AGE STRUCTURED STOCK ASSESSMENT

OF LAKE ERIE WALLEYE

(Report of the July 22-24, 1986 Workshop)

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ABSTRACT

A workshop was organized to introduce the catch-at-age stock assessment method and software described in Deriso et al. (1985) to task group members involved with the Lake Erie Committee of the Great Lakes Fishery Commission and to apply the Catch at AGE Analysis (CAGEAN) software system to Lake Erie walleye and produce an initial analysis. Existing methodology used for stock assessment was reviewed and the new methods were presented. Problems were identified with the current methodology and alternative methods were described. A large range of data analysis schemes were conducted with the efficient software and microcomputer organization of the workshop. The basic conclusion reached was that the catch-at-. age methods all produce estimates of abundance of walleye that are substantially lower than those produced by the standard sequential projection (SP) method. The SP method is currently employed for stock assessment. We found that the SP method could be made to agree with the CAGEAN estimates by changing the scaling factor in SP now used to extrapolate bottom trawl young-of-the-year (YOY) indices to abundance of one-year-old walleye. Abundance estimates from CAGEAN show more of a flat and lower recent yearly trend than the trend given by the standard SP method. Whether this result indicates a need for the SP method to be updated (a possible update is given) or not, it is clear that the catch-at-age estimates are consistently different from the SP estimates. Evidence supporting the CAGEAN estimates include the sports CPUE, the survey CPUE, and the ability to make SP estimates agree by updating the relationship between YOY indices and abundance. Evidence supporting the standard SP estimates includes Ontario commercial CPUE, range expansion of walleye, and apparent reductions in growth rate.

This report summarizes the results of a three day workshop conducted by R. Deriso and sponsored by the Great Lakes Fishery Commission. The objectives of the workshop were:

1. to introduce the catch-at-age stock assessment method and software described in Deriso et al. (1985) to task group members of the Lake Erie Committee, Great Lakes Fishery Commission.

2. to apply the Catch at AGE ANalysis (CAGEAN) software system to Lake Erie walleye and produce an initial analysis.

Current methodology used for stock assessment was reviewed. Problems were identified with the current methodology and alternative methods were described (Appendix). We were able to conduct a large range of data analysis schemes with the efficient software and microcomputer organization available.

MATERIALS - DATA SETS

A side benefit of the workshop was the development of a computerized data set for Lake Erie walleye. The data set is stored on a floppy diskette (formatted to 360kb for ms-dos). The naming convention and data formats conform to those outlined in the CAGEAN USER MANUAL (July 1986). The data set covers:

a) ten years 1976-1985,
b) eight ages (2-9) to ten ages (1-10) depending on data.

1. CATCH DATA - in logarithm of numbers caught by six gear codes

   1 - Ontario commercial gillnet (central and western basins)
   2 - total sports catch (central and western basins)
   3 - Ontario sports catch
   4 - Ohio sports catch (western basin)
   5 - total interagency survey gillnet
   6 - survey trap-net

   Note: missing values are coded as 0.0 and 1976-1977 data for gear 1 were treated in the analysis as missing since this start-up period appears different from later years.

2. EFFORT DATA - actual effort units depend on gear-type

1 - kilometers of gillnet
2 - angler hours (Ontario rod hour units were converted to Ohio equivalent angler hours by multiplying rod hours by 1.185, a factor found in a CAGEAN run where Ontario and Ohio data were separate
3 - rod hours
4 - angler hours

Note: missing values are coded as 1.0.

3. WEIGHT DATA - Weights are generic values (multi-year averages) for the sports and commercially caught fish (in kg units).

4. FECUNDITY DATA - Generic values used with units in millions of eggs.

METHODS

Our base catch-at-age analysis used three categories of data (commercial, sports, gillnet survey). Each was given equal weighting in the estimation procedure described in Deriso et al. (1985). A multiple gear version of CAGEAN was applied to this data. Effort data were given half (lambda = 0.5) the weighting given to catches. A spawner - recruit relationhip was given only minor weighting in the analysis (S/R lambda = 0.1) and had little influence. The use of survey data in CAGEAN is a new twist on the original methodology, and R. Deriso plans on publishing this new approach in the near future.

