24,255	3	--	--	776,160
	1994	379,260	48	359,415	45	--	--	55,125	7	--	--	793,800
	1995	465,255	80	83,790	14	--	--	30,870	5	--	--	579,915
	1996	512,293	72	186,695	26	--	--	9,041	1	--	--	708,029
	1997	829,353	77	219,664	20	--	--	23,360	2	--	--	1,072,377
	1998	811,903	73	274,993	25	--	--	28,527	3	--	--	1,115,423
Unit 4	1988	568,890	98	--	--	--	--	2,205	<1	8,820	2	579,915
	1989	438,795	78	--	--	--	--	0	0	121,275	22	560,070
	1990	282,240	88	--	--	--	--	0	0	37,485	12	319,725
	1991	160,965	87	--	--	--	--	0	0	24,255	13	185,220
	1992	114,660	85	--	--	--	--	0	0	19,845	15	134,505
	1993	72,765	85	--	--	--	--	0	0	13,230	15	85,995
	1994	52,920	83	--	--	--	--	0	0	11,025	17	63,945
	1995	33,075	83	--	--	--	--	0	0	6,615	17	39,690
	1996	30,495	82	--	--	--	--	2,205	6	4,472	12	37,172
	1997	36,171	87	--	--	--	--	3,049	7	2,387	6	41,607
	1998	48,457	93	--	--	--	--	538	1	3,175	6	52,170
Lakewide Totals	1988	11,838,645	79	2,813,580	19	167,580	1	180,810	1	8,820	<1	15,009,435
	1989	11,589,480	71	4,171,860	25	332,955	2	211,680	1	121,275	1	16,427,250
	1990	7,064,820	73	2,110,185	22	231,525	2	185,220	2	37,485	<1	9,629,235
	1991	4,193,910	69	1,618,470	27	94,815	2	152,145	3	24,255	<1	6,083,595
	1992	4,515,840	78	1,091,475	19	66,150	1	77,175	1	19,845	<1	5,770,485
	1993	3,752,910	73	1,217,160	24	123,480	2	24,255	<1	13,230	<1	5,131,035
	1994	2,443,140	55	1,838,970	42	66,150	1	55,125	1	11,025	<1	4,414,410
	1995	2,096,955	54	1,673,595	43	77,175	2	30,870	1	6,615	<1	3,885,210
	1996	2,537,953	53	2,135,836	44	134,810	3	11,246	<1	4,472	<1	4,824,317
	1997	3,783,548	60	2,370,571	38	111,819	2	26,409	<1	2,387	<1	6,294,734
	1998	3,828,351	65	1,871,779	32	132,051	2	29,065	<1	3,175	<1	5,864,421

* processor weight

Table 2b. Catch, effort and catch per unit effort summaries for Lake Erie yellow perch fisheries in Management Unit 2 (western Central Basin) by agency and gear type, 1988-1998.

		Unit 2		
		Ohio		Ontario
	Year	Trap Nets	Sport	Gill Nets
Catch (pounds)	1988	46,305	374,850	5,596,290
	1989	200,655	870,975	5,578,650
	1990	650,475	302,085	2,873,115
	1991	302,085	381,465	2,171,925
	1992	145,530	355,005	2,522,520
	1993	114,660	379,260	1,933,785
	1994	304,290	740,880	1,300,950
	1995	257,985	546,840	1,073,835
	1996	323,334	500,091	1,290,998
	1997	498,945	580,937	1,826,180
	1998	304,661	323,283	1,797,458
Catch (Metric) (tonnes)	1988	21	170	2,538
	1989	91	395	2,530
	1990	295	137	1,303
	1991	137	173	985
	1992	66	161	1,144
	1993	52	172	877
	1994	138	336	590
	1995	117	248	487
	1996	147	227	585
	1997	226	263	828
	1998	138	147	815
Effort *(a)*	1988	448	402,180	17,315
	1989	1,403	572,612	25,679
	1990	6,238	400,676	31,613
	1991	6,480	452,277	34,739
	1992	4,753	340,917	35,348
	1993	2,558	320,891	25,569
	1994	7,139	538,977	23,441
	1995	6,467	388,238	18,337
	1996	5,834	316,736	14,572
	1997	8,721	575,365	24,974
	1998	7,943	422,176	23,823
Catch Rates *(b)*	1988	46.9	2.4	146.6
	1989	64.9	3.4	98.5
	1990	47.3	1.5	41.2
	1991	21.1	2.2	28.4
	1992	13.9	3.0	32.4
	1993	20.3	3.1	34.3
	1994	19.3	3.3	25.2
	1995	18.1	3.5	26.6
	1996	25.1	4.2	40.1
	1997	25.9	2.8	33.2
	1998	17.4	2.6	34.2

(a) sport effort in angler-hours; gill net effort in km; trap net effort in lifts
(b) catch rates for sport in fish/hr, gill net in kg/km, trap net in kg/lift

Table 2c. Catch, effort and catch per unit effort summaries for Lake Erie yellow perch fisheries in Management Unit 3 (eastern Central Basin) by agency and gear type, 1988-1998.

		Unit 3					
		Ohio		Ontario	Pennsylvania		
	Year	Trap Nets	Sport	Gill Nets	Gill Nets	Trap Nets	Sport
Catch (pounds)	1988	330,750	196,245	2,487,240	178,605		
	1989	635,040	564,480	2,414,475	211,680		
	1990	447,615	57,330	2,127,825	185,220		
	1991	185,220	68,355	1,212,750	152,145		
	1992	101,430	83,790	1,190,700	77,175		
	1993	68,355	77,175	606,375	24,255		
	1994	141,120	218,295	379,260	55,125		
	1995	63,945	19,845	465,255	30,870		
	1996	103,414	83,281	512,293	0	5,292	3,749
	1997	54,776	164,888	829,353	0	7,398	15,962
	1998	90,082	184,911	811,903	0	5,291	23,236
Catch (Metric) (tonnes)	1988	150	89	1,128	81		
	1989	288	256	1,095	96		
	1990	203	26	965	84		
	1991	84	31	550	69		
	1992	46	38	540	35		
	1993	31	35	275	11		
	1994	64	99	172	25		
	1995	29	9	211	14		
	1996	47	38	232	0	2.4	1.7
	1997	25	75	376	0	3.4	7.2
	1998	41	84	368	0	2.4	10.5
Effort *(a)*	1988	4,781	172,490	6,203	1,418		
	1989	7,281	248,530	7,098	1,037		
	1990	7,376	31,881	12,472	1,978		
	1991	4,516	54,607	12,247	2,018		
	1992	3,361	84,445	14,540	1,321		
	1993	2,610	96,619	10,017	620		
	1994	3,053	173,706	8,169	1,442		
	1995	3,258	42,234	6,843	1,465		
	1996	2,730	69,887	6,184	0	185	12,850
	1997	2,455	126,530	9,423	0	441	43,377
	1998	2,512	111,425	10,809	0	305	30,612
Catch Rates *(b)*	1988	31.4	2.7	181.8	57.1		
	1989	39.6	4.1	154.3	92.6		
	1990	27.5	1.9	77.4	42.5		
	1991	18.6	2.0	44.9	34.2		
	1992	13.7	1.8	37.1	26.5		
	1993	11.9	1.7	27.5	17.7		
	1994	21.0	2.3	21.1	17.3		
	1995	8.9	1.3	30.8	9.6		
	1996	17.2	2.8	37.5		13.0	0.8
	1997	10.2	3.1	39.9		7.6	0.9
	1998	16.3	3.6	34.0		7.9	1.5

(a) sport effort in angler-hours; gill net effort in km; trap net effort in lifts
(b) catch rates for sport in fish/hr, gill net in kg/km, trap net in kg/lift

Table 2d. Catch, effort and catch per unit effort summaries for Lake Erie yellow perch fisheries in Management Unit 4 (Eastern Basin) by agency and gear type, 1988-1998.

		Unit 4					
		New York		Ontario	Pennsylvania		
	Year	Trap Nets	Sport	Gill Nets	Gill Nets	Trap Nets	Sport
	1988	8,820		568,890	2,205		
	1989	17,640	103,635	438,795	0		
	1990	19,845	17,640	282,240	0		
	1991	15,435	8,820	160,965	0		
	1992	11,025	8,820	114,660	0		
Catch (pounds)	1993	6,615	6,615	72,765	0		
	1994	4,410	6,615	52,920	0		
	1995	3,122	6,615	33,075	0		
	1996	2,822	1,650	30,495	0	0	2,205
	1997	1,241	1,146	36,171	0	0	3,049
	1998	1,345	1,830	48,457	0	0	538
	1988	4.0		258	1		
	1989	8.0	47.0	199	0		
	1990	9.0	8.0	128	0		
	1991	7.0	4.0	73	0		
Catch (Metric) (tonnes)	1992	5.0	4.0	52	0		
	1993	3.0	3.0	33	0		
	1994	2.0	3.0	24	0		
	1995	1.4	3.0	15	0		
	1996	1.3	0.7	14	0	0	1.0
	1997	0.6	0.5	16	0	0	1.4
	1998	0.6	0.8	22	0	0	0.2
	1988	2,132		2,719	8		
	1989	1,136	65,370	2,628	0		
	1990	981	24,463	3,924	0		
	1991	918	22,090	3,859	0		
	1992	632	52,398	3,351	0		
Effort *(a)*	1993	761	26,297	2,008	0		
	1994	555	14,800	1,642	0		
	1995	532	12,115	1,375	0		
	1996	533	6,535	1,063	0	0	7,292
	1997	292	8,905	1,073	0	0	13,747
	1998	178	7,073	1,081	0	0	3,784
	1988	1.9	1.7	94.9	125.0		
	1989	7.0	2.2	75.7			
	1990	9.2	0.4	32.6			
	1991	7.6	0.6	18.9			
	1992	7.9	0.4	15.5			
Catch Rates *(b)*	1993	3.9	0.4	16.4			
	1994	3.6	0.4	14.6			
	1995	2.7	0.8	10.9			
	1996	2.4	0.5	13.1			0.6
	1997	1.9	0.4	14.9			1.0
	1998	3.4	0.7	20.4			0.5

(a) sport effort in angler-hours; gill net effort in km; trap net effort in lifts
(b) catch rates for sport in fish/hr, gill net in kg/km, trap net in kg/lift

Table 3. Lake Erie 1998 yellow perch harvest (numbers of fish) by gear, age and management unit (Unit).

Gear	Age	Unit 1 Number	Unit 1 %	Unit 2 Number	Unit 2 %	Unit 3 Number	Unit 3 %	Unit 4 Number	Unit 4 %	Lakewide Number	Lakewide %
Gill Nets	1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	2	157,253	3.1	3,299,498	44.7	404,150	14.6	6,767	3.7	3,867,668	25.0
	3	1,821,574	35.5	1,951,963	26.4	1,387,029	50.2	47,016	25.6	5,207,582	33.7
	4	2,712,120	52.8	1,891,725	25.6	773,890	28.0	86,978	47.4	5,464,712	35.3
	5	407,443	7.9	204,996	2.8	177,999	6.4	42,818	23.3	833,255	5.4
	6+	37,414	0.7	33,234	0.5	21,728	0.8	0	0.0	92,375	0.6
	Total	5,135,804		7,381,416		2,764,794		183,579		15,465,593	
Trap Nets	1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	2	18,116	3.6	402,956	31.9	213	0.4	848	25.1	422,133	23.1
	3	195,392	39.1	328,152	26.0	801	1.4	74	2.2	524,419	28.7
	4	217,720	43.5	468,709	37.1	28,562	49.4	1,706	50.6	716,697	39.3
	5	51,428	10.3	40,867	3.2	15,807	27.3	590	17.5	108,692	6.0
	6+	17,370	3.5	23,541	1.9	12,482	21.6	154	4.6	53,547	2.9
	Total	500,026		1,264,225		57,865		3,372		1,825,488	
Sport	1	1,443	0.03	0	0.0	0	0.0	0	0.0	1,443	0.0
	2	1,166,738	26.8	598,464	54.5	104,677	23.7	4,237	57.0	1,874,115	31.8
	3	1,699,311	39.1	229,294	20.9	90,836	20.6	368	4.9	2,019,809	34.3
	4	1,183,250	27.2	207,370	18.9	188,621	42.7	1,889	25.4	1,581,129	26.8
	5	233,012	5.4	37,861	3.4	26,566	6.0	737	9.9	298,176	5.1
	6+	64,462	1.5	25,085	2.3	30,745	7.0	207	2.8	120,499	2.0
	Total	4,348,216		1,098,074		441,444		7,438		5,895,171	
All Gear	1	1,443	0.0	0	0.0	0	0.0	0	0.0	1,443	0.0
	2	1,342,107	13.4	4,300,918	44.1	509,039	15.6	11,852	6.1	6,163,917	26.6
	3	3,716,277	37.2	2,509,409	25.8	1,478,666	45.3	47,458	24.4	7,751,811	33.4
	4	4,113,090	41.2	2,567,804	26.4	991,073	30.4	90,573	46.6	7,762,539	33.5
	5	691,883	6.9	283,724	2.9	220,371	6.8	44,145	22.7	1,240,123	5.3
	6+	119,245	1.2	81,860	0.8	64,954	2.0	361	0.2	266,421	1.1
	Total	9,982,602		9,743,715		3,264,103		194,389		23,186,252	

Table 4. Estimates of Lake Erie yellow perch population size, biomass, exploitation and survival rates from the three-gear CAGEAN model. S is the annual survival rate and u is the annual exploitation rate. Results are presented for ages 2+ and ages 3+ from 1988 through 1998 by management unit (Unit).

