Report of the Lake Erie Yellow Perch Task Group

March 2000
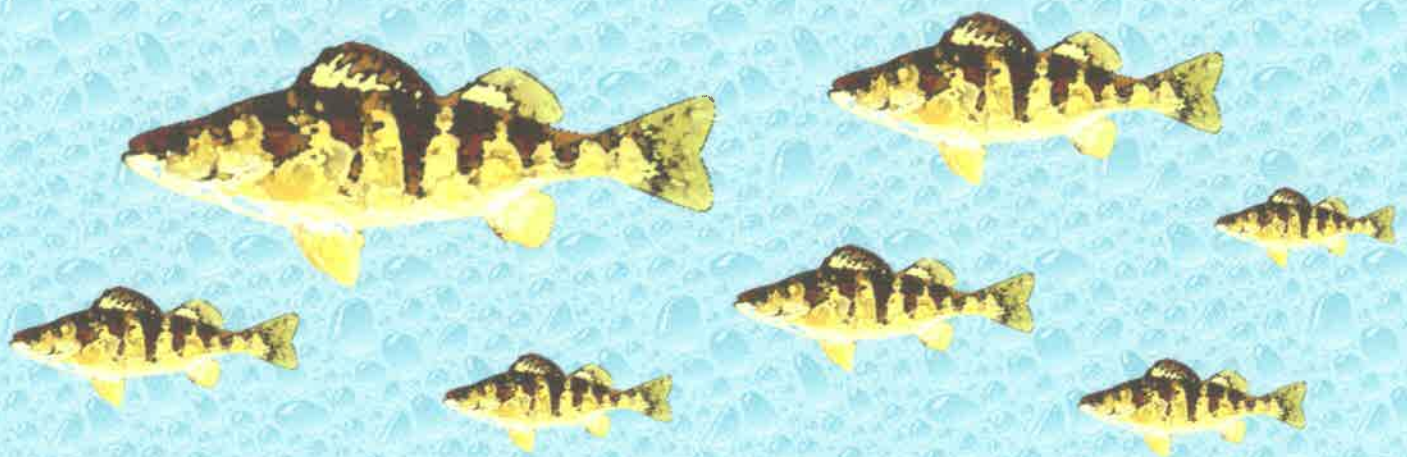
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Presented to: Standing Technical Committee
Lake Erie Committee
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Introduction

In 1999, the Lake Erie Committee assigned the Yellow Perch Task Group (YPTG) six 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 and recruitment indices of yellow perch. 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 fourth charge on which we will report examines the potential for genetic research on Lake Erie yellow perch stocks. Two new charges were given to the task group in 1999: (1) Investigate independent management of yellow perch stocks in the Eastern Basin of Lake Erie (Management Unit 4), and (2) Investigate yellow perch bioenergetics.

1999 Fisheries Review

The reported harvest of yellow perch from Lake Erie in 1999 totaled 5.698 million pounds (2,584 metric tonnes or 2.584 million kgs), which was a 3% decrease over the 1998 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 (pounds) increased over 1998 levels for Ohio (+19%) and New York (+2%), but declined for Ontario (-13%), Michigan (-23%), and Pennsylvania (-29%).

In comparison with 1998, each agency's proportion of the lakewide harvest (in pounds) changed only slightly. Ohio's proportion increased from 32% to 39% of the lakewide harvest, Ontario's proportion decreased from 65% to 59%, 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 1988-1999 by management unit, year, agency, and gear type in Table 2, parts a through d. Trends over a longer time series (1975-1999) are depicted graphically for harvest (Figure 2), fishing effort (Figure 3), and catch rates (Figure 4) by management unit and gear type. Harvest summed by management unit showed minor decreases in Units 1 (-10%) and 3 (-8%), and a minor increase (+5%) in Unit 2. Unit 4 harvest exhibited an increase for the third consecutive year (+25%, but the actual numerical increase was small). Unit 4 fisheries exhibited the largest harvest since

