Report of the Lake Erie Yellow Perch Task Group

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Presented to:

Standing Technical Committee of the Lake Erie Committee
Great Lakes Fishery Commission

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Introduction

The Yellow Perch Task Group (YPTG) was assigned five charges by the Lake Erie Committee. As in previous years, the task group was charged with producing a lake-wide recommended allowable harvest (RAH) level, and to maintain and update the centralized time-series data set of harvest, effort, growth and maturity and agency abundance indices of yellow perch. The task group was also charged with the completion of the joint YPTG/Statistics and Modeling Task Group (SAM) report, documenting the procedures used to develop a recommendable allowable harvest. Two charges assigned to the YPTG in 1994, an examination of the effect of increased minimum size limits on yellow perch yield, and determination of a minimum spawning stock biomass necessary for sustaining fishable yellow perch stocks in Lake Erie, were repeated in 1995 and are still being addressed by the group.

1995 Fisheries Review

The reported harvest of yellow perch from Lake Erie in 1995 totaled 1,762 metric tonnes (3.88 million pounds), which was 88% of the 1994 harvest (Table 1). As in the recent past, the YPTG partitions Lake Erie into four Management Units, or MUs (Figure 1). Perch catches declined for Ontario, Ohio, Pennsylvania and New York, but increased in Michigan. Ontario experienced a decrease in harvest in all MUs except MU-3, where there was a 23% increase over the 1994 harvest. The Ontario harvest declined by 26% in MU-1, 17% in MU-2, and 38% in MU-4. The Pennsylvania harvest showed the greatest decrease (56% of 1994 harvest). The Ohio yellow perch harvest experienced the smallest decrease among the agencies (91% of 1994 harvest), due largely to the increased harvest in MU-1 (up 81%). The Ohio MU-2 harvest was 77% of the 1994 level. The largest decline in Ohio's fishery occurred in Management Unit 3, where harvest dropped to 23% of the 1994 level. The Michigan harvest increased by 15% over 1994. New York's harvest declined to 60% of the 1994 harvest.

In comparison with 1994, each agency's proportion of the lakewide harvest was largely unchanged. Ohio's proportion increased from 42% to 43% of the lakewide harvest, Michigan's proportion increased from 1% to 2%, Ontario's decreased from 55% to 54%, while New York's and Pennsylvania's shares remained unchanged.

The allowable harvest level range recommended by the YPTG for 1994 was 3.374 to 4.488 million pounds lakewide. The Lake Erie Committee supported a lakewide allocation of 4 million pounds.

Harvest, fishing effort, and catch rates are summarized by Management Unit, year, agency, and gear type in Table 2. The trends over time (1975-1995) are depicted for harvest (Figure 2), fishing effort (Figure 3), and catch rate (Figure 4) by Management Unit and gear type. Commercial gillnet harvest declined in Units 1, 2 and 4, down from the 1994 harvest by 26%, 17% and 38% respectively. The commercial gillnet harvest in Unit 3 increased by 14% over the 1994 level. Harvest from commercial trapnets decreased in all Management Units: MU-1 decreased by 35%, by 15% in MU-2, and by 55% in Unit 3. Trapnet harvest in Unit 4 decreased by 50%. Sport harvest increased substantially in Unit 1 (+ 125%), stayed approximately the same in Unit 4, and decreased in Units 2 and 3, down by 26% and 90% respectively.

Commercial gillnet effort in 1994 declined in all management units: down by 5% in Unit 1, 22% in Unit 2, 14% in Unit 3 and 16% in Unit 4, from 1994 levels. Trapnet effort declined in Units 1, 2 and 4 (down 14%, 9% and 4% respectively), from 1994, but increased by 6% in Unit 3. Sport fishing effort increased by 4% in Unit 1 in 1995, but declined by 28% in Unit 2, 76% in Unit 3, and 18% in Unit 4.

Catch rates for the 1995 commercial gillnet fishery increased by 6% over 1994 in Unit 2 and by 32% in Unit 3. The gillnet catch rates declined by 22% in Unit 1, and by 25% in Unit 4, relative to 1994. Commercial trapnet catch rates decreased in all Management Units. Unit 1 catch rates dropped 24% from 1994, Unit 2 declined by 6%, Unit 3 by 58%, and Unit 4 decreased 48% from 1994. Catch rates from the sport fisheries increased in Unit 1 (up 113%), Unit 2 (up 3%) and Unit 4 (up 25%) from 1994. The sport fishery catch rate from Unit 3 decreased by 63% from 1994.

Recruitment of year classes to the fisheries has been variable since 1990; however, there have been no year classes as large as those seen in the mid 1980s. The failure to produce large year classes has resulted in yellow perch stock size, harvest and catch rates reaching historic lows.

The 1992 year class remained a strong contributor throughout all management units, but the 1993 year class made a marked contribution to the harvest in Units 1 and 4. Older fish (age 6+) continue to dominate the trapnet and sport fishing harvest from Unit 4 (Table 3).

Stock Assessment

Age and Growth

In response to an apparent trend of increasing growth of yellow perch, noted in the 1995 YPTG report, the task group reviewed the growth model to compare with the work done previously. 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 accounted for in the CAGEAN model, the CAGEAN analysis will overestimate the abundance of the cohorts that have experienced that change.

The task group uses growth data in a Beverton-Holt yield-per-recruit model to determine F_{opt}. The inputs required for this model are derived from the VonBertalanffy growth formula (VBGF). The data used for this exercise were from Ontario's partnership index gillnetting program. These data were selected for several reasons: the survey was conducted consistently in all areas of the lake, it occurred in the fall (the end of the growing season), and it provided an unbiased estimate for all size and age groups.

The data from each Management Unit were pooled from 1990 to 1994. The model parameters were derived using the VonBertalanffy regression method (Pauly, 1984) over the more popular Ford-Walford (Everhart and Youngs 1981) method, as these estimates were deemed more realistic, and were not subject to the biases inherent in the Ford-Walford method.

When the revised VBGF values were entered into the yield-per-recruit model, the task group found there was little change in the resulting F_{opt} values. The results of the VBGF models and the yield-per-recruit models are summarized in Appendix A.

Catch-at-Age Analysis (CAGEAN) and the 1995 Population Estimate

CAGEAN 1995

As discussed in the 1995 YPTG report, the long-term data series (1975 - present) includes data from a period which the task group feels embodied conditions significantly different than those found from 1988 on. The introduction of zebra and quagga mussels, combined with reduced nutrient loadings have resulted in a system which exhibits dynamics different than those experienced prior to 1988. In addition, the large 1984 year class altered the behaviour of all Lake Erie's fisheries, raising catches and catch rates, and persisting in large numbers into the early 1990's. Indeed, the 1984 year class is still the largest component of New York's fisheries. The task group felt that the 1984 year class had a strong influence over the CAGEAN model, masking the true dynamics of the population. For that reason, the data from 1988 to present were incorporated in the CAGEAN model. Data was blocked from 1988-1990 and 1991-1994 to distinguish the most recent changes in Lake Erie. 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), which decreased variability in the shortened data series (T. Quinn - personal communication).

The effort lambda, 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 completed. The 1995 CAGEAN estimates of Lake Erie yellow perch populations are supported by abundance indices from all agencies.

A three-gear (gillnet, trapnet and sport: harvest and effort) version of the CAGEAN model was used to estimate the 1995 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 1996 age 2 abundance estimates derived from the recruitment-regression module (Table 4), and one that consists of 1996 age 2 abundance estimates derived from averaged CAGEAN age 2 estimates from 1993-1995 (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 1995, stock size estimates of age 3 and older fish increased in Management Units 1, 2 and 3, while decreasing slightly in Unit 3 (Tables 4 and 5, Figure 5). Biomass estimates for age 3 and older fish in 1995 increased over 1994 levels in all Units except Unit 4. Nearly half the population (by numbers) in Unit 1 in 1995 consisted of age 2 fish. Age 2 fish are a smaller component of the population in Units 2 and 3 (35% and 16%, respectively). In Unit 4, age 2 fish comprise 64% of the population.