	Year	Number - Ages 2+ (millions)	Biomass - Ages 2+ (millions kg)	Biomass - Ages 2+ (millions lbs)	S	u	Number - Ages 3+ (millions)	Biomass - Ages 3+ (millions kg)	Biomass - Ages 3+ (millions lbs)	S	u
Unit 1	1988	75.827	9.138	20.150	0.485	0.230	52.665	6.992	15.418	0.420	0.312
	1989	38.993	5.041	11.116	0.372	0.374	36.774	4.856	10.708	0.357	0.393
	1990	19.352	3.156	6.959	0.385	0.357	14.504	2.519	5.555	0.315	0.448
	1991	18.040	2.262	4.988	0.435	0.294	7.452	1.203	2.653	0.243	0.543
	1992	20.720	2.419	5.333	0.471	0.248	7.842	1.066	2.351	0.266	0.513
	1993	16.236	1.878	4.142	0.398	0.340	9.761	1.436	3.166	0.265	0.513
	1994	19.945	2.271	5.008	0.510	0.198	6.465	0.910	2.006	0.299	0.468
	1995	37.196	3.897	8.592	0.552	0.147	10.180	1.303	2.873	0.369	0.378
	1996	53.693	5.689	12.545	0.533	0.170	20.520	2.449	5.401	0.384	0.358
	1997	45.249	4.839	10.671	0.499	0.213	28.628	3.349	7.384	0.414	0.321
	1998	64.229	6.457	14.239	0.554	0.144	22.563	2.624	5.786	0.388	0.353
	1999	49.212	4.274	9.424			35.578	3.565	7.861		
Unit 2	1988	92.885	12.681	27.962	0.523	0.183	51.650	7.967	17.567	0.446	0.280
	1989	52.305	8.273	18.242	0.378	0.367	48.555	7.990	17.619	0.361	0.388
	1990	26.959	4.502	9.927	0.330	0.429	19.747	3.651	8.050	0.254	0.528
	1991	29.510	4.132	9.111	0.445	0.280	8.884	1.691	3.729	0.266	0.512
	1992	38.449	4.770	10.518	0.482	0.235	13.143	2.003	4.417	0.327	0.432
	1993	27.881	3.339	7.361	0.360	0.389	18.518	2.661	5.868	0.268	0.510
	1994	27.730	3.559	7.848	0.499	0.213	10.047	1.644	3.624	0.347	0.406
	1995	27.924	3.742	8.251	0.481	0.236	13.828	2.093	4.615	0.368	0.379
	1996	46.053	5.661	12.483	0.540	0.161	13.428	2.105	4.642	0.392	0.348
	1997	34.670	4.440	9.789	0.386	0.356	24.869	3.505	7.729	0.315	0.447
	1998	68.115	7.924	17.473	0.532	0.171	13.392	2.124	4.682	0.343	0.412
	1999	49.272	5.461	12.042			36.235	4.575	10.087		
Unit 3	1988	47.077	8.569	18.894	0.538	0.163	38.193	7.189	15.852	0.510	0.199
	1989	28.911	5.178	11.418	0.475	0.243	25.349	4.818	10.624	0.450	0.275
	1990	17.589	3.625	7.993	0.383	0.360	13.732	3.180	7.012	0.312	0.452
	1991	16.666	2.524	5.566	0.466	0.254	6.741	1.413	3.115	0.236	0.553
	1992	13.136	1.848	4.075	0.412	0.323	7.763	1.264	2.787	0.265	0.514
	1993	7.772	1.114	2.456	0.389	0.352	5.408	0.833	1.836	0.284	0.488
	1994	13.322	1.252	2.761	0.564	0.131	3.026	0.542	1.195	0.313	0.450
	1995	13.299	1.733	3.820	0.572	0.121	7.516	1.066	2.350	0.506	0.204
	1996	19.831	2.573	5.674	0.572	0.122	7.608	1.171	2.583	0.451	0.274
	1997	17.787	2.158	4.758	0.492	0.222	11.335	1.697	3.743	0.410	0.326
	1998	20.926	2.751	6.067	0.555	0.143	8.744	1.432	3.157	0.439	0.288
	1999	17.587	1.956	4.314			11.610	1.580	3.484		
Unit 4	1990	13.146	2.828	6.236	0.579	0.113	12.528	2.767	6.101	0.576	0.117
	1991	8.195	1.950	4.299	0.600	0.086	7.615	1.878	4.142	0.597	0.091
	1992	5.350	1.174	2.590	0.632	0.048	4.920	1.161	2.561	0.629	0.051
	1993	4.207	0.877	1.933	0.625	0.056	3.378	0.788	1.738	0.616	0.067
	1994	3.665	0.605	1.335	0.639	0.038	2.629	0.533	1.176	0.633	0.046
	1995	5.348	0.846	1.866	0.658	0.015	2.343	0.578	1.275	0.651	0.024
	1996	5.817	0.680	1.499	0.650	0.026	3.520	0.534	1.178	0.641	0.036
	1997	4.274	0.662	1.460	0.638	0.039	3.778	0.630	1.390	0.635	0.043
	1998	3.350	0.644	1.419	0.627	0.053	2.728	0.584	1.289	0.620	0.062
	1999	2.910	0.655	1.445			2.100	0.617	1.361		

Table 5. Yellow perch stock size (millions of fish) at the start of the year, estimated by CAGEAN for the years 1988 to 1998. The 1999 population estimates use age 2 estimates derived from regressions of CAGEAN age 2 abundance against YOY and yearling trawl indices.

	Age	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Unit 1	2	23.162	2.220	4.848	10.588	12.878	6.475	13.480	27.017	33.173	16.621	41.666	13.634
	3	23.177	14.636	1.378	2.887	6.031	7.676	3.877	8.244	16.763	20.746	10.720	26.816
	4	22.787	9.527	5.045	0.341	0.554	1.470	1.984	1.141	3.030	6.419	9.091	4.651
	5	2.398	9.367	3.284	1.249	0.065	0.135	0.380	0.584	0.419	1.160	2.211	3.105
	6+	4.304	3.243	4.798	2.975	1.192	0.479	0.224	0.210	0.308	0.303	0.540	1.006
	2 and Older	75.827	38.993	19.352	18.040	20.720	16.236	19.945	37.196	53.693	45.249	64.229	49.212
	3 and Older	52.665	36.774	14.504	7.452	7.842	9.761	6.465	10.180	20.520	28.628	22.563	35.578
Unit 2	2	41.235	3.751	7.213	20.625	25.306	9.363	17.683	14.096	32.625	9.800	54.723	13.037
	3	16.568	25.540	2.218	3.866	10.779	14.223	5.085	10.344	8.334	19.600	5.548	31.648
	4	33.714	7.996	10.094	0.590	0.904	3.399	3.674	1.782	3.781	3.281	6.020	1.866
	5	0.690	14.307	2.523	1.622	0.077	0.206	0.841	1.163	0.586	1.357	0.945	1.863
	6+	0.678	0.711	4.912	2.807	1.383	0.690	0.447	0.540	0.727	0.632	0.879	0.857
	2 and Older	92.885	52.305	26.959	29.510	38.449	27.881	27.730	27.924	46.053	34.670	68.115	49.272
	3 and Older	51.650	48.555	19.747	8.884	13.143	18.518	10.047	13.828	13.428	24.869	13.392	36.235
Unit 3	2	8.884	3.562	3.857	9.925	5.373	2.364	10.296	5.783	12.223	6.452	12.182	5.977
	3	7.605	5.858	2.328	2.456	6.174	3.353	1.488	6.568	3.802	7.908	4.098	7.769
	4	29.754	3.967	2.716	0.796	0.641	1.684	1.000	0.485	3.341	1.814	3.249	1.753
	5	0.725	15.100	1.768	0.831	0.176	0.150	0.441	0.301	0.238	1.394	0.718	1.376
	6+	0.109	0.423	6.919	2.657	0.772	0.222	0.097	0.162	0.227	0.219	0.678	0.712
	2 and Older	47.077	28.911	17.589	16.666	13.136	7.772	13.322	13.299	19.831	17.787	20.926	17.587
	3 and Older	38.193	25.349	13.732	6.741	7.763	5.408	3.026	7.516	7.608	11.335	8.744	11.610
Unit 4	2			0.618	0.581	0.430	0.829	1.036	3.004	2.297	0.496	0.622	0.810
	3			0.556	0.403	0.378	0.285	0.547	0.679	1.996	1.522	0.328	0.409
	4			1.429	0.291	0.205	0.230	0.167	0.321	0.432	1.265	0.956	0.199
	5			0.168	0.218	0.038	0.080	0.070	0.097	0.204	0.274	0.794	0.579
	6+			10.376	6.703	4.299	2.784	1.845	1.247	0.889	0.719	0.649	0.913
	2 and Older			13.146	8.195	5.350	4.207	3.665	5.348	5.817	4.274	3.350	2.910
	3 and Older			12.528	7.615	4.920	3.378	2.629	2.343	3.520	3.778	2.728	2.100

Table 6. Projection of the 1999 Lake Erie yellow perch population. Stock size estimates are derived from CAGEAN. 1999 age 2 estimates are derived from regressions of CAGEAN age 2 abundance against YOY and yearling trawl indices. CV is coefficient of variation in stock size for the last year of CAGEAN runs.

			1998 Parameters				Rate Functions					1999 Parameters				Stock Biomass			
			Stock Size (numbers)				Mortality Rates				Survival Rate		Stock Size (numbers)			Mean Weight in	millions kg		millions lbs.
	CV	Age	Mean	Std. Err.	Min.	Max.	(F)	(Z)	(A)	(u)	(S)	Age	Mean	Min.	Max.	Pop. (kg)	1998	1999	1999
Unit 1		2	41.666	10.194	31.472	51.860	0.041	0.441	0.356	0.033	0.644	2	13.634	6.768	20.499	0.052	3.833	0.709	1.563
	0.250	3	10.720	2.623	8.097	13.343	0.435	0.835	0.566	0.295	0.434	3	26.816	20.255	33.376	0.076	1.072	2.038	4.494
		4	9.091	2.224	6.867	11.315	0.674	1.074	0.658	0.413	0.342	4	4.651	3.513	5.789	0.103	1.118	0.479	1.056
		5	2.211	0.541	1.670	2.752	0.674	1.074	0.658	0.413	0.342	5	3.105	2.346	3.865	0.227	0.324	0.705	1.554
		6+	0.540	0.132	0.408	0.672	0.366	0.766	0.535	0.256	0.465	6+	1.006	0.760	1.253	0.341	0.110	0.343	0.757
		Total	64.229	15.714	48.515	79.942	0.191	0.591	0.446	0.144	0.554	Total	49.212	33.642	64.782		6.457	4.274	9.424
		(3+)	22.563	5.520	17.042	28.083	0.546	0.946	0.612	0.353	0.388	(3+)	35.578	26.874	44.283		2.624	3.565	7.861
Unit 2		2	54.723	15.158	39.565	69.881	0.148	0.548	0.422	0.114	0.578	2	13.037	6.876	19.199	0.068	5.801	0.887	1.955
	0.277	3	5.548	1.537	4.011	7.085	0.690	1.090	0.664	0.420	0.336	3	31.648	22.882	40.415	0.109	0.686	3.450	7.606
		4	6.020	1.667	4.352	7.687	0.773	1.173	0.690	0.455	0.310	4	1.866	1.349	2.383	0.164	0.983	0.306	0.675
		5	0.945	0.262	0.683	1.207	0.464	0.864	0.578	0.310	0.422	5	1.863	1.347	2.379	0.284	0.193	0.529	1.167
		6+	0.879	0.244	0.636	1.123	0.250	0.650	0.478	0.184	0.522	6+	0.857	0.620	1.095	0.338	0.261	0.290	0.639
		Total	68.115	18.868	49.247	86.982	0.231	0.631	0.468	0.171	0.532	Total	49.272	33.074	65.471		7.924	5.461	12.042
		(3+)	13.392	3.710	9.682	17.101	0.671	1.071	0.657	0.412	0.343	(3+)	36.235	26.198	46.272		2.124	4.575	10.087
Unit 3		2	12.182	4.605	7.577	16.787	0.050	0.450	0.362	0.040	0.638	2	5.977	3.008	8.946	0.063	1.320	0.377	0.830
	0.378	3	4.098	1.549	2.549	5.648	0.449	0.849	0.572	0.303	0.428	3	7.769	4.832	10.706	0.105	0.522	0.816	1.799
		4	3.249	1.228	2.021	4.478	0.460	0.860	0.577	0.308	0.423	4	1.753	1.090	2.416	0.167	0.578	0.293	0.645
		5	0.718	0.271	0.446	0.989	0.460	0.860	0.577	0.308	0.423	5	1.376	0.856	1.896	0.203	0.148	0.279	0.616
		6+	0.678	0.256	0.422	0.935	0.109	0.509	0.399	0.085	0.601	6+	0.712	0.443	0.981	0.270	0.183	0.192	0.424
		Total	20.926	7.910	13.016	28.836	0.189	0.589	0.445	0.143	0.555	Total	17.587	10.229	24.944		2.751	1.956	4.314
		(3+)	8.744	3.305	5.439	12.049	0.423	0.823	0.561	0.288	0.439	(3+)	11.610	7.221	15.998		1.432	1.580	3.484
Unit 4		2	0.622	0.238	0.384	0.860	0.018	0.418	0.341	0.014	0.659	2	0.810	0.277	1.568	0.047	0.059	0.038	0.084
	0.383	3	0.328	0.126	0.203	0.454	0.101	0.501	0.394	0.080	0.606	3	0.409	0.253	0.566	0.094	0.047	0.038	0.085
		4	0.956	0.366	0.590	1.322	0.101	0.501	0.394	0.080	0.606	4	0.199	0.123	0.275	0.124	0.170	0.025	0.054
		5	0.794	0.304	0.490	1.099	0.098	0.498	0.392	0.077	0.608	5	0.579	0.357	0.801	0.172	0.187	0.100	0.220
		6+	0.649	0.249	0.401	0.898	0.012	0.412	0.338	0.010	0.662	6+	0.913	0.563	1.263	0.498	0.180	0.455	1.003
		Total	3.350	1.283	2.067	4.632	0.067	0.467	0.373	0.053	0.627	Total	2.910	1.573	4.473		0.644	0.655	1.445
		(3+)	2.728	1.045	1.683	3.773	0.078	0.478	0.380	0.062	0.620	(3+)	2.100	1.296	2.905		0.584	0.617	1.361

Table 7. Estimated harvest of Lake Erie yellow perch for 1999. The exploitation rate is derived from optimal yield policy, and the stock size estimate are from CAGEAN and trawl regressions. Stock size and catch in numbers are in millions of fish. Catch weight is presented in millions of kilograms and pounds.