were: Unit 1, 2.3 million pounds; Unit 2, 3.0 million pounds; Unit 3, 1.1 million pounds; Unit 4, 0.1 million pounds. The YPTG RAH mean values from CAGEAN and age-2 regression estimates were identical to the TAC. The 1999 harvest of Lake Erie yellow perch in each management unit did not exceed total allowable catch set by the Lake Erie Committee. The 1999 harvest amounts, in millions of pounds by management unit, were: Unit 1, 2.058 million pounds; Unit 2, 2.547 million pounds; Unit 3, 1.027 million pounds; and Unit 4, 0.065 million pounds. The 1999 Lake Erie yellow perch fisheries attained (calculated from exact harvest values in Table 1) 89% of TAC in Unit 1, 85% of TAC in Unit 2, 93% of TAC in Unit 3 and 65% 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 1999. In Unit 1, the 1995 year class still is showing some strength. Poor growth due to shorter growing seasons led to the underestimation of the 1995 year class strength in 1997. The 1996 year class, strong by current measures, did not fully recruit to all the fishery gear even in 1999. This year class rebounded from a weaker showing the previous year due to reduced growth of these fish and selectivity of fishery gear. This trend was apparent again this year and may have led to the underestimation of the strength of the 1996 year class in CAGEAN runs, particularly in the Western Basin. In all Units, the 1996 year class, then the 1995 and 1994 year classes were strong contributors in the harvest (Table 3). The 1997 year class was predicted by our recruitment-regression module to be one of the weakest in recent times. Selectivity by the fisheries to larger and older fish may also have caused a bias in the CAGEAN estimates of this year class. Relatively speaking, it still performed as expected, with low percentages of age 2 fish showing up in the harvest. In all management units, we can point to the contribution of three moderate to strong year classes and potential recruitment of two moderate year classes (1998 and 1999) as a sign that recovery of the yellow perch population continues. We must temper our enthusiasm by the apparent weakness of the 1997 year class.

In examination of the growth of both the 1995 and 1996 year classes, we observed that

length and weight across ages were substantially below mean values or recent trends since about 1988 (Appendix A). Concerned that overall lake productivity might be affecting yellow perch growth, condition, maturity and ultimately recruitment into the fishery, we investigated this issue further. There appears to be a downward trend for growth of older yellow perch in Unit 1. However, 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. Because these fish are sampled in the fall, there may also be strong selection by the fisheries for faster growing individuals for younger age groups. We will monitor this trend in the future and quantify its effect on the population.

The 1997 through 1999 year classes are showing improved growth rates at the early life stages; lengths and weights are at the ten-year mean or higher (Appendix A). Some of the older age groups in the central and eastern basins are also showing some increasing growth trends (at age) for the last two years. Specific age-growth data and the relationship of summer climatic factors were examined again this year. Similar to last year's report (YPTG 1999) summer growth of yellow perch at age 0 and age 1 was positively correlated to summer heat indices such as cooling degree days (sum of daily mean temperature above 65 degrees F).

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 growth data and F_{opt} values according to methods previously described (YPTG 1996, 1998), but no changes were made to last year's von Bertalanffy model or F_{opt} values.

Catch-at-Age Analysis (CAGEAN) and Population Estimates

The Yellow Perch Task Group continues to use a version of CAGEAN presented to us by Terry Quinn at a workshop held in the mid 1990s. In an effort to refine these techniques and address new methods for performing this analysis the members of the Yellow Perch Task Group attended an AD model builder workshop held in January 2000 at Cornell University. The workshop taught by Dr. Pat Sullivan and Cliff Kraft examined the use and implementation of catch-at-age analysis using AD Model Builder software and C++ programming language. The advantages of this program are many, including the ability to run models over a longer time series, batch processing of surface response requests, multiple blocking of parameters such as

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catchability and selectivity, and ability to add survey gear as an additional time series. While the model program is powerful, it is also complex and requires some programming background. To date, the YPTG has begun initial development of an AD Model Builder CAGEAN. Complete data files and a working model run have been completed for each of the four management units; however, there is still some model design, fitting, and ground-truthing to be completed. We will examine this issue in the next year and will build tuned models for all four management units.

CAGEAN 1999/2000

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 harvests 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 1999-2000 CAGEAN model ran efficiently as model iterations were low (usually 3 to 6), no apparent trends were depicted in the residuals, and 40 bootstraps were completed. A three-gear (gill net, trap net and sport angling: harvest-by-age, effort, and weight-at-age) version of the CAGEAN model was used to estimate the 1999 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 age 2 abundance estimates in 2000 derived from a refined recruitment-regression model (Tables 4 and 5 and Appendix B). Numbers and

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biomass by management unit are presented for age 2 and older. Population estimates (in numbers of yellow perch) using the regression model are depicted in Figure 5, and biomass estimates are presented in Figure 6.

