Report of the
Lake Erie Yellow Perch Task Group

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Introduction

The Yellow Perch Task Group (YPTG) was charged with describing the status of yellow perch in Lake Erie, producing population estimates and presenting a recommended allowable harvest (RAH) for 1995 in each of the four management units (Figure 1). The results of these charges are presented in this report. The task group was also charged with the completion of the joint YPTG/Statistics and Modelling Task Group (SAM) report, documenting the procedures used to develop a recommendable allowable harvest. Work was done on this additional charge in 1994; however, it is incomplete.

New charges addressed by the YPTG in 1994 include: (1) examination of the effect of increased minimum size limits on yellow perch yield and (2) determination of a minimum spawning stock biomass necessary for sustaining fishable yellow perch stocks in Lake Erie.

1994 Fisheries Review

The reported harvest of yellow perch from Lake Erie in 1994 totalled 2,002 metric tonnes (4.4 million pounds), which was 14% less than the 1993 harvest (Table 1). Perch catches declined for Michigan, Ontario and New York, but increased in Ohio and Pennsylvania. Pennsylvania harvest showed the greatest increase at +127%, but their overall effect on the lakewide harvest was low (1% of the lakewide harvest). Ohio harvest was up 51% to the previous year. Ohio's harvest was realized in sizable increases in management units 2 (+112%) and 3 (+147%), but a decrease in Unit 1 (- 25%). Ohio's harvest represents 42% of the lakewide total. Ontario fisheries saw a 35% decline in reported yellow perch harvest compared to 1993. Ontario harvested 55% of the lakewide reported catch. Michigan had a 46% decline in perch harvest; they represented just over 1% of the lakewide harvest.

In comparison to 1993, Ohio's share of the actual lakewide harvest increased from 24% to 42%, Ontario's share of the harvest decreased from 73% to 55%, and the remaining three jurisdictions, Michigan, Pennsylvania and New York, slid from 3% each to 1% each of the lakewide harvest.

The allowable harvest level recommended by the YPTG for 1993 was 6 million pounds lakewide. The Lake Erie Committee supported a lakewide allocation of 5 million pounds.

Harvest, fishing effort, and catch rate are summarized by Unit, year, agency, and gear type in Table 2. The trends over time (1975-1994) are depicted for harvest (Figure 2), fishing effort (Figure 3), and catch rate (Figure 4) by management unit (Unit) and gear type. Commercial gill net harvest declined in all Units: 1 (- 38 %), 2 (- 33 %), 3 (- 31%) and 4 (- 27%) compared to the 1993 harvest. Harvest from commercial trap nets increased slightly in Unit 1 (+ 4%), with more substantial increases in Units 2 (+ 165%) and 3 (+ 106%). Trap net harvest in Unit 4 remained low and decreased somewhat (- 33%). Sport harvest decreased substantially in Unit 1 (- 38%), stayed approximately the same in Unit 4, and increased greatly in Units 2 (+ 95%) and 3 (+ 183%).

Commercial gill net effort in 1994 declined in all management units: 1 (- 2%), 2 (- 8%), 3 (- 10%) and 4 (- 18%), as compared to 1993. Sizable increases in trap net effort were seen in Units 2 (+ 179%) and 3 (+ 17%). Decreases in trap net effort were seen in Units 1 (- 16%) and 4 (- 27%). Sport fishing effort declined in Units 1 (- 11%) and 4 (- 44%) in 1994, but increased 68% in Unit 2 and 80% in Unit 3.

Catch rates for 1994 commercial gill net fisheries decreased in comparison to 1993 in all management units: 1 (- 36%), 2 (- 26%), 3 (- 23%), and 4 (- 11%). Commercial trap net catch rates increased in Units 1 (+ 24%) and 3 (+ 76%), and decreased slightly in Units 2 (- 5%) and 4 (- 9%). Catch rates from the sport fisheries decreased in Unit 1 (- 31%), but increased in all the other Units: 2 (+ 15%), 3 (+ 58%), and 4 (+ 82%).

Recruitment of year classes since 1990 have been variable but persistent; there have been no missing or failed year classes as was seen in the late 1980s. Without very large year classes akin to those seen in the mid-1970s and mid-1980s, harvest and catch rates have declined to historic lows. Unit 1 sport angler harvest rates (reported herein as a catch rate) were lower this year due to high numbers of age 1 perch from the strong

1993 year class being caught and released; the release rate was nearly as high as the harvest rate (ODNR 1995).