		Stock Size (numbers)			Exploitation Rate				Catch (millions of fish)			Mean Wt. in Harvest	RAH Catch (millions of kg)			RAH Catch (millions of lbs)		
	Age	Mean	Min.	Max.	F(opt)	s(age)	(F)	(u)	Mean	Min.	Max.	(kg)	Mean	Min.	Max.	Mean	Min.	Max.
Unit 1	2	13.634	6.768	20.499	0.519	0.060	0.031	0.025	0.347	0.172	0.522	0.085	0.029	0.015	0.044	0.065	0.032	0.098
	3	26.816	20.255	33.376	0.519	0.645	0.335	0.237	6.359	4.803	7.915	0.098	0.623	0.471	0.776	1.374	1.038	1.710
	4	4.651	3.513	5.789	0.519	1.000	0.519	0.339	1.579	1.193	1.965	0.116	0.183	0.138	0.228	0.404	0.305	0.503
	5	3.105	2.346	3.865	0.519	1.000	0.519	0.339	1.054	0.796	1.312	0.144	0.152	0.115	0.189	0.335	0.253	0.417
	6+	1.006	0.760	1.253	0.519	0.543	0.282	0.204	0.206	0.155	0.256	0.227	0.047	0.035	0.058	0.103	0.078	0.128
	Total	49.212	33.642	64.782				0.194	9.545	7.120	11.970	0.108	1.034	0.774	1.295	2.281	1.706	2.855
	(3+)	35.578	26.874	44.283				0.259	9.198	6.948	11.448	0.109	1.005	0.759	1.251	2.216	1.674	2.758
Unit 2	2	13.037	6.876	19.199	0.477	0.191	0.091	0.072	0.939	0.495	1.382	0.102	0.096	0.050	0.141	0.211	0.111	0.311
	3	31.648	22.882	40.415	0.477	0.892	0.426	0.290	9.171	6.631	11.712	0.118	1.082	0.782	1.382	2.386	1.725	3.047
	4	1.866	1.349	2.383	0.477	1.000	0.477	0.318	0.593	0.429	0.757	0.135	0.080	0.058	0.102	0.176	0.128	0.225
	5	1.863	1.347	2.379	0.477	0.600	0.286	0.207	0.386	0.279	0.493	0.156	0.060	0.044	0.077	0.133	0.096	0.169
	6+	0.857	0.620	1.095	0.477	0.324	0.154	0.118	0.102	0.073	0.130	0.197	0.020	0.014	0.026	0.044	0.032	0.056
	Total	49.272	33.074	65.471				0.227	11.190	7.907	14.473	0.120	1.338	0.949	1.728	2.951	2.092	3.809
	(3+)	36.235	26.198	46.272				0.283	10.251	7.412	13.091	0.121	1.242	0.898	1.587	2.739	1.981	3.498
Unit 3	2	5.977	3.008	8.946	0.466	0.108	0.051	0.041	0.243	0.122	0.364	0.115	0.028	0.014	0.042	0.062	0.031	0.092
	3	7.769	4.832	10.706	0.466	0.978	0.456	0.306	2.379	1.480	3.278	0.127	0.302	0.188	0.416	0.666	0.414	0.918
	4	1.753	1.090	2.416	0.466	1.000	0.466	0.312	0.546	0.340	0.753	0.149	0.081	0.051	0.112	0.180	0.112	0.247
	5	1.376	0.856	1.896	0.466	1.000	0.466	0.312	0.429	0.267	0.591	0.170	0.073	0.045	0.100	0.161	0.100	0.222
	6+	0.712	0.443	0.981	0.466	0.237	0.110	0.086	0.062	0.038	0.085	0.215	0.013	0.008	0.018	0.029	0.018	0.040
	Total	17.587	10.229	24.944				0.208	3.659	2.247	5.071	0.136	0.498	0.306	0.689	1.097	0.675	1.519
	(3+)	11.610	7.221	15.998				0.294	3.416	2.125	4.707	0.138	0.470	0.292	0.647	1.036	0.644	1.427
Unit 4	2	0.810	0.277	1.568	0.391	0.175	0.068	0.054	0.044	0.015	0.085	0.108	0.005	0.002	0.009	0.011	0.004	0.020
	3	0.409	0.253	0.566	0.391	1.000	0.391	0.270	0.111	0.068	0.153	0.113	0.013	0.008	0.017	0.028	0.017	0.038
	4	0.199	0.123	0.275	0.391	1.000	0.391	0.270	0.054	0.033	0.074	0.127	0.007	0.004	0.009	0.015	0.009	0.021
	5	0.579	0.357	0.801	0.391	0.963	0.376	0.262	0.152	0.093	0.210	0.132	0.020	0.012	0.028	0.044	0.027	0.061
	6+	0.913	0.563	1.263	0.391	0.118	0.046	0.037	0.034	0.021	0.047	0.274	0.009	0.006	0.013	0.021	0.013	0.028
	Total	2.910	1.573	4.473				0.135	0.394	0.231	0.569	0.136	0.053	0.032	0.077	0.118	0.070	0.169
	(3+)	2.100	1.296	2.905				0.167	0.350	0.216	0.484	0.139	0.049	0.030	0.067	0.107	0.066	0.148

Table 8. Lake Erie yellow perch harvest estimates for 1999. All estimates are based on CAGEAN outputs and the F(opt) fishing strategy. The model estimates the 1997 year class recruiting into the fishery in 1999 using the standard parametric regression model.

Yield (Millions of Pounds)				**Yield (Millions of Kilograms)**			
	RAH				RAH		
	Mean	Min.	Max.		Mean	Min.	Max.
Unit 1	2.281	1.706	2.855	Unit 1	1.034	0.774	1.295
Unit 2	2.951	2.092	3.809	Unit 2	1.338	0.949	1.728
Unit 3	1.097	0.675	1.519	Unit 3	0.498	0.306	0.689
Unit 4	0.118	0.070	0.169	Unit 4	0.053	0.032	0.077
Total	**6.446**	**4.543**	**8.353**	**Total**	**2.924**	**2.060**	**3.788**

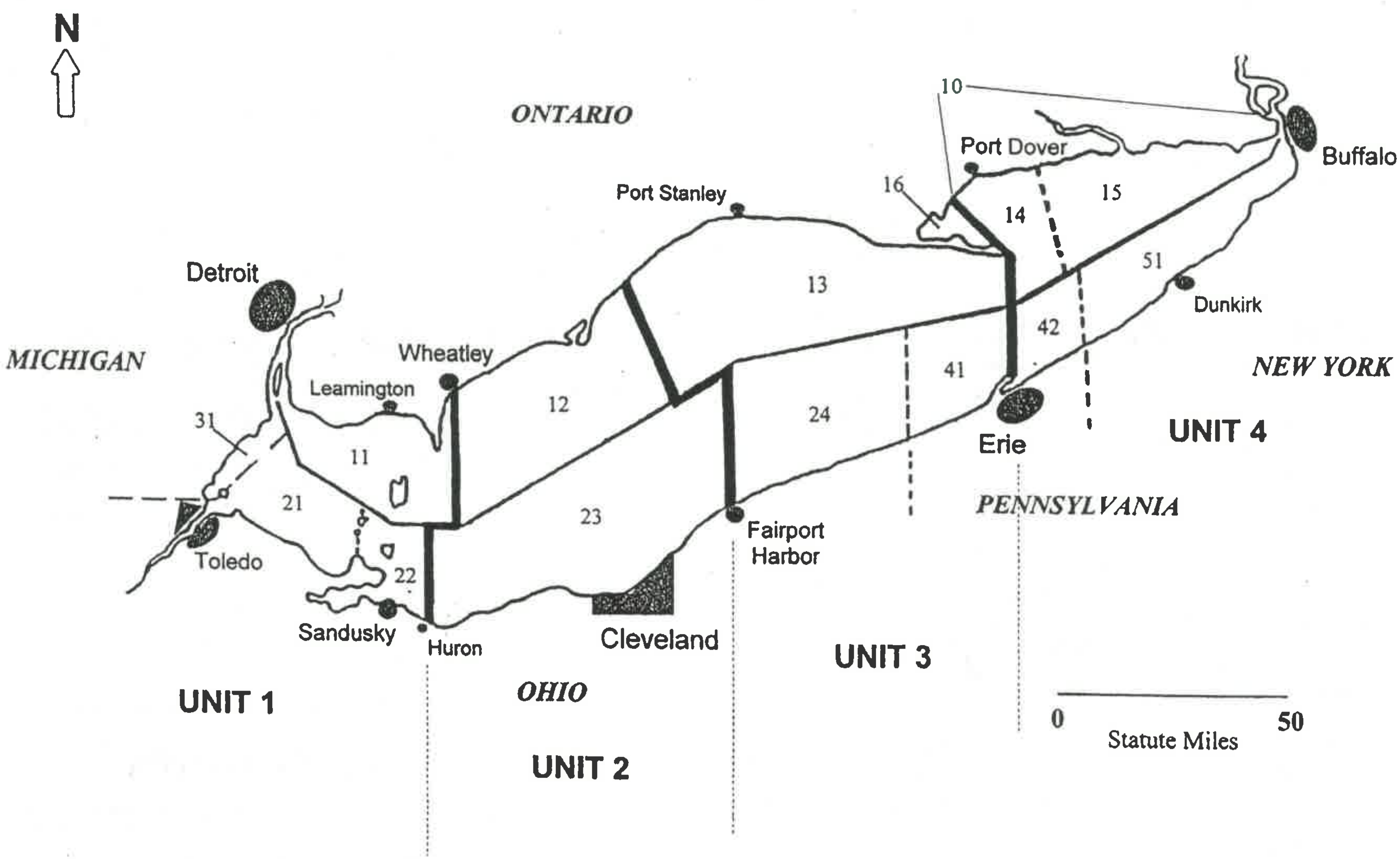

Figure 1. Lake Erie Management Units defined and used by the Yellow Perch Task Group.

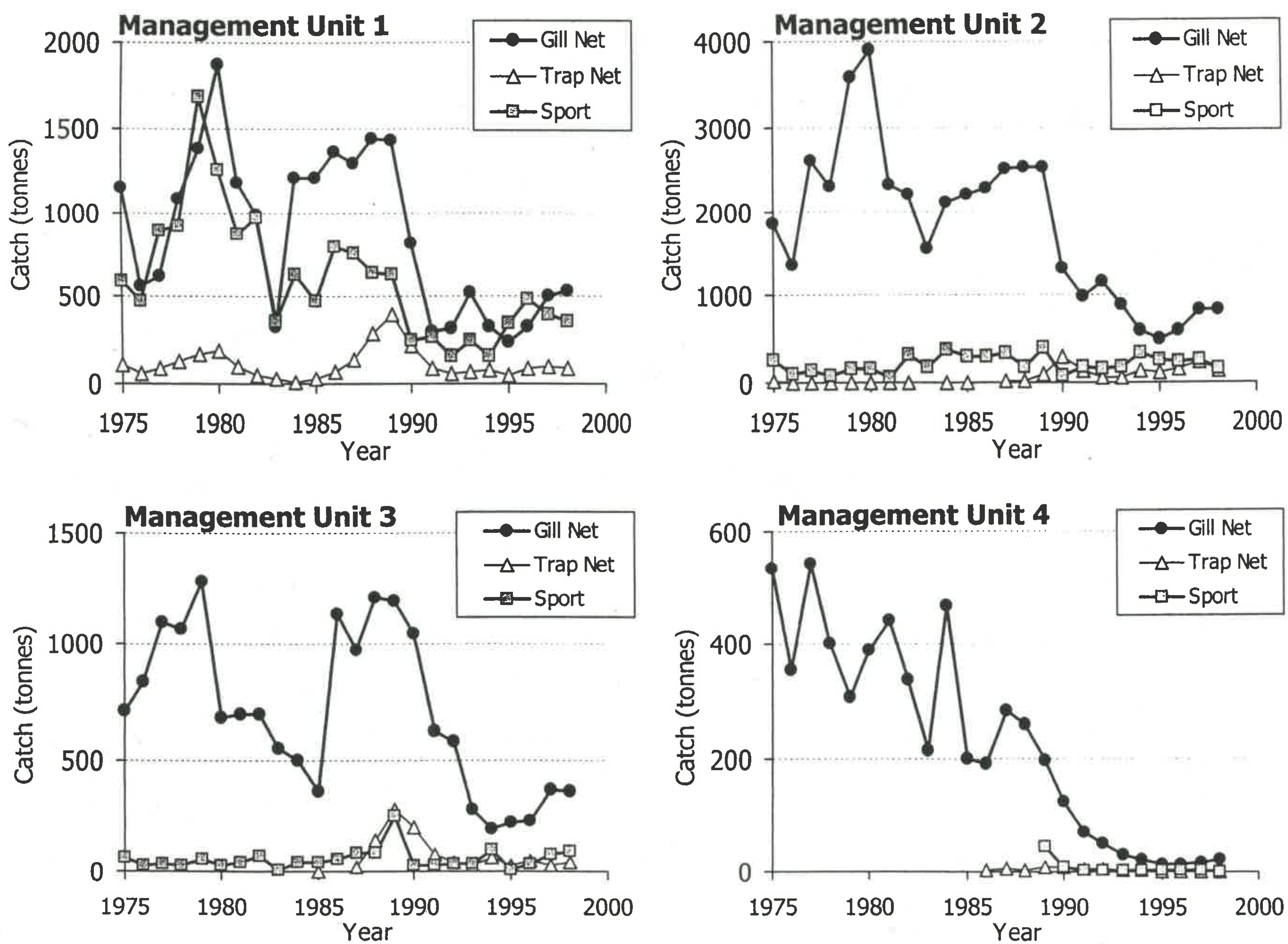

Figure 2. Lake Erie yellow perch harvest by management unit and gear type.