Sensitivity of results from our base analysis was investigated with a series of alternative configurations of CAGEAN. The primary alternatives are as follows:

Survey emphasis - the gillnet survey data were given ten times the weighting given to either the commercial or sports data

More survey emphasis - the gillnet survey data were locked into by CAGEAN by giving it a million times the weighting that was given other gears. This is our version of a stock assessment driven by the gillnet survey.

Higher natural mortality (M=0.4) - tagging data suggest that M is around 0.4, as compared with our base assumption that M is 0.2. Other parameters are the same as those given in the base case.

Trap-net survey emphasis - the trap-net data replace gill-net survey data in this alternative. Ten times the weighting was given to the survey data.

Pool older ages (age 6+ combined) - aging errors are one possible problem in catch-at-age analysis. Here, catches of age 6 fish and older are combined and a different model similar to the one in Deriso (1980) is used to track the abundance of the older group of fish. Other parameters are the same as those in the base case.

RESULTS AND DISCUSSION

The basic conclusion reached at the end of the workshop was that the catch-at-age methods all produce estimates of abundance of walleye that are substantially lower than those produced by the standard sequential projection (SP) method. The SP method is currently employed for stock assessment. We found that this method could be made to agree with the CAGEAN estimates by changing the scaling factor in SP now used to extrapolate bottom trawl young-of-the-year (YOY) indices to the abundance of yearling walleye (we refer to this scaler as the YOY scaling factor).

Figure 1 shows predicted and observed catches for each of the three groups of catch-effort data that we considered in our base estimation. The root mean square (rms) from the base run is about 0.5, which means that the average difference between observed and predicted log catch is about 0.5. This may not appear large except that in terms of actual catches, 0.5 translates into about a 50% coefficient of variation. Obviously, CAGEAN estimates show some important differences with the observed data. By comparison, application of CAGEAN to Pacific halibut typically shows a root mean square of less than 0.1.

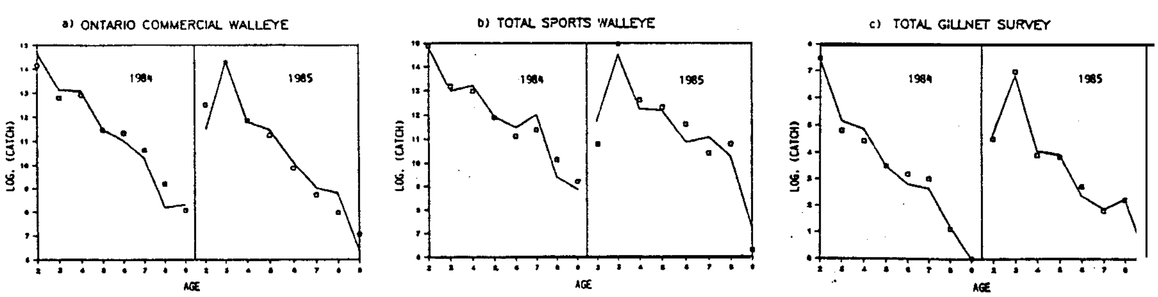

Figure 1. Predicted (-) and observed (▭) catches of walleye for 1984 and 1985 from each of three groups of data: a) Ontario commercial, b) interagency sports data, c) interagency gillnet survey catch.