The 1990 year class remained a strong contributor throughout all management units, but the 1992 year class and the 1991 year class also contributed heavily in Units 1 and 2. Older fish (age 6+) continue to dominate the trap net and sport fishing catches from Unit 4 (Table 3).

Stock Assessment

Age and Growth

During the past several years, a trend was noted that yellow perch growth was increasing. In 1994, the YPTG reviewed the available time series of length-at-age data from all the agencies with the purpose of documenting any noticeable trend in growth during recent years. Appendix A (Tables A-1 through A-7) contains the time series of yellow perch length-at-age data available for recent years. A review of these data indicates a positive trend in yellow perch growth, as reflected in mean length-at-age, since the late 1980's. Data for the western basin most clearly illustrate the trend. The Ontario partnership index fishing program, Ohio sport fishery catch sampling, Michigan sport fishery catch sampling, and Michigan trap net survey data all indicate a significant increase in yellow perch growth in the western basin since the late 1980's. The Ontario partnership index fishing data and Pennsylvania commercial harvest data suggest a positive trend in growth may also be present for the eastern central and eastern basins. However, small sample sizes and short time series confound growth trends for these basins.

A positive trend in yellow perch growth at this time is not surprising. The trend may be a direct result of a density dependent response to the documented decline in yellow perch abundance since the late 1980's. Another factor may be an improvement in the forage base. Hayward and Margraf (1987) suggested that yellow perch in the western basin experienced restricted growth due to reduced size structure of the benthic prey base. Since the colonization of zebra mussels in the late 1980's, the benthic forage base has changed greatly. For example, mounting evidence suggests that recolonization of the western basin by burrowing mayflies is underway. Rautio (1994) found that benthic invertebrates were more abundant and that yellow perch grew faster in the presence of zebra mussels. An improvement in the quality and quantity of benthic forage may be involved in the observed trend in yellow perch growth in Lake Erie.

Trends in growth may have important ramifications for the application of the CAGEAN analysis to yellow perch in Lake Erie. Improved growth over time results in a temporal change in vulnerability to the various gear types involved in the fisheries. If such a change is not somehow accounted for in the CAGEAN model, the CAGEAN analysis will overestimate of the abundance of the cohorts that have experienced that change. In the case of Lake Erie yellow perch, implications are greatest for age 2 due to the fact that previously they were not considered fully vulnerable to the fisheries.

Catch-at-Age-Analysis (CAGEAN) and the 1994 Population Estimate

CAGEAN Workshop

During the last year, the Yellow Perch and Walleye Task Groups stated a need for a workshop on catch-at-age analysis and theory. The YPTG sought out Dr. Terrence Quinn, one of the original authors of the CAGEAN work and literature. A working manual, "Quantitative Fish Dynamics" written by Terrence J. Quinn and Richard B. Deriso, outlined the workshop in Columbus on August 9-11, 1994. Theories of fish mortality, catch-age analysis, cohort analysis, virtual population analysis, and age-based assessment methods were discussed. The CAGEAN model was then simplified with a spreadsheet review of the calculations.

Catch-at-age analysis data alone can not be used to estimate absolute abundance; many parameter estimates are linear combinations of other estimates making catch-at-age analysis useful in only short trends over time. For catch-at-age analysis to produce accurate estimates, auxiliary information must be incorporated. Auxiliary information stabilizes relative estimates of abundance even when parameters are fixed. If the number of parameters can be reduced, then the least squares and likelihood objective functions can be used to obtain parameter estimates. Reductions in model variability can be achieved by increasing observations within parameters and pooling ages.

Estimates of selectivity relationships are depicted in catch curve analysis and are applied to a particular year class. When selectivity relationships are applied to several year classes in the same year, assumptions of constant recruitment are made. If the assumption of constant recruitment is not made, a different slope to the catch curve results. This would lead to an increase in the recruitment estimate which underestimates Z.

Catchability coefficients are applied under the assumption that each unit of fishing effort operates independently and is additive. The instantaneous change in catch would be proportional to fishing effort per unit time and abundance.

The importance of accurate data (including correct aging techniques) is critical for cohort analysis. This minimizes error in the calculation of terminal fishing mortalities.

The effort lambda, λ_E, is a pre-specified weight term to govern how strongly the catchability relationship should influence the overall fit of the model. As λ_E approaches infinity, then the constant catchability assumption is strictly satisfied. The term λ_E may be thought of as the ratio of the variances of catch observations to effort observations. The smallest value of λ_E that does not exhibit a trend in the effort residuals is used to diminish robustness. By keeping λ_E as small as possible, this keeps the model fit as good as possible. λ_E can be varied over a wide range to test the sensitivity of the model. The effects of λ_E does not vary the results over a wide range. The goal is to get the measurement error down to a point where it is at around 5-10% of the numerical abundance estimate.