Survival rates for age 3 and older perch declined slightly in Unit 2, and increased slightly in Units 1, 3 and 4 (Figure 9). Survival rates for age 2 and older perch increased in all Management Units 1 and 4, but decreased in Units 2 and 3. Exploitation rates for age 3 and older yellow perch decreased in all management units; however, exploitation rates for age 2 and older fish increased in all areas except Unit 4 (Figure 10).

Recruitment

In recent years, age 2 yellow perch recruits have been projected using regressions of annual index trawling values for each year class as young-of-the-year and yearlings against CAGEAN estimates of abundance for those year classes as age 2 fish. The 1996 age 2 recruit projections from the 1994 year class are considered by the task group to be unreasonably high. Although the 1994 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. Population projections from previous years' recruitment-regression modules have continually overestimated the age 2 yellow perch populations. With this in mind, the task group feels the 1996 age 2 projection should be founded upon a more reasonable expectation of its abundance. This value was calculated from the average value of the last three years (1993-1995) 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.

1996 Population Size Projection

Stock size estimates for 1996 (age 3 and older) were projected from the CAGEAN 1995 population size estimates and age-specific survival rates in 1994 (Tables 8 and 9). Recruitment of the 1994 year class in 1996 (age 2 fish) was estimated from various agency trawling indices of young-of-the-year and yearling yellow perch in the recruitment-regression module (Table 8) and by using the averaging method described above (Table 9).

Projections of stock size for 1996 initially appear to be at a level similar to 1995; however, this is due to the predicted estimate of age 2 abundance (Tables 6 and 7). In Unit 1, the projection of age 3 and older abundance is close to the 1995 level. In all other Units, the number of age 3 and older fish is lower than in 1995, but within the range experienced in recent years.

Biomass of age 2 and older fish remains another representative indicator of fishable stock available in 1995 (Tables 4 and 5). Biomass estimates in the 1996 projection, using the averaging method for age 2 fish, show slight declines in all Management Units (down by 11% in Unit 1, by 11% in Unit 2, and by 3% in Unit 3). The biomass of age 3 and older fish represents the spawning stock biomass for 1996. The projections of age 3 and older biomass shows a slight increase from 1995 in Units 1 and 4 (2% and 7%, respectively), and a decline of 8% in Unit 2 and 17% in Unit 3.

Yield per Recruit

The yield per recruit model used to determine a recommended harvest in 1996 is the same as that used in 1995. 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. As discussed above, the task group reviewed all the model inputs in 1995, and has revised the F_{opt} values.

The 1996 harvest estimates for age 2 and older fish are summarized in Tables 10 and 11. These values are the sum of the estimates of the harvest in numbers of each age group. The harvest estimates are derived by scaling the $F_{0.1}$ value by the selectivity for that age, and applying the resulting F_{opt} to the 1996 population projection for that age. The harvest in weight is then calculated by multiplying the age specific catch (in millions of fish) by the mean weight in the harvest (5 year average, 1991-1995).

Recommended Allowable Harvest

In 1995, a lakewide harvest of 4 million pounds of yellow perch was adopted by the Lake Erie Committee. The 1995 lakewide harvest was 3.88 million pounds.

For 1995, we present two harvest scenarios (Table 12). Both strategies employ the unadjusted CAGEAN estimates of population size for ages 3 to 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 population estimates for 1996. One scenario uses the "traditional" recruitment-regression module from interagency trawls (Tables 8 and 10), the other uses the mean of the CAGEAN age 2 abundance estimates from 1993 to 1995 (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 6.269 million pounds RAH from the traditional regression method. The YPTG is also aware that the averaging method for age 2 yellow perch entering the fishery may be conservative; however, the task group feels that these estimates are closer to reality than the regression estimates are. The 1995 CAGEAN estimates of age 2 and older fish are representative of the populations in all Management Units. By relying solely on these methods (age 2 averaging and CAGEAN), the RAH would be 3.300 million pounds.

The Yellow Perch Task Group recognizes that the 1994 year class appears to be of moderate size, based on interagency trawl indices. With this in mind, the task group recommends the lakewide Recommended Allowable Harvest for 1996 be in the range between 3.30 and 4.80 million pounds. Harvest scenarios for specific management units should be based on proportions seen within the range of percentages of the regression (traditional) and averaging models. Averaging method proportions based on a 4 million pounds total allocation: MU-1, 1.372 million lbs. (34.3%); MU-2, 1.817 million lbs. (45.4%); MU-3, 715,000 lbs.

(17.8%); MU-4, 96,000 lbs. (2.4%). Traditional, regression method proportions based on a 4 million pounds total allocation: MU-1, 1.723 million lbs. (43.1%); MU-2, 1.718 million lbs. (43.0%); MU-3, 460,000 lbs. (11.5%); MU-4, 98,000 lbs. (2.4%). The Yellow Perch Task Group recommends adopting a distribution by Management Unit within these ranges.

Additional Task Group Charges

Minimum Size Limits

One of the charges assigned to the Yellow Perch Task Group in 1994, and again in 1995 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."

This charge was addressed in the 1995 report of the Yellow Perch Task Group. Using a model developed by Clark (1983), the task group found that the MSL of 8.0" approximated by the minimum mesh size of the gillnet fishery provided a good balance between weight harvested and change in stock size. The number of fish less than 8.0" in total length harvested by the gillnet fishery suggests the effective MSL is closer to 7". By imposing an effective 8.0" MSL on the gillnet fishery, it would impose a considerable expense in retooling the fishery's gear, and only result in a 2% gain in stock size while reducing harvest 15%. An effective MSL of 6.0" to 6.5" was estimated for the sport fishery; however increasing the MSL from 6.0" to 8.0" would only result in a 5% increase in the stock size yet would yield a 40% decline in harvest. The trapnet fishery is currently the only fishery on Lake Erie with an enforced MSL: 8.5". As with the gillnet MSL, this provides the best balance between stock size and harvest.

Another approach, not investigated by the task group but being implemented at various levels by different agencies, is the effect on harvest of other restrictions such as seasons and sport fishing bag limits. Currently, Ohio and Ontario have imposed a restriction on the spring commercial harvest of yellow perch to delay harvest until after spawning. Most agencies have regulated their sport fisheries to some degree: Ohio, Michigan and Pennsylvania have imposed bag limits for yellow perch, and Ontario has banned the sale of angler caught fish. The YPTG feels that work on these various aspects within this charge should render it completed at the present time.

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".

Several models are under review by the task group. Indicators of spawning stock size have included catch rates for mature yellow perch during or immediately following spawning, and indicators of recruitment have included indices of juvenile abundance or catch rates of 2 year old fish as they become vulnerable to the fisheries. A number of problems in the analysis and interpretation have been considered during the review. For example, the relationship between the size of the spawning stock and the resulting recruitment is confounded by the occurrence of highly variable year class strengths, which is typical for yellow perch and other species which are present in Lake Erie. Also the changing habitat and the presence of a succession of invading species such as zebra mussels must be considered in the evaluation of the success of yellow perch. The Yellow Perch Task Group will continue to pursue this topic in 1996.

Joint YPTG/SAM Report on RAH Procedures

The completion of the joint YPTG/Statistics and Modeling Task Group (SAM) report, documenting the procedures used to develop a recommendable allowable harvest is on track for a 1996 report date. Since our recent CAGEAN workshop, many of these techniques have been refined and streamlined, and this document will serve as a good point-in-time reference regarding RAH procedures. It will be published, possibly as a Great Lakes Fishery Commission Special Report rather than incorporating the report into the YPTG annual report.