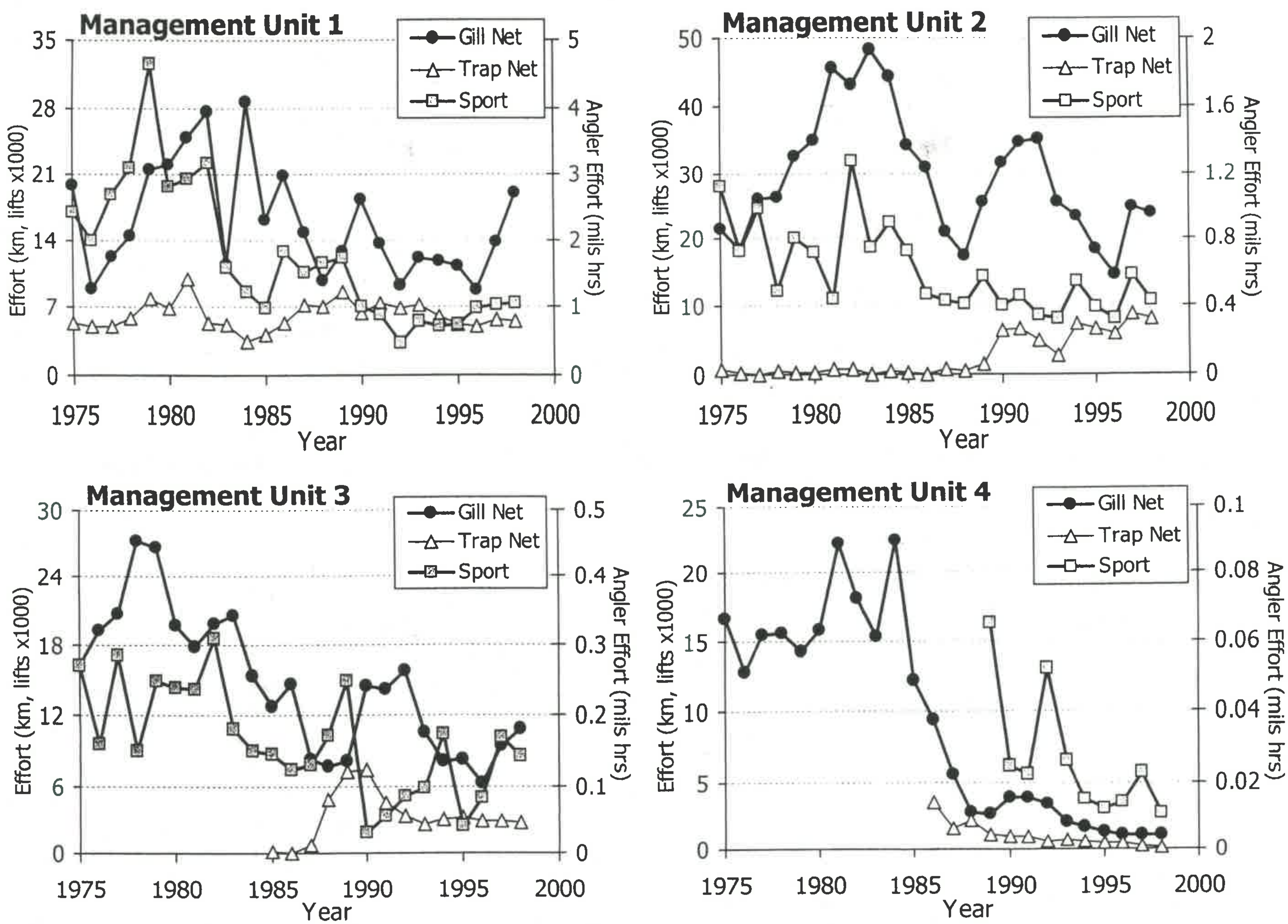

Figure 3. Lake Erie yellow perch effort by management unit and gear type.

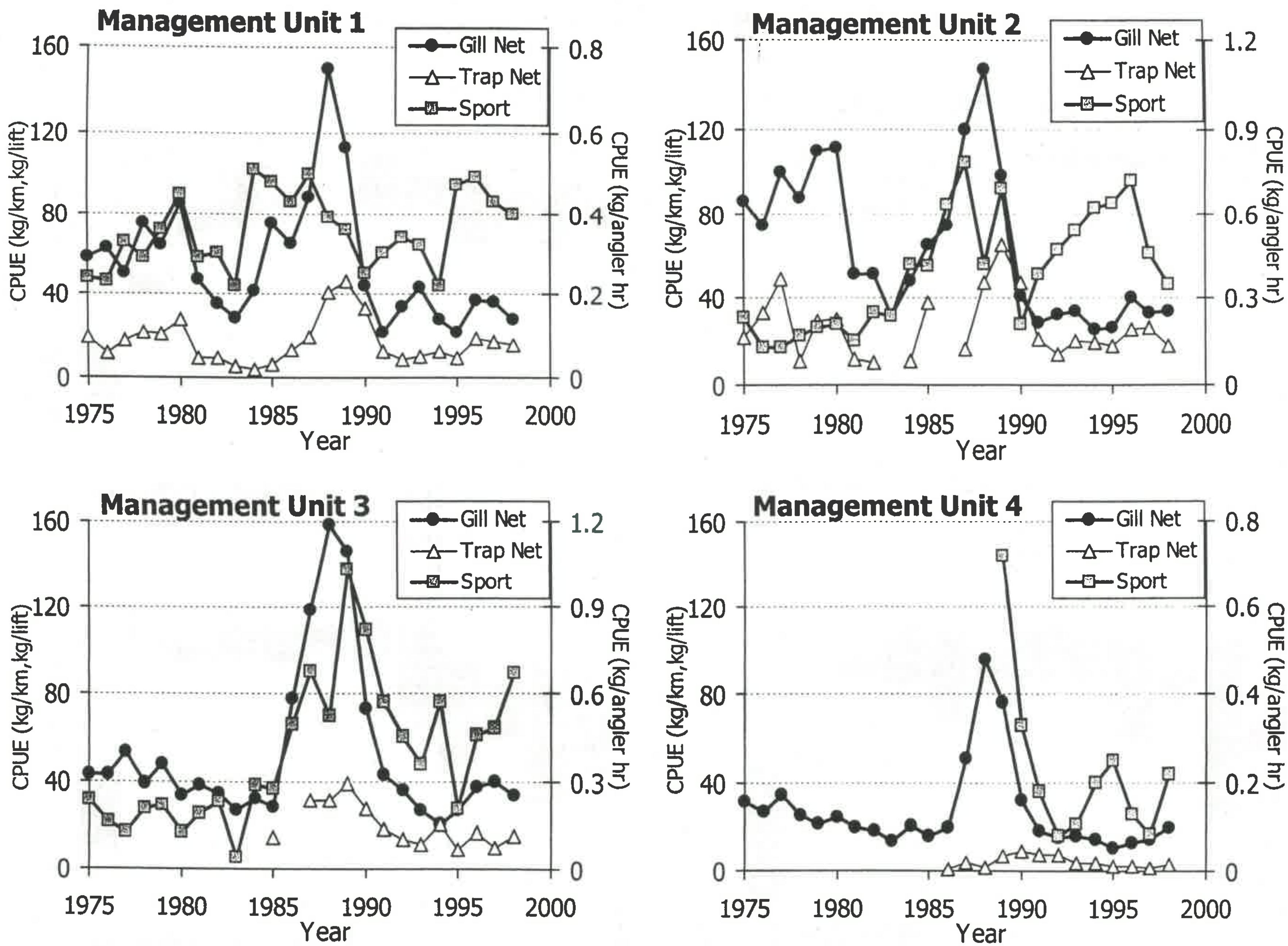

Figure 4. Lake Erie yellow perch catch per unit effort by management unit and gear type.

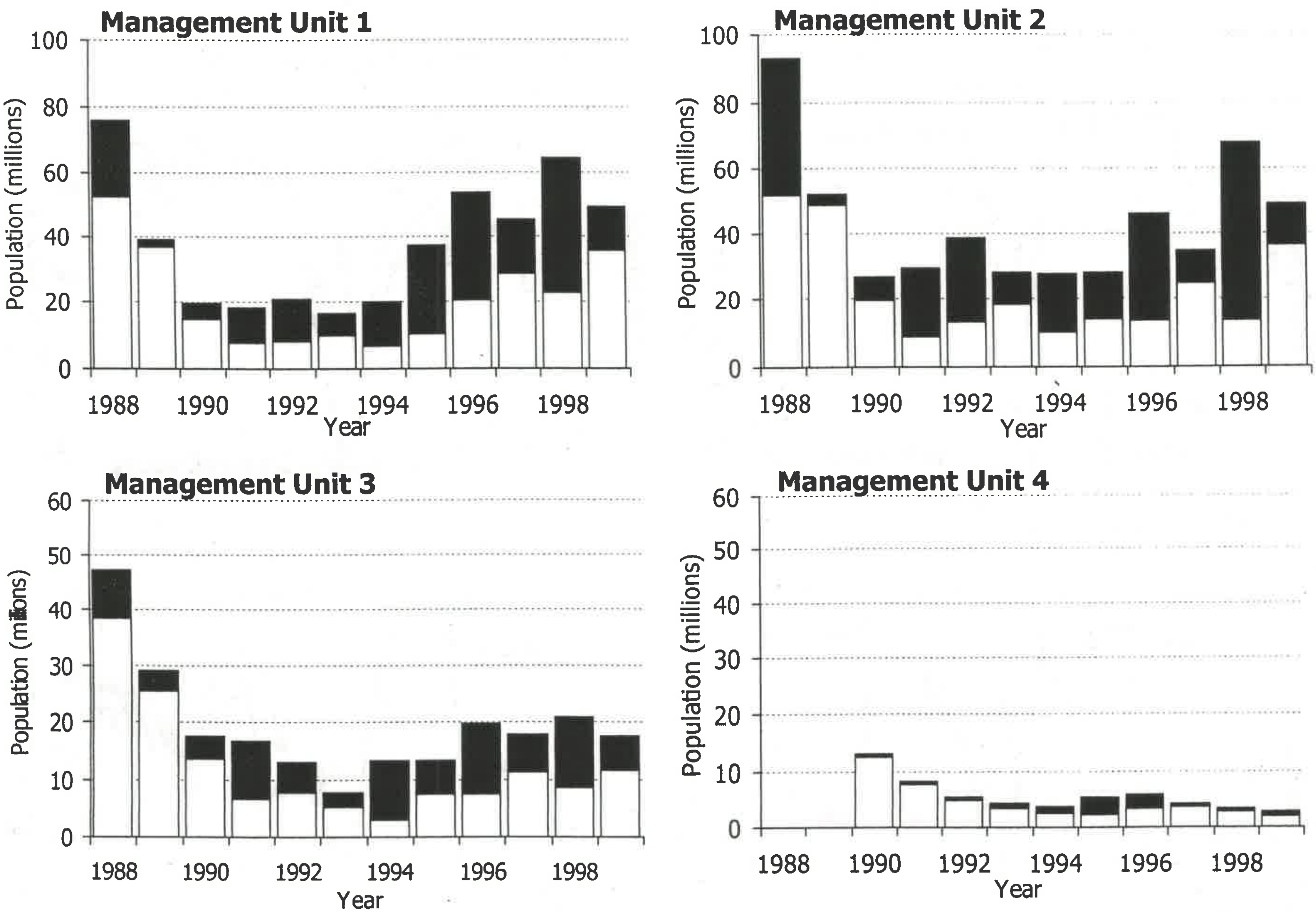

Figure 5. Lake Erie yellow perch population estimates by management unit for age 2 (dark bars) and ages 3+ (light bars). Estimates for 1999 are from CAGEAN and parametric regressions for age 2.

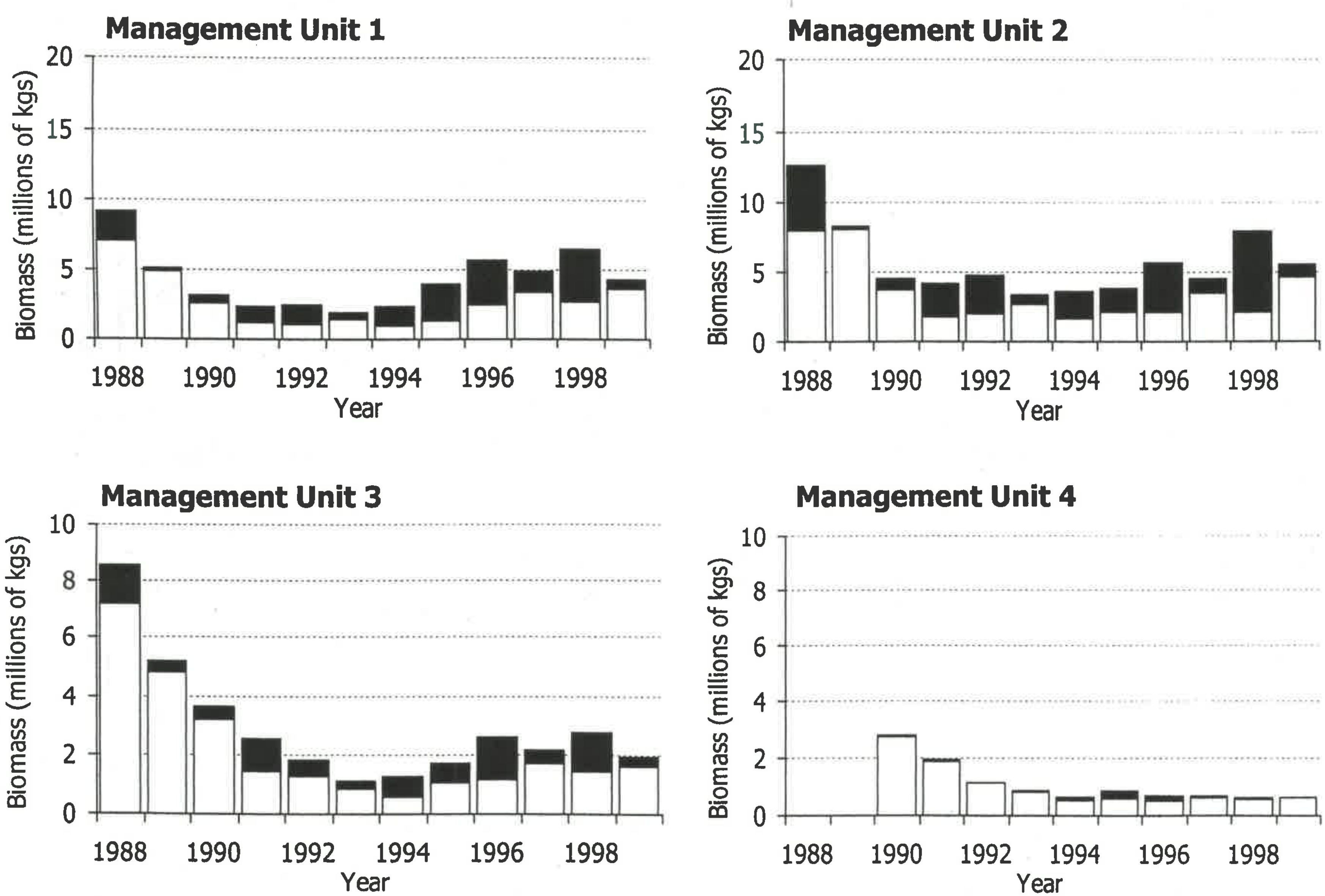

Figure 6. Lake Erie yellow perch biomass estimates by management unit for age 2 (dark bars) and ages 3+ (light bars). Estimates for 1999 are from CAGEAN and parametric regressions for age 2.