CAGEAN 1995

Because of an increase in growth rates of 2 year old yellow perch, selectivity was adjusted for ages 2-6 for gill nets and angling (Unit 1). Also, 1994 provided one more year of data in Lake Erie's current state of high transparency and declining nutrients.

Data was blocked from 1988-1990 and 1991-1994 to distinguish this most recent change in Lake Erie. The accuracy and credibility of the model was improved by reducing parameters, which decreased variability in the shortened data series (Quinn - personal communication). The long term data set (1979-1994) adds higher variability from years prior to 1987, and is therefore less credible as an estimator of current yellow perch populations. The long term data set CAGEAN runs produced mean numerical abundance estimates that were not significantly different from the shortened data set. The long term data set did project significantly lower numerical abundances compared to last year's (1993)CAGEAN runs.

λ_E was adjusted for each gear type as the ratio of the variances of catch observations to effort observations. The 1995 CAGEAN model ran efficiently as model iterations were low (less than 10, usually 3 or 4), no trends were depicted in the residuals, and bootstraps were easily obtained. The 1995 CAGEAN estimates of Lake Erie yellow perch populations are supported by abundance indices within each agency.

A three gear (gill net, trap net and sport harvest and effort) version of the CAGEAN model was used to estimate the 1994 population size. 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).

Population size, in numbers and biomass, and population parameters such as survival and exploitation rates are presented for two stock size estimates: one that consists of 1995 age 2 abundance estimates derived from the recruitment-regression module (Table 4), and one that consists of 1995 age 2 abundance estimates derived from averaged CAGEAN age 2 estimates from 1992-1994 (Table 5). In both cases numbers and biomass are presented for both age 2 and older and age 3 and older. Population estimates are depicted in Figures 5 and 6, and biomass estimates are presented in Figures 7 and 8. Age 2 fish do contribute considerably to the harvest; however, a cohort contributes more significantly at age 3 and older, when it is fully vulnerable to all gears throughout the year.

In 1994, stock size estimates of age 3 and older fish increased slightly in management units 1 and 4 and decreased slightly in management units 2 and 3 (Tables 4 and 5, Figure 5). Stock size estimates for all management units were at levels typical of the early 1980s, prior to the 1984 year class. Stock size estimates for Unit 1 in 1995 were better than those of 1994 but still near historical low levels. Biomass estimates for age 3 and older fish in 1994 increased or remained near 1993 levels in all Units and the 1994 population consisted primarily of age 2 fish (Tables 6 and 7).

Survival rates for age 3 and older perch declined slightly in Units 2 and 3, and increased slightly in Units 1 and 4 (Figure 9). Survival rates for age 2 and older perch increased slightly in all management units. Exploitation rates for age 3 and older yellow perch decreased in all management units, as did exploitation rates for age 2 and older, except for a modest increase in Unit 1 (Figure 10).

Recruitment

In recent years, age 2 yellow perch recruits have been projected using the respective regressions of annual index trawling values for each management unit and CAGEAN age 2 population size estimates (recruitment-regression module). The 1995 age 2 recruit projections from the 1993 year class are considered by the task group to be unreasonably high (Appendix B). Even though the 1993 year class of yellow perch is thought to be of modest size based upon initial trawl estimates, the recruitment-regression module projecting year class size at age 2 far exceeds assessment observations. Index trawling regression projections from previous years' recruitment-regression modules have continually overestimated the age 2 yellow perch populations as attested by the significantly reduced CAGEAN backcast values of age 2 yellow perch for successive earlier population estimates from the improved CAGEAN runs this year.

Therefore, the 1995 age 2 projection was founded upon a more reasonable expectation of its abundance. This value was calculated from the average value of the last three years (1992-1994) age 2 CAGEAN estimates; it is considered the best available reference to the abundance of age 2 yellow perch recruiting to the fishable stock during the latest period of yellow perch life history.

1995 Population Size Projection

Stock size estimates for 1995 (age 3 and older) were projected from the CAGEAN 1994 population size estimates and age-specific survival rates in 1994 (Tables 8 and 9). Recruitment of the 1993 year class in 1995 (age 2 fish) was estimated from various agency trawling indices of age 0 and age 1 yellow perch in the recruitment-regression module (Table 8) and by using the averaging method described above (Table 9).