Factors Affecting Recruitment

In 1992, the Yellow Perch Task Group was charged with "... review factors affecting the recruitment of yellow perch ...". The review of these factors the YPTG thinks are important in affecting yellow perch recruitment is summarized in table form as Appendix B.

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 YPTG will continue to explore alternatives to the present age 2 estimator for incorporation into following task group reports.

The task group is keenly aware of changing trophic conditions in Lake Erie. Whether harvest (and possibly abundance) differences seen on the north and south shores of the lake are due to yellow perch migration or differential survival is in need of further investigation. Additional work on productivity differences or gradients, and their changes within recent decades, should also be addressed.

We are also aware of claims that high walleye abundance may have some negative impact on the yellow perch population. Diet studies conducted basinwide by several agencies conclude that the effect of walleye predation on yellow perch populations is negligible at this time. Further diet work will continue to provide insight into this interaction between predators and their prey.

The task group is also interested in current yellow perch genetic work, which may assist in our ability to recognize individual stocks which may require a more focused management than at the Management Unit level. The YPTG will also continue to address current charges regarding long term data sets, RAH, and spawning stock biomass.

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Table 1. Summary of total catch (tonnes) of yellow perch by management unit and agency, Lake Erie 1985-1995.

	Year	Ontario Catch	Ontario %	Ohio Catch	Ohio %	Michigan Catch	Michigan %	Pennsylvania Catch	Pennsylvania %	New York Catch	New York %	Total Catch
Unit 1	1985	1,347	73	476	26	22	1	--	--	--	--	1,845
	1986	1,360	61	775	35	82	4	--	--	--	--	2,217
	1987	1,298	59	785	36	102	5	--	--	--	--	2,185
	1988	1,445	61	846	36	76	3	--	--	--	--	2,367
	1989	1,432	59	862	35	151	6	--	--	--	--	2,445
	1990	808	67	296	24	105	9	--	--	--	--	1,209
	1991	294	46	309	48	43	7	--	--	--	--	646
	1992	312	59	184	35	30	6	--	--	--	--	526
	1993	517	62	262	31	56	7	--	--	--	--	835
	1994	322	59	197	36	30	5	--	--	--	--	549
	1995	238	38	356	57	35	6	--	--	--	--	629
Unit 2	1985	2,127	87	308	13	--	--	--	--	--	--	2,435
	1986	2,289	89	289	11	--	--	--	--	--	--	2,578
	1987	2,512	88	344	12	--	--	--	--	--	--	2,856
	1988	2,538	93	191	7	--	--	--	--	--	--	2,729
	1989	2,530	84	486	16	--	--	--	--	--	--	3,016
	1990	1,303	75	432	25	--	--	--	--	--	--	1,735
	1991	985	76	310	24	--	--	--	--	--	--	1,295
	1992	1,144	83	227	17	--	--	--	--	--	--	1,371
	1993	877	80	224	20	--	--	--	--	--	--	1,101
	1994	590	55	474	45	--	--	--	--	--	--	1,064
	1995	487	57	365	43	--	--	--	--	--	--	852
Unit 3	1985	370	81	43	9	--	--	43	9	--	--	456
	1986	1,101	92	60	5	--	--	30	3	--	--	1,191
	1987	908	84	108	10	--	--	64	6	--	--	1,080
	1988	1,128	78	239	17	--	--	81	6	--	--	1,448
	1989	1,095	63	544	31	--	--	96	6	--	--	1,735
	1990	965	76	229	18	--	--	84	7	--	--	1,278
	1991	550	75	115	16	--	--	69	9	--	--	734
	1992	540	82	84	13	--	--	35	5	--	--	659
	1993	275	78	66	19	--	--	11	3	--	--	352
	1994	172	48	163	45	--	--	25	7	--	--	360
	1995	211	80	38	14	--	--	14	5	--	--	263
Unit 4	1985	190	75	--	--	--	--	14	5	51	20	255
	1986	143	89	--	--	--	--	16	10	2	1	161
	1987	260	90	--	--	--	--	23	8	6	2	289
	1988	258	98	--	--	--	--	1	<1	4	2	263
	1989	199	78	--	--	--	--	0	0	55	22	254
	1990	128	88	--	--	--	--	0	0	17	12	145
	1991	73	87	--	--	--	--	0	0	11	13	84
	1992	52	85	--	--	--	--	0	0	9	15	61
	1993	33	85	--	--	--	--	0	0	6	15	39
	1994	24	83	--	--	--	--	0	0	5	17	29
	1995	15	83	--	--	--	--	0	0	3	17	18
Lakewide Totals	1985	4,034	81	827	17	22	<1	57	1	51	1	4,991
	1986	4,893	80	1,124	18	82	1	46	1	2	<1	6,147
	1987	4,978	78	1,237	19	102	2	87	1	6	<1	6,410
	1988	5,369	79	1,276	19	76	1	82	1	4	<1	6,807
	1989	5,256	71	1,892	25	151	2	96	1	55	1	7,450
	1990	3,204	73	957	22	105	2	84	2	17	<1	4,367
	1991	1,902	69	734	27	43	2	69	3	11	<1	2,759
	1992	2,048	78	495	19	30	1	35	1	9	<1	2,617
	1993	1,702	73	552	24	56	2	11	0	6	<1	2,327
	1994	1,108	55	834	42	30	1	25	1	5	<1	2,002
	1995	951	54	759	43	35	2	14	1	3	<1	1,762

Table 2. Catch and effort summaries for Lake Erie yellow perch fisheries by management unit (MU),agency and gear type, 1985-1995.