Part of the reason for the high rms for walleye is that the data do not all show the same trend in abundance. Figure 2 shows the trends in abundance from the three gear groups

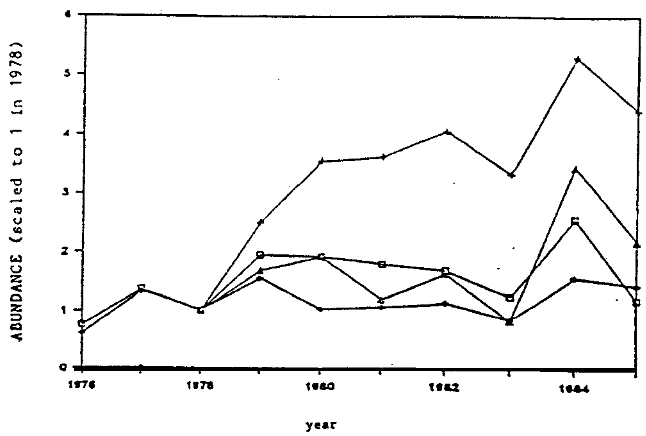

Figure 2. Trends in abundance of walleye estimated from the base abundance estimate (0) and the three gear **groups:** commercial (+), sport (◆), survey (Δ).

and from the base abundance estimate (referred to as our estimate number 1). The data were scaled so that all four curves had a relative value of 1.0 in year 1978. Note that the time trends are similar for the CAGEAN, sports, and survey estimates, while the commercial data suggests an increasing trend since 1978 (much like the standard SP estimates). Results from the catch-at-age method followed the two gears that were similiar in their time trends. Abundance estimates given in all the results from CAGEAN are for walleye of ages 2-9.

The sensitivity study indicates that the trend in abundance in the base estimate is fairly robust to a number of alternative assumptions, as detailed in the previous section (Table 1). All scenarios generally show an erratic trend in

Table 1 : Estimates of abundance of walleye from all catch-at-age analyses (for age 2 through age 9 year olds in millions).

YEAR	Base case	Survey emphasis	More Survey	Higher M (=0.4)	Trap net emphasis	Pool old ages
1976	5.2	5.2	5.3	8.9	7.0	4.7
1977	9.4	9.4	9.8	15.0	14.6	9.1
1978	6.8	6.7	6,.4	10.5	9.8	6.1
1979	13.3	13.0	10.3	20.9	18.9	12.1
1980	13.2	12.8	9.5	19.5	15.6	12.5
1981	12.3	12.0	10.1	16.6	13.9	11.2
1982	11.6	10.7	8.2	16.0	13.6	11.9
1983	8.6	7.8	5.8	11.4	10.5	9.2
1984	17.5	17.2	14.5	22.5	20.0	22.2
1985	8.1	7.6	5.9	10.0	9.3	13.2
Average	10.6	9.8	8.6	15.1	13.3	11.2

abundance which reached a peak in 1984 but then decreased in 1985 to levels of the late 1970s. Abundance estimates for 1985 show a wide spread within the CAGEAN alternatives, but are 50% or more below the standard SP estimates (Fig. 3). We

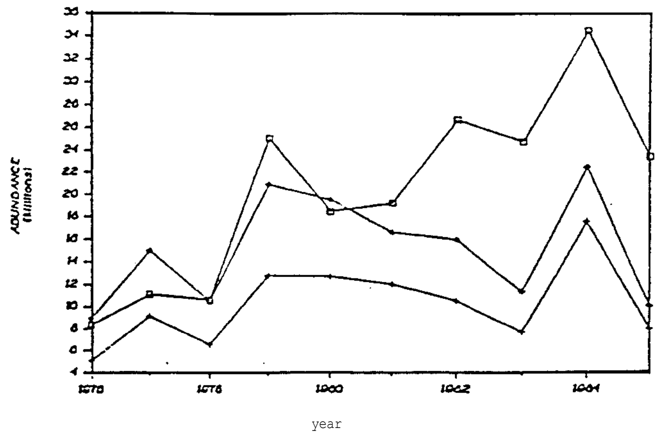

Figure 3. Estimated abundance of walleye using standard sequential projection method (□) rod the two CAGEAN alternatives of survey emphasis (+) and higher natural mortality (◆). All estimates derived with standard YOY scaler.