Projections of stock size for 1995 indicate a stabilizing to slightly increasing number of age 2 and older yellow perch in all Units (Tables 6 and 7); most of this increase is due in part to the 1992 and 1993 year classes. Age 3 and older projections show an approximate 10% increase in Units 1 and 4, and an approximate 10% decrease in Units 2 and 3. The Unit 4 yellow perch stock; however, will continue to be at low levels. More importantly, the Unit 4 population projection is no longer expected to be composed of a large proportion of older fish.

Biomass of age 2 and older fish remains the most representative indicator of fishable stock available in 1995 (Tables 4 and 5) . Biomass estimates in the 1995 projection, using the averaging method for age 2 fish, show increases of 2% in Unit 1, 6% in Unit 2, 92% in Unit 4 (but the biomass is relatively small compared to the other Units) and a 7% decrease in Unit 3. Looking at age 3 and older biomass as an indicator of available spawning stock, CAGEAN shows biomass increases of 28% in Unit 1, 21% in Unit 2, 90% in Unit 4 (again the biomass is relatively small compared to the other Units) and a 7% decrease in Unit 3.

Yield per Recruit

The yield per recruit model used to determine a recommended harvest in 1995 is the same as that used in 1994. 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 $F_{0.1}$, are given in the YPTG report of 1992.

The 1995 harvest estimates of age 2 and older fish is the sum of the estimates of harvest from each age, derived from scaling $F_{0.1}$ by the selectivity at that age. Catch in weight is calculated by multiplying the age specific catch in millions of fish by the mean weight in the harvest (5 year average, 1990-1994). The harvest estimate is the sum of the harvest for age 2 and older fish (Tables 10 and 11).

Recommended Allowable Harvest

In 1994, a lakewide harvest of 5 million pounds of yellow perch was adopted by the Lake Erie Committee. The 1994 lakewide harvest was 4.4 million pounds.

For 1995, we present two harvest scenarios (Table 12). Both strategies employ the unadjusted CAGEAN estimates of population size for ages 3-6+ and a scaled $F_{0.1}$ (or F_{opt}) exploitation strategy. As presented earlier in this report, the difference between the two scenarios is in the treatment of the age 2 recruitment estimate for 1995. One scenario uses the recruitment-regression module from interagency trawls (Tables 8 and 10), the other uses the mean of the 1992-1994 CAGEAN backcast age 2 abundances (Tables 9 and 11).

The recommended allowable harvest (RAH) both lakewide and by management unit is presented in Table 12. The Yellow Perch Task Group is not satisfied with the age 2 estimate from the recruitment-regression module, so it cannot recommend the 5.601 million pounds RAH from the traditional regression method for age 2 and CAGEAN.

The YPTG also is aware that the averaging method for age 2 yellow perch entering the fishery may also be conservative. It still seems to be a robust estimator of the potential of year class strength at age 2 based upon current trophic conditions in

Lake Erie. The YPTG feels confident that CAGEAN estimates have given a better perspective of conditions of age 3 and older populations across all management units, as well as a sharper definition of recent age 2 performance through population backcasting. By relying solely on these methods (age 2 averaging and CAGEAN), the RAH would be 3.374 million pounds.

With this in mind, and also realizing that age 2 yellow perch will continue to be a modest contributor to the 1995 harvest, the Yellow Perch Task Group suggests that the 1995 RAH be a value in the lower half of the range between 3.374 and 5.601 million pounds.

Additional Task Group Charges

Minimum Size Limits

One of the new charges assigned to the Yellow Perch Task Group in 1994 was to "conduct an analysis of the utility and effects of a minimum size limit (MSL) or size specific gear regulation for the exploitation of yellow perch stocks."

Hartman et al. (1980) reviewed the age structure, growth and mortality rates, maturation schedule, and length-fecundity relationship for Lake Erie yellow perch in the 1970's and applied Ricker type equilibrium models to determine the effects of various MSLs on yield, production, average stock weight, potential egg deposition, and the Abrosov spawning frequency indicator. Based on that analysis, Hartman et al. (1980) recommended that a minimum length of at least 8.5 inches be established for all yellow perch fisheries on the lake.

At present, the Ontario small-mesh gill net fishery is restricted by a minimum stretched-mesh size (MMS) of 2.25" (approximating a MSL of 8.0"). The Ohio trap net fishery is regulated by a MSL of 8.5". Lakewide, the sport fisheries are unregulated by any MSL.

In partial response to the 1994 MSL charge from the LEC, a modified yield-per-recruit model was used that accounts for catch and release of legal and sub-legal size fish