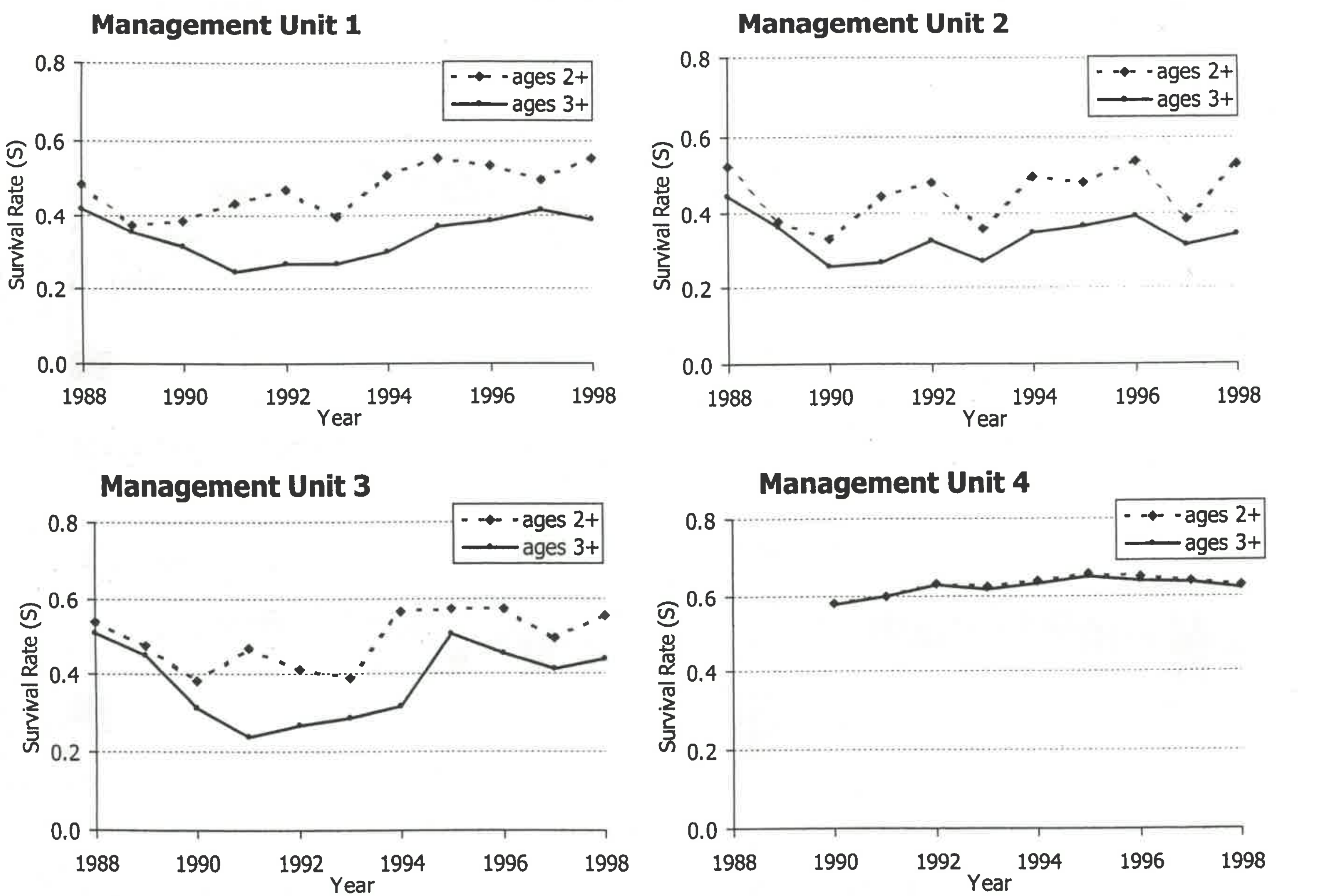

Figure 7. Lake Erie yellow perch survival rates by management unit for ages 2+ (dashed line) and ages 3+ (solid line). Estimates are derived from CAGEAN.

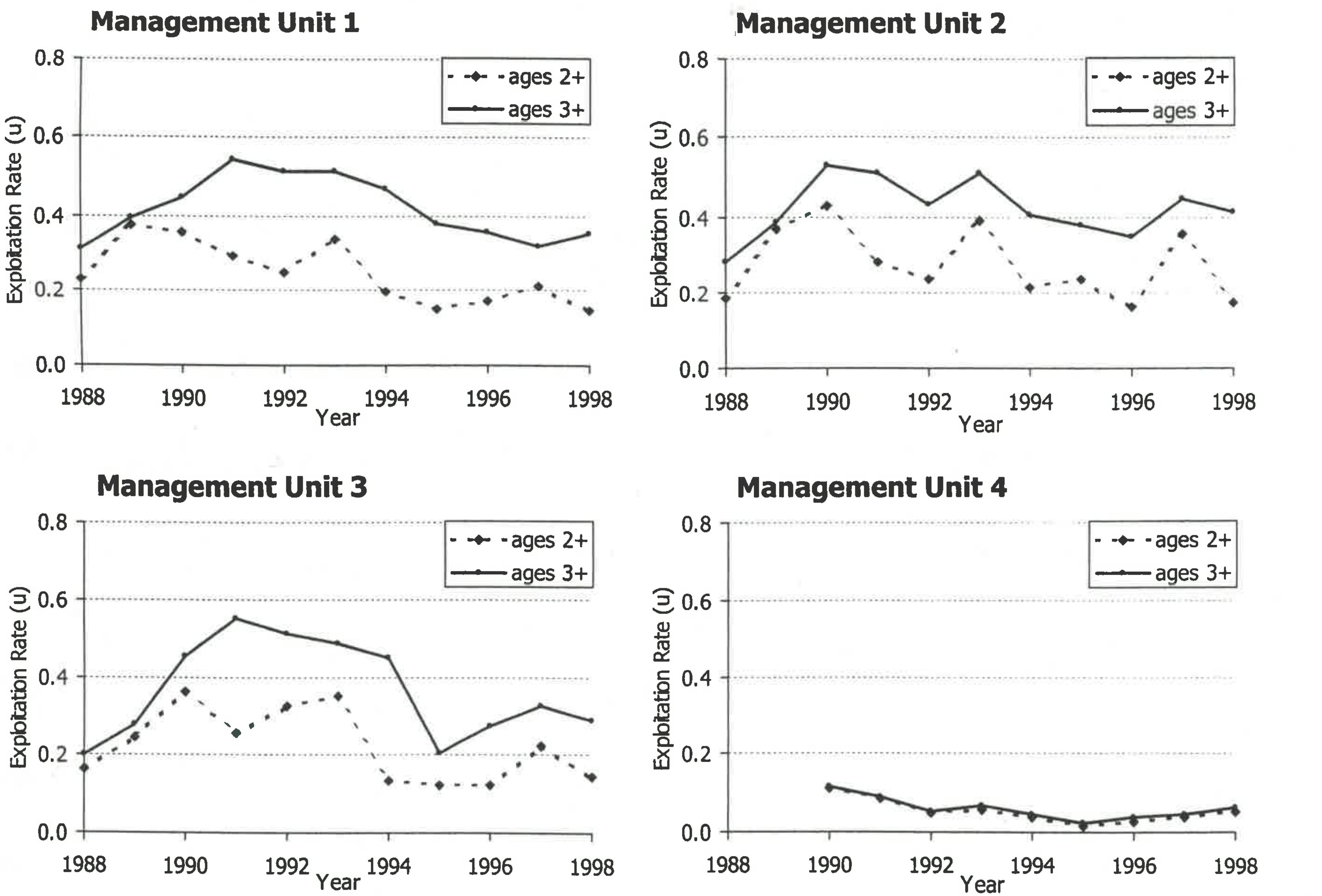

Figure 8. Lake Erie yellow perch exploitation rates by management unit for ages 2+ (dashed line) and ages 3+ (solid line). Estimates are derived from CAGEAN.

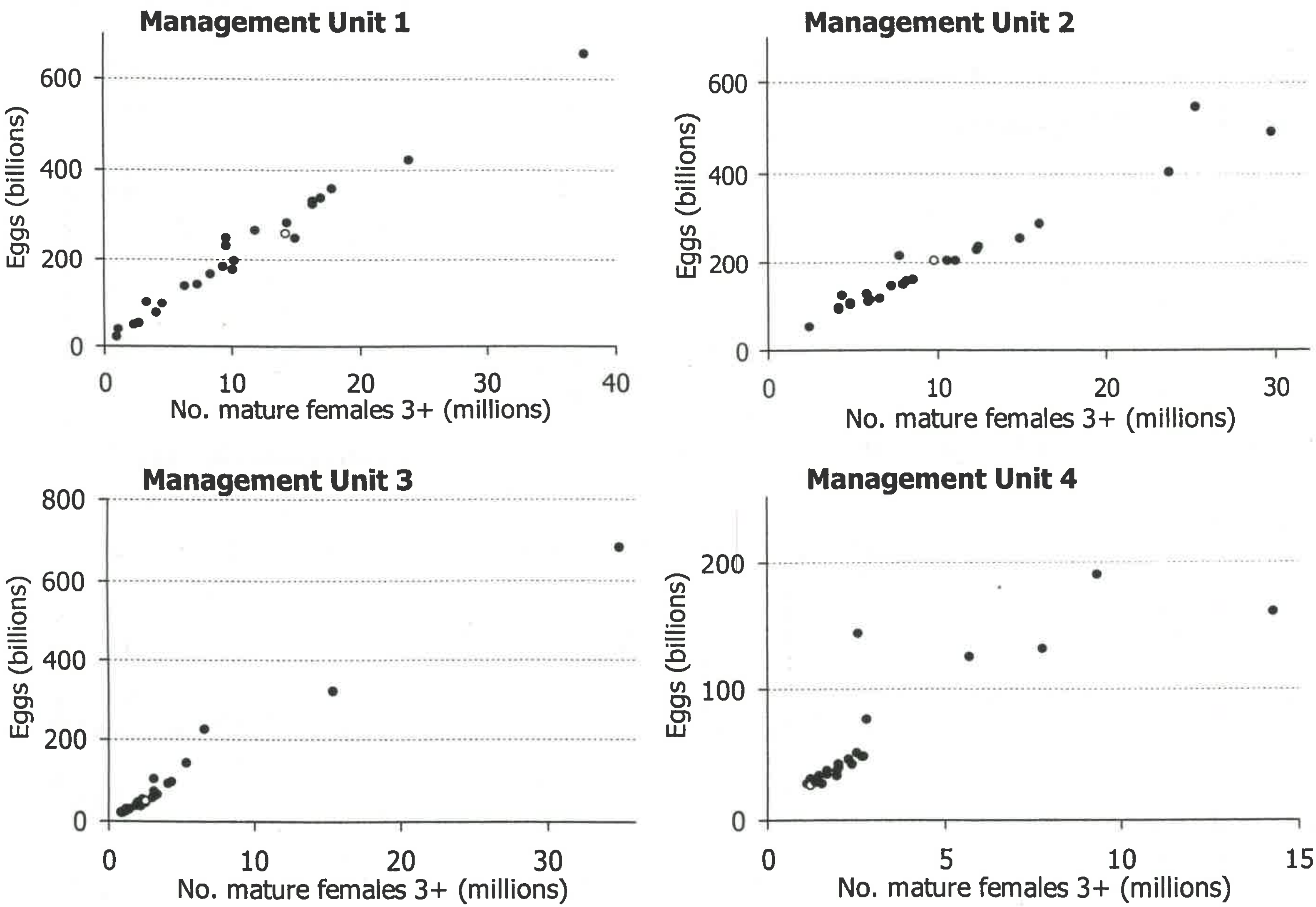

Figure 9. Total yellow perch egg production (in billions) by Lake Erie management unit based on number of mature females ages 3 and older, 1976-1999. Dot with white center represents 1999 value.