set up an approximate SP algorithm, and Fig. 3 shows how the standard configuration compares to two of the CAGEAN estimates. The standard SP algorithm assumes the following relationship between the Ohio adjusted YOY index and abundance of yearlings:

Abundance of YEARLINGS = 233820 * YOY index

Based on a regression of the CAGEAN base estimates of abundance we found that the best linear regression with the YOY index was:

Abundance of YEARLINGS = 102409 * YOY index + 1668497

The new SP algorithm, which incorporates the above regression equation, gives estimates of fishable abundance much more like the estimates produced from catch-at-age analysis (Fig. 4). A

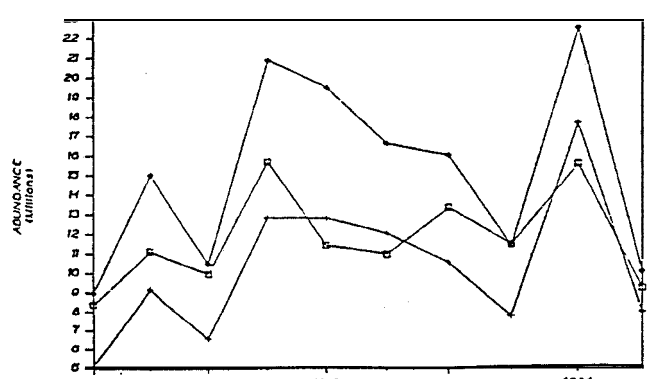

Figure 4. Estimated abundance of walleye using standard sequential projection method (□) and the two CAGEAN alternatives of survey emphasis (+) and higher natural mortality (◆). All estimates derived with updated YOY scaler.

comparison of CAGEAN year-class estimates to various indices. is presented in Table 2.

Table 2. Data and regression estimates comparing CAGEAN year-class esti-tim-ates to various indices of abundance.

YEAR	YOY ODW	YOY ADJ	YOY FWS	YRL	ABUND	ANG CPE	NEW YOY
1974	81	37	35		3.98	.241	19.3
1975	30	15	12		5.15	.198	11.2
1976		4	10		1.44	.034	
1977	270	105	164	36.7	10.20	.442	20.1
1978	10	6	26	9.5	5.27	.152	3.5
1979	67	31		18.8	3.70	.174	10.9
1980	200	81	117	11.9	7.65	.221	14.6
1981	260	28	347	17.9	3.48	.108	
1982		102			16.70	.415	94.2
1983	0	33	1	25.1	0.83	.006	0
1984	71		41				15.0
R2	0.70	0.69	0.92				

Exploitation rates are higher from the CAGEAN estimates, which is to be expected since abundance estimates are lower than the SP numbers. The exploitation rate has averaged between 25% and 44% for the ten year period with the alternative estimates shown in Table 1. The stock appears to be able to handle that mortality well considering that abundance in 1985 is still above the 1976 estimate in all the scenarios. Although CAGEAN shows lower stock levels than derived from SP, the high exploitation rate has not had an adverse effect on the stock to date.

In summary, the CAGEAN estimates show more of a flat and lower recent trend in abundance than the trend given by the standard SP method. Whether or not this result indicates a need for the SP method to be updated, it is clear that the catch-at-age estimates are consistently different from the SP estimates. Evidence supporting the CAGEAN estimates include the sports CPUE, the survey CPUE, and the ability to make SP estimates agree by updating the relationship between YOY indices and abundance. Evidence supporting the standard SP estimates include Ontario commercial CPUE, range expansion of walleye, and apparent reductions in growth rate.

The CAGEAN model was used subsequent to the workshop to examine the effect of changes in the assumptions about catchability coefficient and age-specific selectivities. The most significant response occurred when the data were blocked into two time periods, 1978-82 and 1983-87. The results showed substantially lower estimates for sport and commercial catchability coefficients in the recent block of years

(Table 3). Also, the selectivity curve for the commercial

Table 3. Parameter estimates (selectivities) derived from CAGEAN modeling with unblocked (base run) and blocked data for walleye for the periods 1978-82 and 1983-87.