		Unit 1				Unit 2			Unit 3				Unit 4			
		Ohio		Michigan	Ontario	Ohio		Ontario	Ohio		Ontario	Pennsylvania	New York		Ontario	Pennsylvania
	Year	Trap Nets	Sport	Sport	Gill Nets	Trap Nets	Sport	Gill Nets	Trap Nets	Sport	Gill Nets	Gill Nets	Trap Nets	Sport	Gill Nets	Gill Nets
	1985	27	449	23	1,206	8	300	2,208	2	41	325	43	0		137	14
	1986	71	704	82	1,361	0	289	2,290	0	60	1,101	30	2		143	48
	1987	139	646	102	1,298	10	334	2,512	21	87	908	64	6		260	23
	1988	284	562	76	1,445	21	170	2,538	150	89	1,128	81	4		258	1
Catch	1989	392	470	151	1,432	91	395	2,530	288	256	1,095	96	8	47	199	0
(tonnes)	1990	210	86	105	808	295	137	1,303	203	26	965	84	9	8	128	0
	1991	89	220	43	294	137	173	985	84	31	550	69	7	4	73	0
	1992	56	128	30	312	66	161	1,144	46	38	540	35	5	4	52	0
	1993	72	190	56	517	52	172	877	31	35	275	11	3	3	33	0
	1994	75	122	30	322	138	336	590	64	99	172	25	2	3	24	0
	1995	49	307	35	238	117	248	487	29	9	211	14	0	3	15	0
	1985	4,141	935,645	46,782	16,139	212	728,763	34,187	136	144,309	10,635	2,175	0		8,582	486
	1986	5,279	1,404,286	404,514	20,909	0	461,273	30,920	0	122,007	12,440	2,185	3,513		8,797	569
	1987	7,078	1,046,115	452,460	14,730	630	429,239	20,940	668	129,316	6,667	1,538	1,602		4,908	632
	1988	6,900	1,153,182	494,158	9,616	448	402,180	17,315	4,781	172,490	6,203	1,418	2,132		2,719	8
Effort	1989	8,418	1,028,551	696,973	12,716	1,403	572,612	25,679	7,281	248,530	7,098	1,037	1,136	65,370	2,628	0
(a)	1990	6,299	350,000	634,255	18,305	6,238	400,676	31,613	7,376	31,881	12,472	1,978	981	24,463	3,924	0
	1991	7,259	700,719	164,517	13,629	6,480	452,277	34,739	4,516	54,607	12,247	2,018	918	22,090	3,859	0
	1992	6,795	350,433	120,979	9,221	4,753	340,917	35,348	3,361	84,445	14,540	1,321	632	52,398	3,351	0
	1993	7,092	530,012	244,455	12,006	2,558	320,891	25,569	2,610	96,619	10,017	620	761	26,297	2,008	0
	1994	5,937	469,959	224,744	11,734	7,139	538,977	23,441	3,053	173,706	8,169	1,442	555	14,800	1,642	0
	1995	5,103	598,977	123,616	11,136	6,467	388,238	18,337	3,258	42,234	6,843	1,465	532	12,115	1,375	0
	1985	6.52	0.48	0.49	74.73	37.74	0.41	64.59	14.71	0.28	30.56	19.77	0.00		15.96	28.81
	1986	13.45	0.50	0.20	65.09		0.63	74.06		0.49	88.50	13.73	0.57		16.26	84.36
	1987	19.64	0.62	0.23	88.12	15.87	0.78	119.96	31.44	0.67	136.19	41.61	3.75		52.97	36.39
	1988	41.16	0.49	0.15	150.27	46.88	0.42	146.58	31.37	0.52	181.85	57.12	1.88		94.89	125.00
Catch Rates	1989	46.57	0.46	0.22	112.61	64.86	0.69	98.52	39.56	1.03	154.27	92.57	7.04	0.72	75.72	
(b)	1990	33.34	0.25	0.17	44.14	47.29	0.34	41.22	27.52	0.82	77.37	42.47	9.17	0.33	32.62	
	1991	12.26	0.31	0.26	21.57	21.14	0.38	28.35	18.60	0.57	44.91	34.19	7.63	0.18	18.92	
	1992	8.24	0.37	0.25	33.84	13.89	0.47	32.36	13.69	0.45	37.14	26.50	7.91	0.08	15.52	
	1993	10.15	0.36	0.23	43.06	20.33	0.54	34.30	11.88	0.36	27.45	17.74	3.94	0.11	16.43	
	1994	12.63	0.26	0.13	27.44	19.33	0.62	25.17	20.96	0.57	21.06	17.34	3.60	0.20	14.62	
	1995	9.60	0.51	0.28	21.37	18.09	0.64	26.56	8.90	0.21	30.83	9.56	0.00	0.25	10.91	

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

Table 3. Lake Erie yellow perch harvest in numbers by age and management unit, 1995.

Gear	Age	Unit 1 Number	Unit 1 %	Unit 2 Number	Unit 2 %	Unit 3 Number	Unit 3 %	Unit 4 Number	Unit 4 %
Gillnet	1	2,908	0.1	23,506	0.5	0	0.0	1,181	1.3
	2	641,723	29.7	799,223	18.3	47,339	2.5	47,424	52.7
	3	1,304,805	60.4	2,888,536	66.1	1,724,651	90.7	28,064	31.2
	4	171,114	7.9	556,591	12.7	78,910	4.2	8,130	9.0
	5	29,148	1.3	87,195	2.0	21,458	1.1	2,541	2.8
	6+	11,935	0.6	14,856	0.3	29,082	1.5	2,580	2.9
	Total	2,161,633		4,369,907		1,901,440		89,920	
Trapnet	1	0	0.0	0	0.0	0	0.0	0	0.0
	2	34,250	10.1	89,024	13.3	23,134	12.4	63	1.0
	3	126,212	37.4	215,793	32.2	126,185	67.4	320	5.1
	4	44,388	13.1	137,077	20.4	16,227	8.7	977	15.6
	5	113,289	33.6	167,050	24.9	9,686	5.2	406	6.5
	6+	19,491	5.8	61,642	9.2	11,932	6.4	4,512	71.9
	Total	337,630		670,586		187,164		6,278	
Sport	1	41,768	1.3	0	0.0	0	0.0	0	0.0
	2	2,020,945	61.6	319,481	23.0	12,815	24.8	1,951	19.0
	3	868,505	26.5	679,752	48.9	23,658	45.8	731	7.1
	4	198,634	6.1	167,706	12.1	6,499	12.6	1,754	17.1
	5	119,345	3.6	159,358	11.5	4,599	8.9	413	4.0
	6+	29,223	0.9	64,877	4.7	4,036	7.8	5,431	52.8
	Total	3,278,420		1,391,174		51,607		10,280	
All Gear	1	44,676	0.8	23,506	0.4	0	0.0	1,181	1.1
	2	2,696,918	46.7	1,207,728	18.8	83,288	3.9	49,438	46.4
	3	2,299,522	39.8	3,784,081	58.8	1,874,494	87.6	29,115	27.3
	4	414,136	7.2	861,374	13.4	101,636	4.7	10,861	10.2
	5	261,782	4.5	413,603	6.4	35,743	1.7	3,360	3.2
	6+	60,649	1.0	141,375	2.2	45,050	2.1	12,523	11.8
	Total	5,777,683		6,431,667		2,140,211		106,478	

Table 4. Estimates of Lake Erie yellow perch population size, 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 populations consisting of age 2 and older fish , and for age 3 and older fish. 1996 estimates use age 2 abundance estimates derived from CAGEAN estimates regressed against YOY and yearling trawl indices.

		Age 2 and Older				Age 3 and Older			
	Year	Number (millions)	Biomass (millions kg)	S	u	Number (millions)	Biomass (millions kg)	S	u
Unit 1	1988	94.778	11.319	0.468	0.205	65.109	8.570	0.386	0.279
	1989	48.747	6.242	0.530	0.417	46.198	6.029	0.523	0.440
	1990	23.364	3.844	0.406	0.303	18.850	3.252	0.364	0.347
	1991	19.457	2.540	0.404	0.234	9.261	1.521	0.405	0.315
	1992	18.887	2.376	0.473	0.559	7.708	1.202	0.477	0.342
	1993	15.429	1.939	0.452	0.225	8.730	1.481	0.438	0.486
	1994	18.624	2.196	0.470	0.225	6.902	1.012	0.438	0.383
	1995	17.705	2.123	0.497	0.241	8.875	1.275	0.466	0.313
	1996	54.864	4.224			8.839	1.306		
Unit 2	1988	102.374	10.746	0.541	0.208	61.916	7.996	0.485	0.298
	1989	58.959	9.591	0.422	0.363	55.374	9.321	0.409	0.384
	1990	33.088	5.757	0.441	0.331	24.854	4.785	0.392	0.400
	1991	35.713	5.449	0.407	0.282	14.581	2.948	0.377	0.317
	1992	38.020	5.267	0.475	0.307	14.544	2.700	0.425	0.464
	1993	28.100	3.842	0.452	0.331	18.060	3.115	0.413	0.456
	1994	33.385	4.520	0.522	0.231	12.709	2.280	0.468	0.343
	1995	26.793	3.944	0.486	0.288	17.422	2.848	0.448	0.250
	1996	63.309	5.997			13.010	2.626		
Unit 3	1988	69.491	12.886	0.530	0.134	59.769	11.376	0.507	0.384
	1989	41.799	7.736	0.468	0.247	36.804	7.231	0.441	0.280
	1990	25.510	5.310	0.468	0.286	19.553	4.623	0.409	0.370
	1991	21.566	3.744	0.456	0.220	11.933	2.665	0.386	0.304
	1992	14.077	2.548	0.428	0.337	9.828	2.087	0.370	0.394
	1993	7.996	1.528	0.450	0.319	6.032	1.294	0.405	0.382
	1994	14.738	1.721	0.570	0.133	3.597	0.952	0.445	0.352
	1995	10.026	1.477	0.515	0.213	8.398	1.289	0.492	0.245
	1996	20.226	2.186			5.167	1.068		
Unit 4	1990	9.263	1.958	0.593	0.128	8.730	1.905	0.590	0.135
	1991	5.819	1.374	0.592	0.118	5.494	1.334	0.590	0.122
	1992	3.622	0.825	0.636	0.040	3.446	0.819	0.636	0.042
	1993	2.578	0.583	0.615	0.078	2.304	0.554	0.613	0.081
	1994	1.901	0.371	0.619	0.069	1.586	0.349	0.615	0.074
	1995	3.293	0.520	0.647	0.040	1.176	0.330	0.633	0.099
	1996	13.561	1.182			2.129	0.354		

Table 5. Lake Erie yellow perch estimates of population size, 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 populations consisting of age 2 and older fish , and for age 3 and older fish. 1996 estimates use age 2 estimates derived from averaged CAGEAN age 2 estimates from 1993-1995.