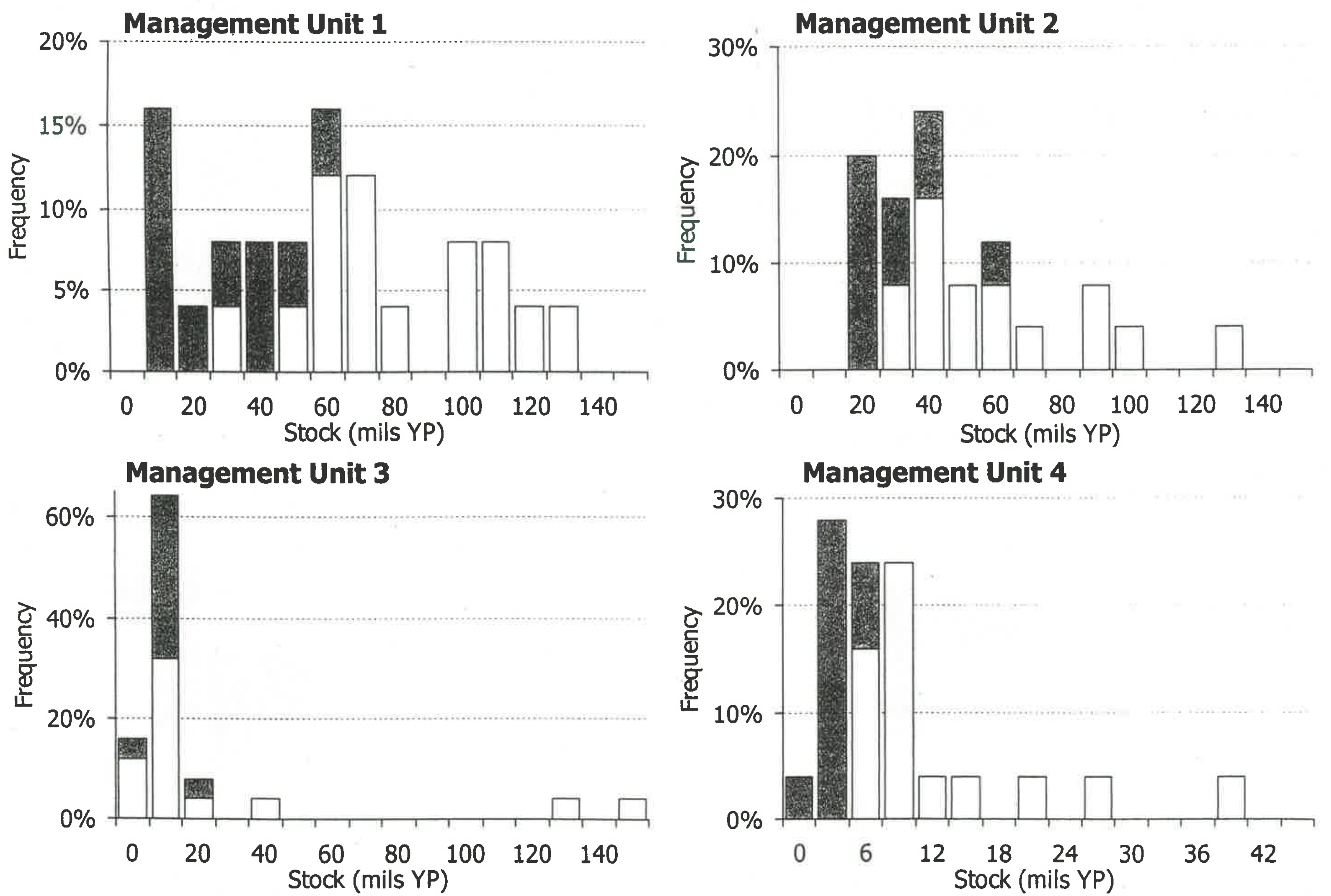

Figure 10. Frequency plots of Lake Erie yellow perch stock estimates from 1975 through 1999 by management unit for ages 2 and older. Dark bars represent stock values from the 1990s.

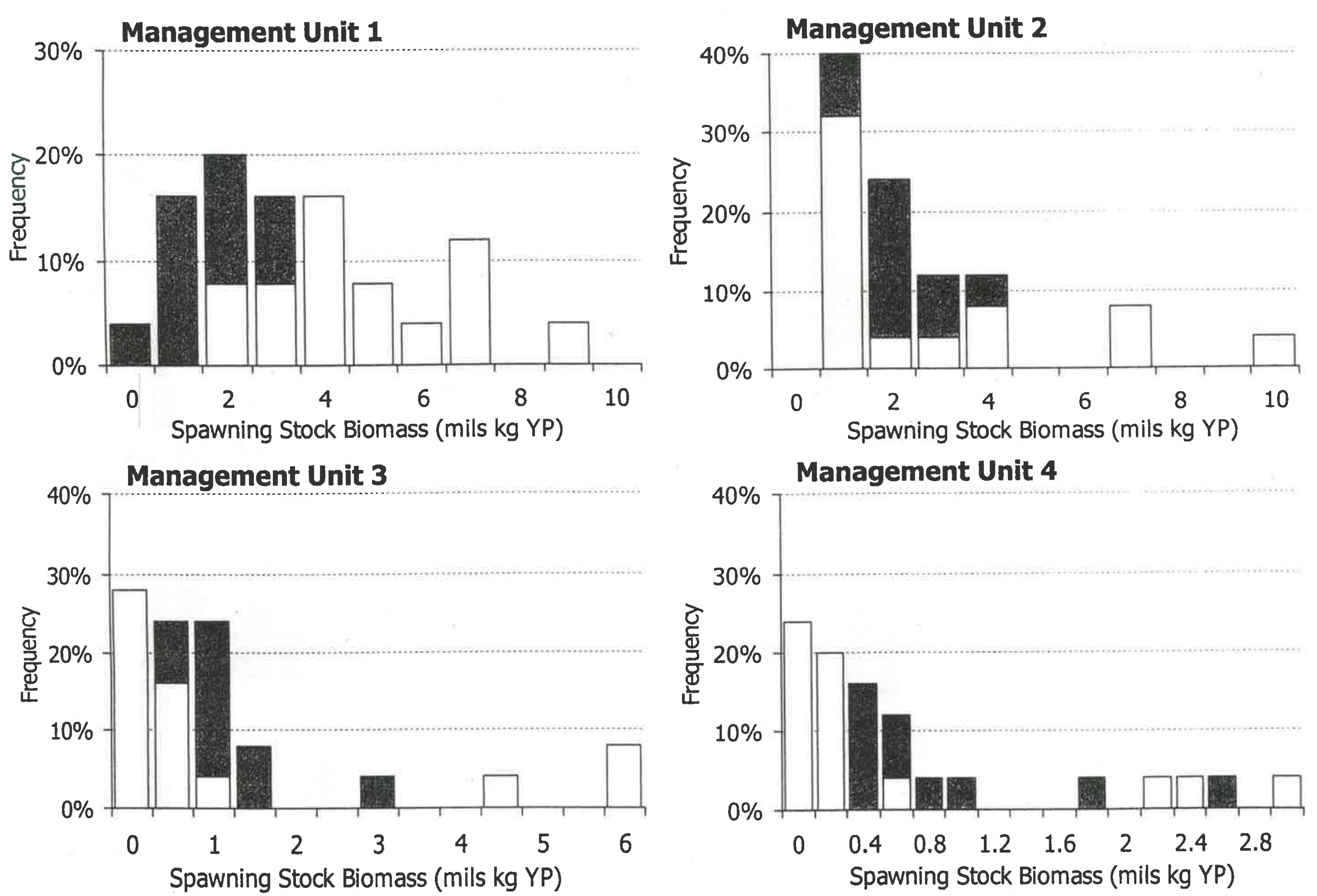

Figure 11. Frequency plots of Lake Erie yellow perch spawning stock biomass estimates from 1975 through 1999 by management unit for ages 3 and older. Dark bars represent biomass values from the 1990s.

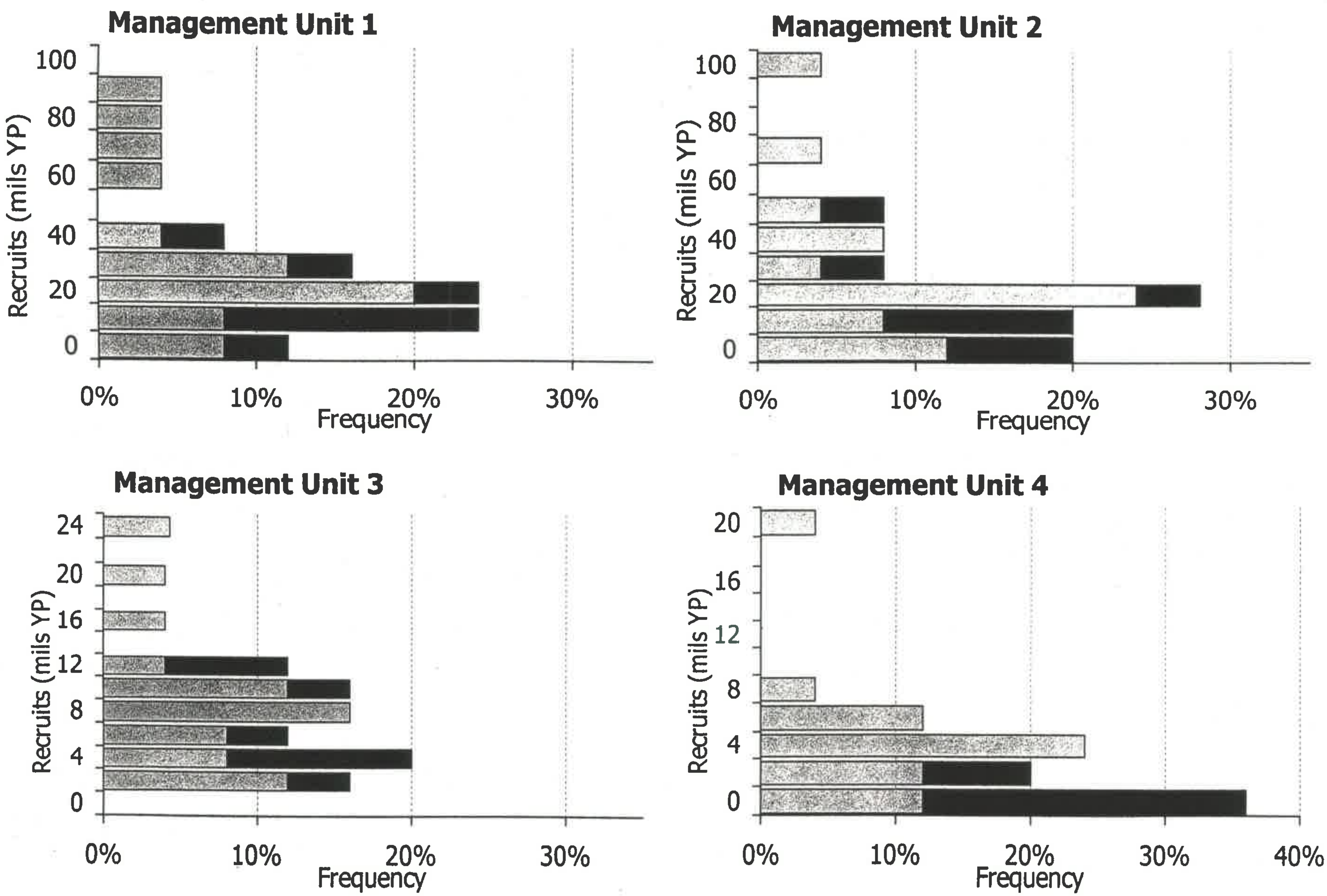

Figure 12. Frequency plots of Lake Erie yellow perch age 2 recruit estimates from cohorts 1973 through 1997 by management unit for ages 2 and older. Dark bars represent recruit values from the 1990s.

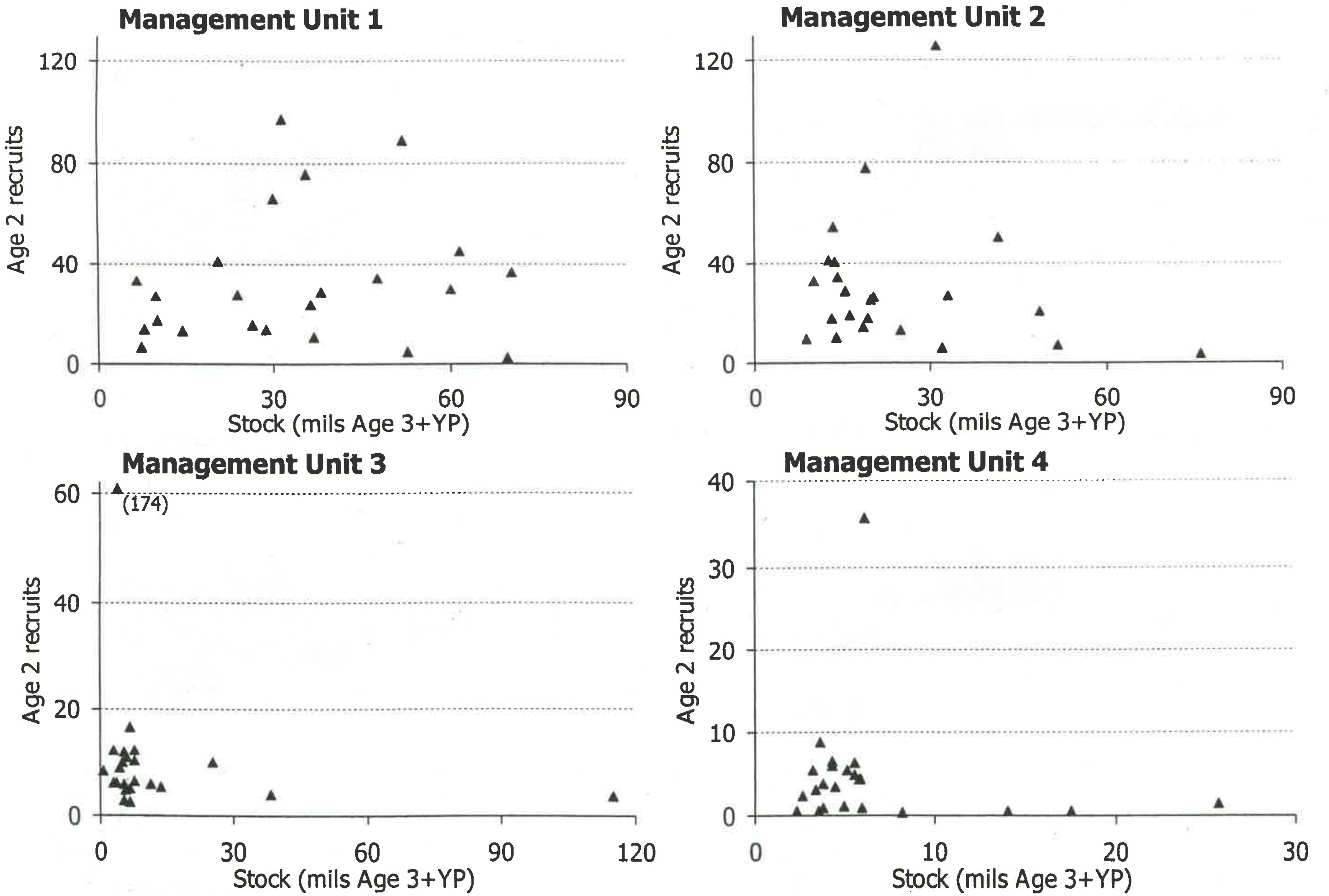

Figure 13. Stock-recruit scatter plots of Lake Erie yellow perch estimates from 1975 through 1997 by management unit for ages 2 and older.