	Base Run		Blocked Data			
	Commercial	Sport	Commercial		Sport	
Age	1978-87	1978-87	1978-82	1983-87	1978-82	1983-87
2	0.50	0.21	0.52	0.32	0.45	0.73
3	1.00	0.31	1.00	1.00	0.46	0.78
4	0.90	0.47	0.99	0.79	1.00	1.00
5	0.63	0.36	0.69	0.78	1.00	1.00
6	0.62	0.40	0.47	0.69	1.00	1.00
7	0.44	1.12	0.17	0.38	1.00	1.00
8	0.92	2.62				
Catchability Coefficient			$7.2E^{-3}$	$2.6E^{-5}$	$10.4E^{-6}$	$5.3E^{-6}$
R^2	0.60		0.40			

gear decreased for age 2 fish, while estimates of age selectivities for the sport gear remained similar in both blocks of time. The estimated selectivities for the sport fishing gear indicated an increase from age 2 to an unrealistic maximum at age 9 (similar to results from the base run>. To avoid potential errors associated with the aging of old fish, age 7 and older fish were treated as pooled catch. Selectivities for ages 4 - 7 were then assigned a full recruitment of 1. The resulting selectivity estimates for sport gear indicated lower selectivities for age 2 and age 3 but did not allow any differences between age 4 and older walleye (Table 3).

These changes resulted in stock size estimates in the range of 30 to 40 million walleye since 1984 and a decreased R from 0.5 to 0.4. The higher stock size estimates and new parameter estimates are consistent with the strong influence of the dominant 1982 year class in the fishery. Since 1984 there has been an expansion of the fishery into central basin waters where densities of walleye are lower.

The CAGEAN model has also been used to substantiate cohort analysis with the yellow perch data base in Lake Erie. Stock size estimates from the CAGEAN model compared very well with those from cohort analyses for recent years. Although the CAGEAN model seems to be more appropriate than cohort analysis for assessing the most recent years' stock sizes, the projection of future stock sizes still involves some uncertainty.

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APPENDIX

WORKSHOP AGENDA

July 22 A.M. Review of Catch at Age Analysis
- virtual population analysis and cohort analysis
- catch model development
- role of auxiliary information
- assumptions and other things that go wrong (multi-gear fisheries and changes in catchabilities, ageing problems)

P.M. Laboratory
- introduction, data set-up and analysis with CAGEAN (Catch Age Analysis program)
- VPA with Lotus 1,2,3.

July 23 A.M. Population Estimation
- Current methodology and problems of population assessment of walleye in Lake Erie
- alternate methods of assessment
- how can catch at age analysis help or accomodate current methods

P.M. Prepare options and decide on ones to pursue
- data analysis

July 24 A.M. Produce results utilizing good options
Sensitivity analysis

P.M. Wrap-up and summary remarks

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79-I Illustrated field guide for the classification Of sea lamprey attack marks on Great Lakes lake trout. 1979. E.L. King and T.A. Edsall. 41 p.

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83-1 Quota management of Lake Erie fisheries. 1983. Edited by J.F. Koonce, D. Jester, B. Henderson, R. Hatch, and M. Jones. 39 p.

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87-1 Guidelines for fish habitat management and planning in the Great Lakes (Report of the Habitat Planning and Management Task Force and Habitat Advisory Board of the Great Lakes Fishery Commission). 1987. 15 p.

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87-3 Temperature relationships of Great Lakes fishes: A data compilation. 1987. D.A. Wismer and A.E. Christie. 195 p.

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88-2 A proposal for a bioassay procedure to assess impact of habitat conditions on lake trout reproduction in the Great Lakes (Report of the ad hoc Committee to Assess the Feasibility of Conducting Lake Trout Habitat Degradation Research in the Great Lakes). 1988. Edited by R.L. Eshenroder. 11 p.