		Age 2 and Older				Age 3 and Older			
	Year	Number (millions)	Biomass (millions kg)	S	u	Number (millions)	Biomass (millions kg)	S	u
Unit 1	1988	94.778	11.319	0.487	0.205	65.109	8.570	0.415	0.279
	1989	48.747	6.242	0.387	0.401	46.198	6.029	0.373	0.423
	1990	23.364	3.844	0.396	0.381	18.850	3.252	0.339	0.458
	1991	19.457	2.540	0.396	0.266	9.261	1.521	0.388	0.406
	1992	18.887	2.376	0.462	0.559	7.708	1.202	0.452	0.397
	1993	15.429	1.939	0.447	0.239	8.730	1.481	0.428	0.529
	1994	18.624	2.196	0.475	0.231	6.902	1.012	0.605	0.407
	1995	17.705	2.123	0.493	0.225	8.875	1.275	0.473	0.263
	1996	17.922	1.882			8.839	1.306		
Unit 2	1988	102.374	10.746	0.541	0.208	61.916	7.996	0.485	0.298
	1989	58.959	9.591	0.422	0.363	55.374	9.321	0.409	0.384
	1990	33.088	5.757	0.441	0.331	24.854	4.785	0.392	0.400
	1991	35.713	5.449	0.407	0.282	14.581	2.948	0.377	0.317
	1992	38.020	5.267	0.475	0.307	14.544	2.700	0.425	0.464
	1993	28.100	3.842	0.452	0.331	18.060	3.115	0.413	0.456
	1994	33.385	4.520	0.390	0.231	12.709	2.280	0.605	0.407
	1995	26.793	3.944	0.493	0.184	17.422	2.848	0.473	0.263
	1996	26.372	3.522			13.010	2.626		
Unit 3	1988	69.491	12.886	0.530	0.134	59.769	11.376	0.507	0.384
	1989	41.799	7.736	0.468	0.247	36.804	7.231	0.441	0.280
	1990	25.510	5.310	0.468	0.286	19.553	4.623	0.409	0.370
	1991	21.566	3.744	0.456	0.220	11.933	2.665	0.386	0.304
	1992	14.077	2.548	0.428	0.337	9.828	2.087	0.370	0.394
	1993	7.996	1.528	0.450	0.319	6.032	1.294	0.405	0.382
	1994	14.738	1.721	0.570	0.133	3.597	0.952	0.445	0.352
	1995	10.026	1.477	0.515	0.213	8.398	1.289	0.492	0.245
	1996	10.078	1.433			5.167	1.068		
Unit 4	1990	9.263	1.958	0.593	0.128	8.730	1.905	0.590	0.135
	1991	5.819	1.374	0.592	0.118	5.494	1.334	0.590	0.122
	1992	3.622	0.825	0.636	0.040	3.446	0.819	0.636	0.042
	1993	2.578	0.583	0.615	0.078	2.304	0.554	0.613	0.081
	1994	1.901	0.371	1.120	0.069	1.586	0.349	0.470	0.074
	1995	3.293	0.520	0.702	0.092	1.176	0.330	0.350	0.119
	1996	3.031	0.419			2.129	0.354		

Table 6. Yellow perch stock size (millions of fish) at the start of the year, estimated by CAGEAN for the years 1988 to 1995. The 1996 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
Unit 1	2	29.670	2.549	4.514	10.196	11.179	6.699	11.721	8.830	46.025
	3	27.649	19.194	1.638	2.866	4.118	5.245	3.165	5.747	4.662
	4	31.748	11.979	7.472	0.536	0.965	1.705	2.155	1.390	2.672
	5	2.519	12.527	4.220	2.230	0.180	0.399	0.700	0.947	0.646
	6+	3.193	2.498	5.519	3.630	2.445	1.380	0.882	0.791	0.859
	2 and Older	94.778	48.747	23.364	19.457	18.887	15.429	18.624	17.705	54.864
	3 and Older	65.109	46.198	18.850	9.261	7.708	8.730	6.902	8.875	8.839
Unit 2	2	39.879	3.585	8.233	21.132	23.477	10.041	20.676	9.372	50.299
	3	19.616	25.084	2.185	4.834	9.046	11.880	5.250	11.477	5.209
	4	41.268	9.503	10.331	0.734	1.076	3.102	4.442	2.321	4.938
	5	0.951	19.920	3.824	3.223	0.163	0.369	1.160	1.964	0.999
	6+	0.660	0.868	8.515	5.791	4.258	2.709	1.857	1.660	1.864
	2 and Older	102.374	58.959	33.088	35.713	38.020	28.100	33.385	26.793	63.309
	3 and Older	62.495	55.374	24.854	14.581	14.544	18.060	12.709	17.422	13.010
Unit 3	2	9.722	4.995	5.957	9.633	4.249	1.964	11.141	1.627	15.059
	3	7.581	6.481	3.320	3.929	5.217	2.397	1.152	6.797	1.033
	4	50.946	3.999	2.977	0.932	0.754	1.285	0.736	0.441	3.248
	5	0.992	25.678	1.739	0.784	0.179	0.186	0.394	0.282	0.211
	6+	0.251	0.647	11.518	6.289	3.678	2.164	1.315	0.879	0.675
	2 and Older	69.491	41.799	25.510	21.566	14.077	7.996	14.738	10.026	20.226
	3 and Older	59.769	36.804	19.553	11.933	9.828	6.032	3.597	8.398	5.167
Unit 4	2			0.533	0.325	0.176	0.273	0.315	2.117	11.431
	3			0.494	0.339	0.203	0.114	0.173	0.200	1.384
	4			1.066	0.238	0.146	0.112	0.053	0.085	0.118
	5			0.265	0.346	0.060	0.064	0.033	0.018	0.043
	6+			6.906	4.571	3.037	2.014	1.327	0.874	0.584
	2 and Older			9.263	5.819	3.622	2.578	1.901	3.293	13.561
	3 and Older			8.730	5.494	3.446	2.304	1.586	1.176	2.129

Table 7. Yellow perch stock size (millions of fish) at the start of the year, estimated from CAGEAN for the years 1988 to 1995. The 1996 population estimate uses an age 2 value derived from an average of CAGEAN age 2 estimates for the previous three years, 1993-1995.