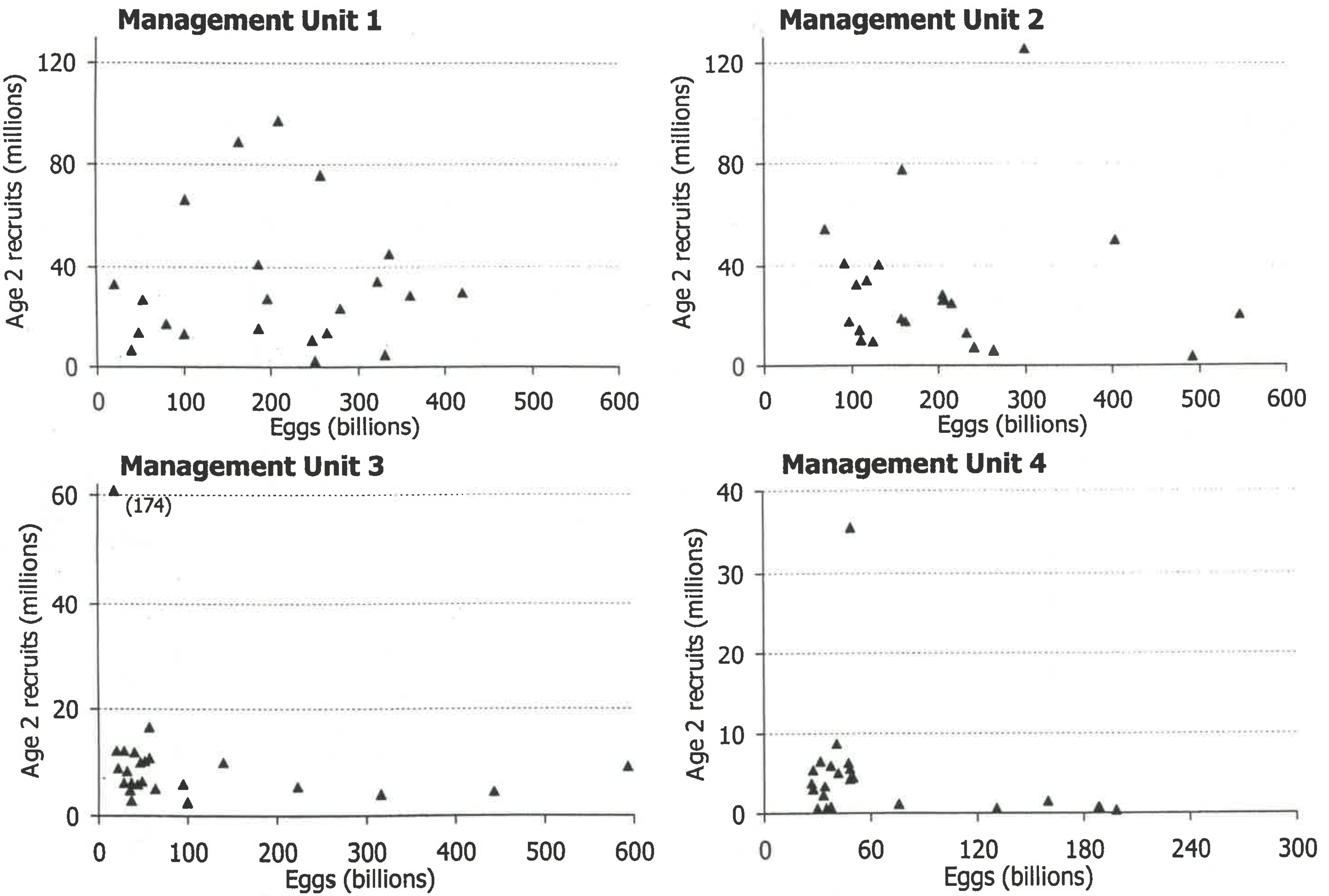

Figure 14. Egg-recruit scatter plots of Lake Erie yellow perch estimates from 1975 through 1997 by management unit for ages 2 and older.

Appendix B. Age 2 Recruitment Regressions and Index Trawl Data Series

In this appendix, the YPTG presents significant regressions that result in the estimation of the number of age 2 yellow perch available to the fishery in 1999. The YPTG continues to use parametric regression analysis to predict age 2 yellow perch abundance by management unit from interagency trawl surveys. Age 2 mean value estimates and their standard error estimates are then incorporated into Tables 6 and 7 in the main body of this report to complete 1999 abundance estimates, yield per recruit and RAH projections.

Trawl series data was updated again this year with interagency data. The 1997 cohort was relatively weak in all management units compared to the last four years. These estimates are substantiated from many trawl series giving significant relationships in each management unit. The Unit 4 estimate is somewhat less robust due to the low number of significant regression models contributing to the estimate.

Table B-1 presents, by management unit, those regressions found significant for predicting age 2 yellow perch. Table B-2 contains trawl data series in arithmetic mean catch per trawl hour. Table B-3 contains trawl data series in geometric mean catch per trawl hour. Definitions of the trawl series abbreviations used in Tables B-2 and B-3 can be found in the Legend that follows these tables.

Appendix B: Table B-1. Agency trawl regression indices found statistically significant for projecting estimates of age 2 yellow perch by management unit.

Management Unit 1

Index	Slope	Intercept	Index Value	P value	Age-2 estimate	R-SQUARE	Lower Age 2 Est.	Upper Age 2 Est.	Std Error of Est.
OHS11A	0.1800	5.8161	7.4	0.0003	7,148,100	0.896	2,048,964	12,247,236	5,045,236
BOHS20A	0.1313	10.1500	77.5	0.002	20,325,750	0.866	14,823,638	25,827,862	5,456,836
OHF10A	0.0552	6.7458	37.2	0.003	8,799,240	0.728	1,728,148	15,870,332	7,046,200
OHF31A	0.2224	13.0154	3.0	0.005	13,682,600	0.757	7,969,004	19,396,196	5,612,852
USS10A	0.0028	12.5506	293.7	0.006	13,372,960	0.689	7,619,772	19,126,148	5,751,816
OHS10A	0.0100	11.8470	58.2	0.006	12,429,000	0.688	6,468,836	18,389,164	5,955,264
OHF21A	0.0753	13.6202	7.5	0.008	14,184,950	0.720	8,246,150	20,123,750	5,901,168
ONTS10G	0.0479	11.3398	11.4	0.010	11,885,860	0.635	5,169,920	18,601,800	6,689,088
USF11A	0.4701	9.7161	19.3	0.011	18,789,030	0.631	11,198,734	26,379,326	7,324,128
USS11G	1.0353	7.4488	3.8	0.013	11,382,940	0.613	2,248,948	20,516,932	8,524,628
OHF20G	0.2907	15.2692	2.1	0.050	15,879,670	0.568	7,343,674	24,415,666	8,313,732
OHF30G	0.3493	15.0242	2.0	0.069	15,722,800	0.516	6,350,864	25,094,736	9,075,584
				mean	**13,633,575**		**6,768,054**	**20,499,096**	6,724,711

Management Unit 2

Index	Slope	Intercept	Index Value	P value	Age-2 estimate	R-SQUARE	Lower Age 2 Est.	Upper Age 2 Est.	Std Error of Est.
BOHF21A	1.2878	10.7946	0.8	0.0001	11,824,840	0.931	7,564,584	16,085,096	3,979,584
OHF20A	0.1342	10.1929	24.2	0.0002	13,440,540	0.954	9,619,912	17,261,168	3,794,756
ONTS10G	0.0683	10.2722	11.4	0.0003	11,050,820	0.866	6,035,768	16,065,872	4,995,256
OHF10A	0.0708	6.1605	37.2	0.0004	8,794,260	0.851	2,573,416	15,015,104	6,198,892
BOHF31A	2.4190	12.5323	0.7	0.0005	14,225,600	0.888	8,735,640	19,715,560	4,802,196
USF10G	0.1932	10.6456	5.6	0.0007	11,727,520	0.828	6,020,196	17,434,844	5,642,056
OHS21A	0.0228	13.9201	7.2	0.001	14,084,260	0.841	8,591,556	19,576,964	5,484,864
USS11G	1.3640	6.6748	3.8	0.002	11,858,000	0.756	3,247,328	20,468,672	8,036,196
USS10A	0.0034	13.9192	293.7	0.003	14,917,780	0.740	8,679,296	21,156,264	6,236,916
OHS10G	0.0710	14.4392	10.8	0.003	15,206,000	0.737	9,012,988	21,399,012	6,161,652
OHS20A	0.0148	14.8812	79.0	0.006	16,050,400	0.811	9,289,968	22,810,832	6,754,160
BOHF30A	1.2487	10.6660	1.0	0.006	11,914,700	0.808	3,461,416	20,367,984	7,919,184
OHS10A	0.0113	13.7317	58.2	0.012	14,389,360	0.622	6,549,752	22,228,968	7,833,140
				mean	**13,037,237**		**6,875,525**	**19,198,949**	5,987,604

Management Unit 3

Index	Slope	Intercept	Index Value	P value	Age-2 estimate	R-SQUARE	Lower Age 2 Est.	Upper Age 2 Est.	Std Error of Est.
OHF21G	0.1603	5.2486	3.2	0.028	5,761,560	0.579	3,052,056	8,471,064	2,600,136
BOHS20A	0.0329	4.9347	77.5	0.039	7,484,450	0.607	4,660,678	10,308,222	2,800,448
OHS11G	0.1386	4.9196	2.8	0.045	5,307,680	0.451	2,300,648	8,314,712	2,893,744
BOHF31A	0.4392	6.1690	0.7	0.046	6,476,440	0.512	3,736,752	9,216,128	2,396,492
BOHF20A	0.2043	4.4050	2.2	0.057	4,854,460	0.550	1,290,200	8,418,720	3,402,168
				mean	**5,976,918**		**3,008,067**	**8,945,769**	2,818,598

Management Unit 4

Index	Slope	Intercept	Index Value	P value	Age-2 estimate	R-SQUARE	Lower Age 2 Est.	Upper Age 2 Est.	Std Error of Est.
USF11G	0.0609	0.6832	6.7	0.019	1,091,230	0.569	553,210	1,629,250	498,624
NYF41A	0.0715	0.5002	0.4	0.072	528,800	0.595	0	1,507,232	920,612
				mean	**810,015**		**276,605**	**1,568,241**	709,618

Appendix B. Table B-2. Geometric index values from lakewide trawl surveys.

Year	ONTS10G	ONTS11G	OHS20G	OHS21G	OHS30G	OHS31G	OHF20G	OHF21G	OHF30G	OHF31G	USS10G	USS11G	USF10G	USF11G	OHS10G	OHS11G	OHF10G	OHF11G
1980	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10.5	0.0	69.0	10.4
1981	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.0	7.9	7.9	-
1982	49.4	4.2	-	-	-	-	-	-	-	-	-	-	-	-	30.0	13.8	31.6	-
1983	1.4	16.1	-	-	-	-	-	-	-	-	4.0	16.0	2.8	17.5	2.0	0.0	2.2	-
1984	118.5	0.2	-	-	-	-	-	-	-	-	7.1	1.9	10.9	2.9	16.3	0.3	5.3	-
1985	36.0	38.2	-	-	-	-	-	-	-	-	6.5	8.4	28.8	12.8	7.0	0.0	3.9	-
1986	56.5	1.1	-	-	-	-	-	-	-	-	141.7	34.1	8.8	22.7	155.8	0.0	7.6	-
1987	0.5	3.6	-	-	-	-	-	-	-	-	1.4	17.3	4.3	12.3	4.3	31.6	4.1	-
1988	88.6	7.2	-	-	-	-	-	-	-	-	43.3	3.6	1.0	0.1	17.1	2.3	3.6	-
1989	126.5	5.4	-	-	-	-	-	-	-	-	32.6	8.1	20.0	1.0	20.4	2.9	18.8	-
1990	111.5	29.6	2.0	62.8	0.4	10.1	16.8	14.2	6.2	5.1	29.2	6.7	59.2	2.0	42.8	9.6	54.1	-
1991	41.3	36.9	3.8	66.4	4.2	10.0	3.9	17.3	0.8	6.4	16.9	17.1	63.4	4.9	20.1	10.8	14.4	0.2
1992	27.4	17.9	68.3	14.4	31.3	4.6	7.7	4.2	17.5	1.3	4.3	0.1	17.3	0.3	12.2	2.0	10.2	0.2
1993	80.2	29.0	8.1	59.9	14.2	8.8	8.1	9.6	11.7	4.2	28.8	0.9	17.3	0.2	86.8	6.6	24.0	0.2
1994	243.2	42.7	13.5	4.9	4.8	2.4	18.4	2.4	7.5	0.8	419.9	8.0	78.7	36.1	64.6	18.2	35.6	22.7
1995	51.9	28.3	0.8	20.0	4.5	9.2	2.9	45.8	11.6	35.1	475.2	23.1	9.3	4.4	26.3	46.4	30.6	0.1
1996	679.0	72.8	61.0	2.7	53.4	1.2	95.0	5.4	76.7	3.2	10633.0	5.3	228.7	3.9	575.2	32.7	262.1	32.1
1997	11.4	21.5	3.5	855.1	0.0	0.0	2.1	42.2	2.0	7.5	18.3	27.1	5.6	9.0	10.8	45.3	5.9	42.9
1998	112.5	0.0	16.9	1.8	8.1	1.2	70.4	3.2	21.8	1.1	74.4	3.8	98.4	6.7	71.8	2.8	104.4	6.8