Backcasting population estimates for 1999 using this year's CAGEAN, and comparing to YPTG (1999) CAGEAN and yield per recruit, stock size estimates of age 3 and older fish were lower than predicted (i.e., they were overestimated last year) in Units 1 (-23%) and 2 (-14%). Estimates of the number of age 3 and older yellow perch in Units 3 (+18%) and 4 (+10%) were higher than values reported last year. Imprecision was due to estimating the 1996 year class and selectivity of fishing gear. In examining backcast estimates of ages 2 and older, last year's CAGEAN and recruitment regression values overestimated the population in all Units (Unit 1, -19%; Unit 2, -27%; Unit 3, -16%; Unit 4, -8%). Error was attributable to overestimates of the 1996 and/or 1997 cohorts. Our original age 2 regression estimates were 13.6 million in Unit 1, 13.0 million in Unit 2, 6.0 million in Unit 3, and 0.8 million in Unit 4. CAGEAN's first read on the 1997 year class estimated 12.544 million in Unit 1, 4.799 million in Unit 2, 1.044 million in Unit 3, and 0.371 million in Unit 4. The 1996 year class, which had exhibited reduced growth early on, became fully recruited to all fishing gear by midyear. Estimates for the 1996 year class declined this year in the latest permutation of CAGEAN. No significant increasing trends in older age groups were apparent.

Age 2+ backcast values of 1999 biomass were slightly lower than last year's YPTG (1999) projections by 7% in Unit 1, 8% in Unit 2, and 13% in Unit 4. Backcast values for 1999 biomass were higher than YPTG (1999) projections by 15% in Unit 3. Backcast estimates decreased the biomass of age 3+ yellow perch in Units 1, 2, and 4; down 11%, 2%, and 14%, respectively. Backcast estimates increased age 3+ biomass in Unit 3 by 36%. Again, most of this imprecision was due to abundance estimates of the not-fully-recruited 1996 year class and a weak 1997 year class. Some differences were apparent due to changes in weight-at-age. Unit 4 imprecision was likely due to the paucity of assessment and experimental samples provided for the model.

In analysis of fishery data, it was apparent that the commercial fishery behaved in a different fashion than the previous few years to capitalize on the larger individuals from the 1995 and 1996 year classes. Fishing pressure early in the season was heavier, and larger mesh sizes (greater than 2¼ inches, but less than 3 inches) were employed to increase selectivity for older fish. This strategy also has effects on the efficiency of CAGEAN. The earlier effort and harvest, larger mesh, and selectivity for older fish during this year would cause an

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underestimate for age 2 fish that were not as greatly selected. CAGEAN could not account for this within a one-year time block. To remedy this situation, we examined regressions of Ontario Partnership gill nets and Ohio Division of Wildlife bottom trawls against the standing stock of age 2 and age 3 yellow perch from 1988 to 1997 in Management Units 1 through 3 (Figures 7-12). In analysis of these data, we chose to use the model that gave us the best regression model fit (highest R-square for a model with a significant F-test probability of less than .05) between the survey and CAGEAN data within the time series. These estimators would give us an alternate value for age 2 and age 3 yellow perch in each of these management units for 1999. This would provide alternate estimates for age 3 and age 4 yellow perch in 2000 after going through the yield per recruit permutation, as well.

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. The YPTG presents the most significant regression equations used in calculating age 2 yellow perch for the 1998 year class entering the fishery in 2000 in Appendix B, Table B-1. 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 in 2000. Regressions that produced negative slopes or did not have index values for 1998 (age 0) or 1999 (age 1) were also omitted from the analyses.

In general, the 1998 year class is moderately strong, falling between the weaker 1997 year class and the stronger 1996 year class. With improved growth rates *(see Appendix A)*, this year class in the coming two to three years may be a contributor on par with the 1993 through 1995 year classes, in contrast to the poorer year classes of the late 1980's and early 1990's.