	Age	1988	1989	1990	1991	1992	1993	1994	1995	1996
Unit 1	2	29.670	2.549	4.514	10.196	11.179	6.699	11.721	8.830	9.083
	3	27.649	19.194	1.638	2.866	4.118	5.245	3.165	5.747	4.662
	4	31.748	11.979	7.472	0.536	0.965	1.705	2.155	1.390	2.672
	5	2.519	12.527	4.220	2.230	0.180	0.399	0.700	0.947	0.646
	6+	3.193	2.498	5.519	3.630	2.445	1.380	0.882	0.791	0.859
	2 and Older	94.778	48.747	23.364	19.457	18.887	15.429	18.624	17.705	17.922
	3 and Older	65.109	46.198	18.850	9.261	7.708	8.730	6.902	8.875	8.839
Unit 2	2	39.879	3.585	8.233	21.132	23.477	10.041	20.676	9.372	13.363
	3	19.616	25.084	2.185	4.834	9.046	11.880	5.250	11.477	5.209
	4	41.268	9.503	10.331	0.734	1.076	3.102	4.442	2.321	4.938
	5	0.951	19.920	3.824	3.223	0.163	0.369	1.160	1.964	0.999
	6+	0.660	0.868	8.515	5.791	4.258	2.709	1.857	1.660	1.864
	2 and Older	102.374	58.959	33.088	35.713	38.020	28.100	33.385	26.793	26.372
	3 and Older	62.495	55.374	24.854	14.581	14.544	18.060	12.709	17.422	13.010
Unit 3	2	9.722	4.995	5.957	9.633	4.249	1.964	11.141	1.627	4.911
	3	7.581	6.481	3.320	3.929	5.217	2.397	1.152	6.797	1.033
	4	50.946	3.999	2.977	0.932	0.754	1.285	0.736	0.441	3.248
	5	0.992	25.678	1.739	0.784	0.179	0.186	0.394	0.282	0.211
	6+	0.251	0.647	11.518	6.289	3.678	2.164	1.315	0.879	0.675
	2 and Older	69.491	41.799	25.510	21.566	14.077	7.996	14.738	10.026	10.078
	3 and Older	59.769	36.804	19.553	11.933	9.828	6.032	3.597	8.398	5.167
Unit 4	2			0.533	0.325	0.176	0.273	0.315	2.117	0.902
	3			0.494	0.339	0.203	0.114	0.173	0.200	1.384
	4			1.066	0.238	0.146	0.112	0.053	0.085	0.118
	5			0.265	0.346	0.060	0.064	0.033	0.018	0.043
	6+			6.906	4.571	3.037	2.014	1.327	0.874	0.584
	2 and Older			9.263	5.819	3.622	2.578	1.901	3.293	3.031
	3 and Older			8.730	5.494	3.446	2.304	1.586	1.176	2.129

Table 8. Projection of the 1996 Lake Erie yellow perch population. Stock size estimates are derived from CAGEAN. 1996 age 2 estimates are derived from regressions of CAGEAN age 2 abundance against YOY and yearling trawl indices.

		1995 Parameters									1996 Parameters				Stock Biomass		
		Stock Size (numbers)				Mortality Rates				Survival Rate		Stock Size (numbers)			Mean Weight in	Biomass (thousand tonnes)	
	Age	Mean	Std. Err.	Min.	Max.	(F)	(Z)	(A)	(u)	(S)	Age	Mean	Min.	Max.	Pop. (kg)	1995	1996
Unit 1																	
	2	8.830	0.691	8.139	9.520	0.239	0.639	0.472	0.176	0.528	2	46.025	41.423	50.628	0.063	0.848	2.917
	3	5.747	0.449	5.297	6.196	0.366	0.766	0.535	0.256	0.465	3	4.662	4.297	5.027	0.090	0.676	0.420
	4	1.390	0.109	1.282	1.499	0.366	0.766	0.535	0.256	0.465	4	2.672	2.463	2.880	0.177	0.199	0.474
	5	0.947	0.074	0.873	1.021	0.366	0.766	0.535	0.256	0.465	5	0.646	0.596	0.697	0.229	0.180	0.148
	6+	0.791	0.062	0.730	0.853	0.236	0.636	0.470	0.174	0.530	6+	0.859	0.792	0.926	0.308	0.219	0.265
	Total	17.705	1.385	16.320	19.090	0.295	0.695	0.501	0.212	0.499	**Total**	54.864	49.570	60.158		2.123	4.224
	(3+)	8.875	0.694	8.181	9.569	0.354	0.754	0.529	0.248	0.471	**(3+)**	8.839	8.148	9.530		1.275	1.306
Unit 2																	
	2	9.372	1.135	8.237	10.506	0.187	0.587	0.444	0.142	0.556	2	50.299	45.269	55.329	0.067	1.096	3.371
	3	11.477	1.389	10.088	12.867	0.444	0.844	0.570	0.300	0.430	3	5.209	4.578	5.840	0.107	1.549	0.559
	4	2.321	0.281	2.040	2.602	0.444	0.844	0.570	0.300	0.430	4	4.938	4.340	5.535	0.193	0.369	0.955
	5	1.964	0.238	1.726	2.201	0.444	0.844	0.570	0.300	0.430	5	0.999	0.878	1.119	0.282	0.415	0.282
	6+	1.660	0.201	1.459	1.861	0.087	0.487	0.386	0.069	0.614	6+	1.864	1.639	2.090	0.446	0.514	0.831
	Total	26.793	3.244	23.550	30.037	0.322	0.722	0.514	0.230	0.486	**Total**	63.309	56.704	69.913		3.944	5.997
	(3+)	17.422	2.109	15.313	19.531	0.404	0.804	0.552	0.277	0.448	**(3+)**	13.010	11.435	14.584		2.848	2.626
Unit 3																	
	2	1.627	0.246	1.381	1.873	0.054	0.454	0.365	0.044	0.635	2	15.059	13.553	16.565	0.074	0.188	1.118
	3	6.797	1.028	5.769	7.825	0.338	0.738	0.522	0.239	0.478	3	1.033	0.877	1.189	0.111	0.893	0.114
	4	0.441	0.067	0.374	0.507	0.338	0.738	0.522	0.239	0.478	4	3.248	2.757	3.739	0.166	0.080	0.538
	5	0.282	0.043	0.239	0.324	0.338	0.738	0.522	0.239	0.478	5	0.211	0.179	0.242	0.465	0.064	0.098
	6+	0.879	0.133	0.746	1.012	0.086	0.486	0.385	0.068	0.615	6+	0.675	0.573	0.777	0.470	0.252	0.318
	Total	10.026	1.516	8.509	11.542	0.263	0.663	0.485	0.192	0.515	**Total**	20.226	17.939	22.513		1.477	2.186
	(3+)	8.398	1.270	7.128	9.668	0.309	0.709	0.508	0.221	0.492	**(3+)**	5.167	4.386	5.948		1.289	1.068
Unit 4																	
	2	2.117	0.532	1.585	2.648	0.025	0.425	0.346	0.020	0.654	2	11.431	7.070	18.483	0.072	0.022	0.828
	3	0.200	0.050	0.150	0.190	0.130	0.530	0.411	0.101	0.589	3	1.384	1.037	1.732	0.092	0.019	0.127
	4	0.085	0.021	0.063	0.605	0.273	0.673	0.490	0.199	0.510	4	0.118	0.088	0.112	0.199	0.006	0.023
	5	0.018	0.004	0.013	0.621	0.273	0.673	0.490	0.199	0.510	5	0.043	0.032	0.308	0.318	0.005	0.014
	6+	0.874	0.219	0.654	0.158	0.018	0.418	0.342	0.015	0.658	6+	0.584	0.437	0.421	0.324	0.319	0.189
	Total	3.293	0.827	2.466	4.120	0.036	0.436	0.353	0.029	0.647	**Total**	13.561	8.664	21.056		0.371	1.182
	(3+)	1.176	0.295	0.881	1.574	0.057	0.457	0.367	0.046	0.633	**(3+)**	2.129	1.595	2.573		0.349	0.354

Table 9. Projection of the 1996 Lake Erie yellow perch population. Stock size estimates are derived from CAGEAN. 1996 population values use age 2 estimates derived from CAGEAN age 2 estimates averaged over the previous three years, 1993 to 1995.