Year	PAF30G	OLP40G	OLP41G	ILP40G	ILP41G	ONOHP10G	BOHS20G	BOHS21G	BOHS30G	BOHS31G	BOHF20G	BOHF21G	BOHF30G	BOHF31G	NYF40G	NYF41G
1980	-	11.8	25.7	77.5	69.0	-	-	-	-	-	-	-	-	-	-	-
1981	23.0	21.6	1.7	357.4	29.9	-	-	-	-	-	-	-	-	-	-	-
1982	26.0	7.9	4.1	229.5	16.0	-	-	-	-	-	-	-	-	-	-	-
1983	0.5	0.0	0.0	25.6	0.0	-	-	-	-	-	-	-	-	-	-	-
1984	385.0	57.0	1.4	414.8	16.0	-	-	-	-	-	-	-	-	-	-	-
1985	4.0	0.7	5.6	6.0	32.7	-	-	-	-	-	-	-	-	-	-	-
1986	125.0	38.5	0.3	465.4	3.8	-	-	-	-	-	-	-	-	-	-	-
1987	25.0	1.1	10.8	0.7	2.6	3.9	-	-	-	-	-	-	-	-	-	-
1988	40.0	47.3	0.4	73.4	0.8	45.4	-	-	-	-	-	-	-	-	-	-
1989	0.5	18.0	6.8	70.0	6.4	61.9	-	-	-	-	-	-	-	-	-	-
1990	3.0	8.2	3.4	27.2	8.9	81.0	0.1	1.9	0.1	0.3	1.0	0.8	0.1	0.4	-	-
1991	5.0	2.0	0.5	8.0	2.8	33.6	0.8	5.5	1.0	3.7	0.5	1.1	1.0	0.6	-	-
1992	50.0	6.1	1.4	46.5	3.3	23.1	68.3	14.4	4.0	0.6	0.6	0.5	4.0	0.2	4.4	1.8
1993	38.0	6.2	1.2	19.2	5.8	107.5	0.7	1.8	1.0	0.8	0.6	0.6	1.0	0.4	54.9	2.1
1994	172.0	26.4	3.3	13.2	3.8	148.5	0.9	0.6	0.7	0.4	0.8	0.3	0.7	0.1	12.8	2.6
1995	20.0	2.4	10.4	1.2	5.4	51.1	0.1	0.4	0.2	0.3	0.2	0.5	0.2	0.6	4.9	9.6
1996	214.8	36.8	1.2	12.6	1.5	649.2	0.5	0.1	0.8	0.1	0.7	0.2	0.8	0.2	24.1	0.2
1997	0.0	2.6	4.5	3.1	1.6	15.0	2.5	82.5	0.0	0.0	0.1	0.4	0.0	0.3	0.1	1.5
1998	0.2	14.3	0.7	383.3	3.6	100.5	0.3	0.1	0.3	0.1	0.5	0.2	0.3	0.2	0.6	0.1

Appendix B. Table B-3. Arithmetic index values from lakewide trawl surveys.

Year	ONTS10A	ONTS11A	OHS20A	OHS21A	OHS30A	OHS31A	OHF20A	OHF21A	OHF30A	OHF31A	USS10A	USS11A	USF10A	USF11A	OHS10A	OHS11A	OHF10A	OHF11A
1980	-	-	-	-	-	-	-	-	-	-	-	-	-	-	122.0	0.0	663.7	191.0
1981	-	-	-	-	-	-	-	-	-	-	-	-	-	-	29.5	56.0	110.6	0.0
1982	965.6	25.1	-	-	-	-	-	-	-	-	-	-	-	-	359.1	124.3	854.0	0.0
1983	3.3	120.8	-	-	-	-	-	-	-	-	19.8	59.2	15.0	43.3	30.5	0.0	5.8	0.0
1984	3020.8	0.6	-	-	-	-	-	-	-	-	28.5	5.8	46.4	11.8	138.3	0.8	110.0	0.0
1985	521.7	769.0	-	-	-	-	-	-	-	-	42.0	34.0	71.4	27.2	26.1	0.0	39.0	0.0
1986	1754.5	7.9	-	-	-	-	-	-	-	-	1295.0	162.3	63.8	76.3	1143.7	0.0	61.5	0.0
1987	0.7	21.4	-	-	-	-	-	-	-	-	5.0	41.0	12.8	61.2	20.0	104.4	18.0	0.0
1988	328.7	15.6	-	-	-	-	-	-	-	-	129.0	10.3	5.8	0.3	145.9	12.6	35.0	0.0
1989	788.4	11.6	-	-	-	-	-	-	-	-	149.8	15.7	34.2	3.3	107.2	15.7	113.5	0.0
1990	739.9	62.5	17.0	448.3	8.7	66.8	89.9	15.3	43.4	8.6	81.0	22.2	176.2	6.3	145.5	26.4	330.0	0.0
1991	111.4	89.6	49.1	281.1	51.6	488.4	22.3	30.9	2.7	12.3	185.2	35.0	210.8	18.0	139.3	34.1	61.8	0.6
1992	271.7	34.8	75.0	56.3	208.0	30.7	76.1	8.9	56.3	2.0	21.0	0.5	75.3	2.5	65.4	12.9	91.5	1.0
1993	766.9	126.0	475.0	213.1	442.5	102.1	19.7	23.7	31.6	7.5	321.7	6.0	137.7	0.5	1261.0	19.6	274.5	4.8
1994	887.7	105.6	658.6	36.2	807.3	98.4	124.2	6.5	28.3	2.6	4282.0	40.3	162.0	57.8	526.5	78.2	289.4	97.4
1995	1337.8	162.5	8.7	278.7	69.1	61.2	8.0	180.4	26.7	87.5	2867.0	223.4	27.5	20.0	348.0	167.8	81.6	0.2
1996	3309.9	352.3	2721.8	31.6	5214.4	8.8	347.0	35.0	330.1	9.9	11444.0	13.2	737.2	9.2	3284.9	105.5	644.2	121.5
1997	109.9	63.9	79.0	1848.0	0.0	0.0	24.2	402.1	7.9	129.4	293.7	85.3	39.3	51.0	58.2	175.4	37.2	156.9
1998	285.4	0.0	641.1	7.2	751.5	8.5	199.7	7.5	105.6	3.0	138.7	11.0	246.2	19.3	195.4	7.4	281.7	23.3

Year	PAF30A	ONTPS10A	ONOHP10A	BOHS20A	BOHS21A	BOHS30A	BOHS31A	BOHF20A	BOHF21A	BOHF30A	BOHF31A	NYF40A	NYF41A
1980	-	-	-	-	-	-	-	-	-	-	-	-	-
1981	-	-	-	-	-	-	-	-	-	-	-	-	-
1982	-	965.6	-	-	-	-	-	-	-	-	-	-	-
1983	-	3.3	-	-	-	-	-	-	-	-	-	-	-
1984	-	3020.8	-	-	-	-	-	-	-	-	-	-	-
1985	-	512.9	-	-	-	-	-	-	-	-	-	-	-
1986	-	1754.5	-	-	-	-	-	-	-	-	-	-	-
1987	-	965.6	10.8	-	-	-	-	-	-	-	-	-	-
1988	-	3.3	224.5	-	-	-	-	-	-	-	-	-	-
1989	-	3020.8	447.9	-	-	-	-	-	-	-	-	-	-
1990	-	512.9	458.8	2.1	127.0	1.4	7.1	22.3	3.4	9.1	1.5	-	-
1991	-	1754.5	126.1	17.1	120.1	24.6	450.7	6.1	8.2	0.7	2.5	-	-
1992	-	0.7	164.4	75.0	56.3	99.9	7.5	18.2	2.1	10.8	0.4	23.0	5.0
1993	-	328.7	1052.5	118.8	53.3	111.0	25.5	4.4	4.7	6.0	1.4	222.4	6.2
1994	-	788.7	702.5	162.2	9.4	255.9	24.4	25.6	1.2	6.1	0.5	102.9	18.7
1995	-	739.8	815.4	0.9	27.9	6.9	6.1	0.9	19.0	3.2	11.2	12.0	30.9
1996	-	111.4	3296.2	235.2	2.8	737.2	1.2	39.3	3.8	35.4	1.1	232.1	0.7
1997	-	271.7	81.2	77.5	1060.0	0.0	0.0	2.2	33.5	1.0	15.9	0.4	12.4
1998	32.5	766.9	235.9	53.5	0.8	93.9	1.1	20.0	0.8	22.3	0.7	2.7	0.4

Appendix B. Legend. Lakewide trawl index series names and codes used in Appendix B.

Geometric Means	
ONTS10G	Ontario Management Unit 1 summer age 0 geometric
ONTS11G	Ontario Management Unit 1 summer age 1 geometric
OHS20G	Ohio Management Unit 2 summer age 0 geometric
OHS21G	Ohio Management Unit 2 summer age 1 geometric
OHS30G	Ohio Management Unit 3 summer age 0 geometric
OHS31G	Ohio Management Unit 3 summer age 1 geometric
OHF20G	Ohio Management Unit 2 fall age 0 geometric
OHF21G	Ohio Management Unit 2 fall age 1 geometric
OHF30G	Ohio Management Unit 3 fall age 0 geometric
OHF31G	Ohio Management Unit 3 fall age 1 geometric
USS10G	USGS Management Unit 1 summer age 0 geometric
USS11G	USGS Management Unit 1 summer age 1 geometric
USF10G	USGS Management Unit 1 fall age 0 geometric
USF11G	USGS Management Unit 1 fall age 1 geometric
OHS10G	Ohio Management Unit 1 summer age 0 geometric
OHS11G	Ohio Management Unit 1 summer age 1 geometric
OHF10G	Ohio Management Unit 1 fall age 0 geometric
OHF11G	Ohio Management Unit 1 fall age 1 geometric
PAF30G	Pennsylvania Management Unit 3 fall age 0 geometric
OLP40G	Outer Long Point Bay Mangement Unit 4 age 0 geometric
OLP41G	Outer Long Point Bay Mangement Unit 4 age 1 geometric
ILP40G	Inner Long Point Bay Mangement Unit 4 age 0 geometric
ILP41G	Inner Long Point Bay Mangement Unit 4 age 1 geometric
ONOHP10G	Ontario/Ohio (Paine) Management Unit 1 summer age 0 geometric
BOHS20G	Ohio Management Unit 2 summer age 0 geometric block depth strata
BOHS21G	Ohio Management Unit 2 summer age 1 geometric block depth strata
BOHS30G	Ohio Management Unit 3 summer age 0 geometric block depth strata
BOHS31G	Ohio Management Unit 3 summer age 1 geometric block depth strata
BOHF20G	Ohio Management Unit 2 fall age 0 geometric block depth strata
BOHF21G	Ohio Management Unit 2 fall age 1 geometric block depth strata
BOHF30G	Ohio Management Unit 3 fall age 0 geometric block depth strata
BOHF31G	Ohio Management Unit 3 fall age 1 geometric block depth strata
NYF40G	New York Management Unit 4 fall age 0 geometric
NYF41G	New York Management Unit 4 fall age 1 geometric

(continued)

Appendix B. Legend (continued)

Arithmetic Means	
ONTS10A	Ontario Management Unit 1 summer age 0 arithmetic
ONTS11A	Ontario Management Unit 1 summer age 1 arithmetic
OHS20A	Ohio Management Unit 2 summer age 0 arithmetic
OHS21A	Ohio Management Unit 2 summer age 1 arithmetic
OHS30A	Ohio Management Unit 3 summer age 0 arithmetic
OHS31A	Ohio Management Unit 3 summer age 1 arithmetic
OHF20A	Ohio Management Unit 2 fall age 0 arithmetic
OHF21A	Ohio Management Unit 2 fall age 1 arithmetic
OHF30A	Ohio Management Unit 3 fall age 0 arithmetic
OHF31A	Ohio Management Unit 3 fall age 1 arithmetic
USS10A	USGS Management Unit 1 summer age 0 arithmetic
USS11A	USGS Management Unit 1 summer age 1 arithmetic
USF10A	USGS Management Unit 1 fall age 0 arithmetic
USF11A	USGS Management Unit 1 fall age 1 arithmetic
OHS10A	Ohio Management Unit 1 summer age 0 arithmetic
OHS11A	Ohio Management Unit 1 summer age 1 arithmetic
OHF10A	Ohio Management Unit 1 fall age 0 arithmetic
OHF11A	Ohio Management Unit 1 fall age 1 arithmetic
PAF30A	Pennsylvania Management Unit 3 fall age 0 arithmetic
ONTPS10A	Ontario (Paine) Management Unit 1 summer age 0 arithmetic
ONOHP10A	Ontario/Ohio (Paine) Management Unit 1 summer age 0 arithmetic
BOHS20A	Ohio Management Unit 2 summer age 0 arithmetic block depth strata
BOHS21A	Ohio Management Unit 2 summer age 1 arithmetic block depth strata
BOHS30A	Ohio Management Unit 3 summer age 0 arithmetic block depth strata
BOHS31A	Ohio Management Unit 3 summer age 1 arithmetic block depth strata
BOHF20A	Ohio Management Unit 2 fall age 0 arithmetic block depth strata
BOHF21A	Ohio Management Unit 2 fall age 1 arithmetic block depth strata
BOHF30A	Ohio Management Unit 3 fall age 0 arithmetic block depth strata
BOHF31A	Ohio Management Unit 3 fall age 1 arithmetic block depth strata
NYF40A	New York Management Unit 4 fall age 0 arithmetic
NYF41A	New York Management Unit 4 fall age 1 arithmetic