2000 Population Size Projection

Stock size estimates for 2000 (age 3 and older) were projected from the CAGEAN 1999 population size estimates and age-specific survival rates in 1999 (Tables 5 and 6). Age 2 recruitment values for the 1998 year class in 2000 (methods described above) were then added

into the age 3 and older population size estimates in each unit to give a 2000 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 similar to the last several 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. Where we employed regression equations for the 1996 and 1997 year class estimates, we calculated the standard errors for the regression equations and entered those values in the corresponding cells in Table 6b.

Stock size abundance estimates for 2000, compared to 1999, using standard CAGEAN estimates and the yield per recruit module for age 2 and older yellow perch show small increases Units 2-4, and small decrease in Unit 1: -5% in Unit 1, +17% in Unit 2, +10% in Unit 3, and +5% in Unit 4 (Tables 4 and 5, Figure 5). Stock size estimates of age 3 and older fish using this same method for 2000 show a moderate to sizable decreases in all management units: -30% in Unit 1, -48% in Unit 2, -46% in Unit 3, and -28% in Unit 4. The estimates changed because of a moderate year class entering at age 2 and a weak year class progressing into age 3, and the possible underestimation of the strength of the 1996 and 1997 year classes (as previously discussed). When examining the alternate stock size projections with the enhanced 1996 and 1997 year class estimates from regressions (Figure 13), populations for 2000 are slightly higher than 1999 in Units 2 (+5%) and 4 (+5%) and lower in Units 1 (-16%) and 3 (-2%).

Biomass estimates for age 2 and older fish using the original CAGEAN and yield per recruit module for the original 2000 projection show declines compared to 1999 levels in all units except a minor increase in Unit 4 (Table 4, Figure 6). This is due to the projections of a moderate 1998 year class, weak 1997 year class, and a not-fully-recruited 1996 year class. Ages 2+ biomass estimates are down 25% in Unit 1, 5% in Unit 2, 16% in Unit 3 and up 3% in Unit 4. Biomass estimates of age 3 and older yellow perch available at the start of 2000 are lower than 1999 in all management units: Unit 1, -37%; Unit 2, -39%; Unit 3, -43%; and Unit 4, -3%. Yellow perch populations in all units will be dominated by fish from the 1996 year class, with the 1995 and 1997 year classes, and to a much smaller extent the 1994 and 1993 year classes persisting in all management units. It is expected that the 1998 year class will contribute about as much as or slightly more than the 1995 year class when it entered the fishery at age 2 several years ago.

Biomass estimates for 2000 using the enhanced estimates of the 1996 and 1997 year

classes based on regression estimators in Units 1-3 show declines compared to 1999 levels (Figure 14); however, the magnitude is smaller in Units 1-3. Using this alternate estimator, biomass estimates for ages 2 and older are down 10% in Unit 1, 2% in Unit 2, 10% in Unit 3, and up 3% in Unit 4. Biomass estimates of age 3 and older yellow perch available at the start of 2000 are lower than 1999 in all management units: Unit 1, -22%; Unit 2, -24%; Unit 3, -25%; and Unit 4, -3%.

Survival rates for ages 2 and older perch in 1999 increased in Units 1-3, and declined slightly in Unit 4 (Figure 15). This trend was also exhibited for survival of ages 3 and older yellow perch in Units 2 and 3 (Table 4, Figure 15), 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 1999 decreased substantially in all management units except Unit 4 (Figure 16). This trend is probably due to lower selectivity of age 2 and the slower-growing age 3 fish from the 1997 and 1996 year classes, respectively. Exploitation of age 3 and older yellow perch increased in Units 1 and 4 but decreased in Units 2 and 3 (Figure 16). 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. These values do show annual variation because recruitment is not a steady state entity. There is a concern by the task group that exploitation rates and fishing mortality at age 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 basic yield per recruit model used to calculate a recommended harvest in 2000 is similar to that used in 1999. 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 the 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). Without sufficient information that identifies significant growth changes in the last year or in the two-year averages used in yield per recruit

calculations, updates to von Bertalanffy inputs and F_{opt} calculations and outputs were not warranted.

The second factor in determining yield per recruit is calculating fishing mortality by age (F_{age}). In previous years (see YPTG 1996, 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. Unfortunately, because fisheries act independently (without direct regard to harvest at age) our actual F_{age} seen from the fisheries may be significantly greater than the projected F_{opt}.

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, the most recent 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 2000 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 2000 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, 1998-1999).

The 2000 harvest estimates are somewhat lower than those calculated for 1999 and