	1995 Parameters										1996 Parameters				Stock Biomass		
		Stock Size (numbers)				Mortality Rates				Survival Rate		Stock Size (numbers)			Mean Weight in	Biomass (thousand tonnes)	
	Age	Mean	Std. Err.	Min.	Max.	(F)	(Z)	(A)	(u)	(S)	Age	Mean	Min.	Max.	Pop. (kg)	1995	1996
Unit 1																	
	2	8.830	0.691	8.139	9.520	0.239	0.639	0.472	0.176	0.528	2	9.083	6.754	11.412	0.063	0.848	0.576
	3	5.747	0.449	5.297	6.196	0.366	0.766	0.535	0.256	0.465	3	4.662	4.297	5.027	0.090	0.676	0.420
	4	1.390	0.109	1.282	1.499	0.366	0.766	0.535	0.256	0.465	4	2.672	2.463	2.880	0.177	0.199	0.474
	5	0.947	0.074	0.873	1.021	0.366	0.766	0.535	0.256	0.465	5	0.646	0.596	0.697	0.229	0.180	0.148
	6+	0.791	0.062	0.730	0.853	0.236	0.636	0.470	0.174	0.530	6+	0.859	0.792	0.926	0.308	0.219	0.265
	Total	17.705	1.385	16.320	19.090	0.295	0.695	0.501	0.212	0.499	Total	17.922	14.902	20.943		2.123	1.882
	(3+)	8.875	0.694	8.181	9.569	0.354	0.754	0.529	0.248	0.471	(3+)	8.839	8.148	9.530		1.275	1.306
Unit 2																	
	2	9.372	1.135	8.237	10.506	0.187	0.587	0.444	0.142	0.556	2	13.363	7.503	19.223	0.067	1.096	0.896
	3	11.477	1.389	10.088	12.867	0.444	0.844	0.570	0.300	0.430	3	5.209	4.578	5.840	0.107	1.549	0.559
	4	2.321	0.281	2.040	2.602	0.444	0.844	0.570	0.300	0.430	4	4.938	4.340	5.535	0.193	0.369	0.955
	5	1.964	0.238	1.726	2.201	0.444	0.844	0.570	0.300	0.430	5	0.999	0.878	1.119	0.282	0.415	0.282
	6+	1.660	0.201	1.459	1.861	0.087	0.487	0.386	0.069	0.614	6+	1.864	1.639	2.090	0.446	0.514	0.831
	Total	26.793	3.244	23.550	30.037	0.322	0.722	0.514	0.230	0.486	Total	26.372	18.938	33.807		3.944	3.522
	(3+)	17.422	2.109	15.313	19.531	0.404	0.804	0.552	0.277	0.448	(3+)	13.010	11.435	14.584		2.848	2.626
Unit 3																	
	2	1.627	0.246	1.381	1.873	0.054	0.454	0.365	0.044	0.635	2	4.911	(0.077)	9.898	0.074	0.188	0.365
	3	6.797	1.028	5.769	7.825	0.338	0.738	0.522	0.239	0.478	3	1.033	0.877	1.189	0.111	0.893	0.114
	4	0.441	0.067	0.374	0.507	0.338	0.738	0.522	0.239	0.478	4	3.248	2.757	3.739	0.166	0.080	0.538
	5	0.282	0.043	0.239	0.324	0.338	0.738	0.522	0.239	0.478	5	0.211	0.179	0.242	0.465	0.064	0.098
	6+	0.879	0.133	0.746	1.012	0.086	0.486	0.385	0.068	0.615	6+	0.675	0.573	0.777	0.470	0.252	0.318
	Total	10.026	1.516	8.509	11.542	0.263	0.663	0.485	0.192	0.515	Total	10.078	4.309	15.847		1.477	1.433
	(3+)	8.398	1.270	7.128	9.668	0.309	0.709	0.508	0.221	0.492	(3+)	5.167	4.386	5.948		1.289	1.068
Unit 4																	
	2	2.117	0.532	1.585	2.648	0.025	0.425	0.346	0.020	0.654	2	0.902	(0.071)	1.874	0.072	0.022	0.065
	3	0.200	0.050	0.150	0.251	0.130	0.530	0.411	0.101	0.589	3	1.384	1.037	1.732	0.092	0.019	0.127
	4	0.085	0.021	0.063	0.106	0.273	0.673	0.490	0.199	0.510	4	0.118	0.088	0.148	0.199	0.006	0.023
	5	0.018	0.004	0.013	0.022	0.273	0.673	0.490	0.199	0.510	5	0.043	0.032	0.054	0.318	0.005	0.014
	6+	0.874	0.219	0.654	1.093	0.018	0.418	0.342	0.015	0.658	6+	0.584	0.437	0.731	0.324	0.319	0.189
	Total	3.293	0.827	2.466	4.120	0.036	0.436	0.353	0.029	0.647	Total	3.031	1.524	4.538		0.371	0.419
	(3+)	1.176	0.295	0.881	1.472	0.057	0.457	0.367	0.046	0.633	(3+)	2.129	1.595	2.664		0.349	0.354

Table 10. Estimated harvest of Lake Erie yellow perch for 1996. 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 in weight is in millions of kilograms.

		Stock Size (numbers)			Exploitation Rate				Catch (millions of fish)			Mean Wt. in Harvest	Catch (millions of kg) - RAH		
	Age	Mean	Min.	Max.	F(opt)	s(age)	(F)	(u)	Mean	Min.	Max.	(kg)	Mean	Min.	Max.
Unit 1															
	2	46.025	41.423	50.628	0.000	0.652	0.257	0.188	8.666	7.800	9.533	0.102	0.886	0.798	0.975
	3	4.662	4.297	5.027	0.423	1.000	0.394	0.272	1.267	1.168	1.366	0.126	0.160	0.147	0.172
	4	2.672	2.463	2.880	0.423	1.000	0.394	0.272	0.726	0.669	0.783	0.151	0.109	0.101	0.118
	5	0.646	0.596	0.697	0.423	1.000	0.394	0.272	0.176	0.162	0.189	0.173	0.030	0.028	0.033
	6+	0.859	0.792	0.926	0.423	0.644	0.254	0.186	0.160	0.147	0.172	0.244	0.039	0.036	0.042
	Total	54.864	49.570	60.158	1.692	4.296	0.243	0.200	10.995	9.946	12.044	0.111	1.225	1.110	1.340
	(3+)	8.839	8.148	9.530	1.692		0.387	0.263	2.329	2.147	2.511	0.145	0.339	0.312	0.365
Unit 2															
	2	50.299	45.269	55.329	0.000	0.422	0.166	0.127	6.388	5.749	7.026	0.115	0.738	0.664	0.811
	3	5.209	4.578	5.840	0.515	1.000	0.394	0.272	1.416	1.245	1.587	0.132	0.187	0.165	0.210
	4	4.938	4.340	5.535	0.515	1.000	0.394	0.272	1.342	1.180	1.505	0.154	0.206	0.181	0.231
	5	0.999	0.878	1.119	0.515	1.000	0.394	0.272	0.271	0.239	0.304	0.206	0.056	0.049	0.063
	6+	1.864	1.639	2.090	0.515	0.197	0.077	0.062	0.115	0.101	0.129	0.302	0.035	0.030	0.039
	Total	63.309	56.704	69.913	2.060	3.619	0.183	0.151	9.532	8.512	10.551	0.128	1.222	1.089	1.354
	(3+)	13.010	11.435	14.584	2.060		0.369	0.242	3.144	2.764	3.525	0.154	0.484	0.425	0.543
Unit 3															
	2	15.059	13.553	16.565	0.000	0.161	0.063	0.051	0.763	0.687	0.839	0.116	0.089	0.080	0.097
	3	1.033	0.877	1.189	0.482	1.000	0.394	0.272	0.281	0.238	0.323	0.135	0.038	0.032	0.044
	4	3.248	2.757	3.739	0.482	1.000	0.394	0.272	0.883	0.749	1.016	0.195	0.172	0.146	0.198
	5	0.211	0.179	0.242	0.482	1.000	0.394	0.272	0.057	0.049	0.066	0.236	0.014	0.011	0.016
	6+	0.675	0.573	0.777	0.482	0.254	0.100	0.079	0.053	0.045	0.061	0.281	0.015	0.013	0.017
	Total	20.226	17.939	22.513	1.928	3.415	0.122	0.101	2.037	1.768	2.306	0.161	0.327	0.282	0.372
	(3+)	5.167	4.386	5.948	1.928		0.371	0.247	1.274	1.081	1.467	0.187	0.239	0.202	0.275
Unit 4															
	2	11.431	7.070	18.483	0.000	0.091	0.036	0.029	0.332	0.206	0.537	0.111	0.037	0.023	0.060
	3	1.384	1.037	1.732	0.398	0.475	0.187	0.142	0.196	0.147	0.245	0.120	0.024	0.018	0.029
	4	0.118	0.088	0.112	0.398	1.000	0.394	0.272	0.032	0.024	0.030	0.130	0.004	0.003	0.004
	5	0.043	0.032	0.308	0.398	1.000	0.394	0.272	0.012	0.009	0.084	0.161	0.002	0.001	0.014
	6+	0.584	0.437	0.421	0.398	0.067	0.027	0.022	0.013	0.009	0.009	0.271	0.003	0.003	0.002
	Total	13.561	8.664	21.056	1.592	2.634	0.052	0.043	0.585	0.395	0.906	0.120	0.070	0.048	0.109
	(3+)	2.129	1.595	2.573	1.592		0.172	0.119	0.252	0.189	0.369	0.131	0.033	0.025	0.049

Table 11. Estimated harvest of Lake Erie yellow perch for 1996. The exploitation rate is derived from optimal yield policy, and the stock size estimate are from CAGEAN and averaged age 2 estimates. Stock size and catch in numbers are in millions of fish. Catch in weight is in millions of kilograms.

		Stock Size (numbers)			Exploitation Rate				Catch (millions of fish)			Mean Wt. in Harvest	Catch (millions of kg) - RAH		
	Age	Mean	Min.	Max.	F(opt)	s(age)	(F)	(u)	Mean	Min.	Max.	(kg)	Mean	Min.	Max.
Unit 1															
	2	9.083	6.754	11.412	0.000	0.652	0.257	0.188	1.710	1.272	2.149	0.102	0.175	0.130	0.220
	3	4.662	4.297	5.027	0.423	1.000	0.394	0.272	1.267	1.168	1.366	0.126	0.160	0.147	0.172
	4	2.672	2.463	2.880	0.423	1.000	0.394	0.272	0.726	0.669	0.783	0.151	0.109	0.101	0.118
	5	0.646	0.596	0.697	0.423	1.000	0.394	0.272	0.176	0.162	0.189	0.173	0.030	0.028	0.033
	6+	0.859	0.792	0.926	0.423	0.644	0.254	0.186	0.160	0.147	0.172	0.244	0.039	0.036	0.042
	Total	17.922	14.902	20.943	1.692	4.296	0.243	0.200	4.039	3.419	4.660	0.111	0.513	0.442	0.585
	(3+)	8.839	8.148	9.530	1.692		0.387	0.263	2.329	2.147	2.511	0.145	0.339	0.312	0.365
Unit 2															
	2	13.363	7.503	19.223	0.000	0.422	0.166	0.127	1.697	0.953	2.441	0.115	0.196	0.110	0.282
	3	5.209	4.578	5.840	0.515	1.000	0.394	0.272	1.416	1.245	1.587	0.132	0.187	0.165	0.210
	4	4.938	4.340	5.535	0.515	1.000	0.394	0.272	1.342	1.180	1.505	0.154	0.206	0.181	0.231
	5	0.999	0.878	1.119	0.515	1.000	0.394	0.272	0.271	0.239	0.304	0.206	0.056	0.049	0.063
	6+	1.864	1.639	2.090	0.515	0.197	0.077	0.062	0.115	0.101	0.129	0.302	0.035	0.030	0.039
	Total	26.372	18.938	33.807	2.060	4.243	0.319	0.263	4.841	3.716	5.966	0.128	0.680	0.535	0.824
	(3+)	13.010	11.435	14.584	2.060		0.426	0.284	3.144	2.764	3.525	0.154	0.484	0.425	0.543
Unit 3															
	2	4.911	0.000	9.898	0.000	0.161	0.063	0.051	0.249	0.000	0.502	0.116	0.029	0.000	0.058
	3	1.033	0.877	1.189	0.482	1.000	0.394	0.272	0.281	0.238	0.323	0.135	0.038	0.032	0.044
	4	3.248	2.757	3.739	0.482	1.000	0.394	0.272	0.883	0.749	1.016	0.195	0.172	0.146	0.198
	5	0.211	0.179	0.242	0.482	1.000	0.394	0.272	0.057	0.049	0.066	0.236	0.014	0.011	0.016
	6+	0.675	0.573	0.777	0.482	0.254	0.100	0.079	0.053	0.045	0.061	0.281	0.015	0.013	0.017
	Total	10.078	4.309	15.847	1.928	4.770	0.302	0.249	1.523	1.081	1.968	0.161	0.267	0.202	0.333
	(3+)	5.167	4.386	5.948	1.928		0.447	0.292	1.274	1.081	1.467	0.187	0.239	0.202	0.275
Unit 4															
	2	0.902	0.000	1.874	0.000	0.091	0.036	0.029	0.026	0.000	0.054	0.111	0.003	0.000	0.006
	3	1.384	1.037	1.732	0.398	0.475	0.187	0.142	0.196	0.147	0.245	0.120	0.024	0.018	0.029
	4	0.118	0.088	0.148	0.398	1.000	0.394	0.272	0.032	0.024	0.040	0.130	0.004	0.003	0.005
	5	0.043	0.032	0.054	0.398	1.000	0.394	0.272	0.012	0.009	0.015	0.161	0.002	0.001	0.002
	6+	0.584	0.437	0.731	0.398	0.067	0.027	0.022	0.013	0.009	0.016	0.271	0.003	0.003	0.004
	Total	3.031	1.524	4.538	1.592	2.722	0.175	0.144	0.279	0.189	0.370	0.120	0.036	0.025	0.047
	(3+)	2.129	1.595	2.664	1.592		0.320	0.221	0.252	0.189	0.316	0.131	0.033	0.025	0.041

Table 12. Lake Erie yellow perch harvest estimates for 1996. All estimates are based on unadjusted CAGEAN outputs and F(opt) fishing strategy. Traditional method estimates 1994 year class in 1996 with regressions of CAGEAN age 2 estimates against YOY and yearling indices. Averaged method predicts 1994 year class in 1996 by averaging CAGEAN age 2 estimates from 1993 to 1995.

Yield (tonnes)

Age 2+ Estimated RAH - Traditional

	Mean	Min.	Max.
Unit 1	1.225	1.110	1.340
Unit 2	1.222	1.089	1.354
Unit 3	0.327	0.282	0.372
Unit 4	0.070	0.048	0.109
Total	**2.843**	**2.529**	**3.175**

Age 2+ Estimated RAH - Averaged

	Mean	Min.	Max.
Unit 1	0.513	0.442	0.585
Unit 2	0.680	0.535	0.824
Unit 3	0.267	0.202	0.333
Unit 4	0.036	0.025	0.047
Total	**1.497**	**1.205**	**1.789**

Age 3+ Estimated RAH

	Mean	Min.	Max.
Unit 1	0.339	0.312	0.365
Unit 2	0.484	0.425	0.543
Unit 3	0.239	0.202	0.275
Unit 4	0.033	0.025	0.041
Total	**1.094**	**0.965**	**1.224**

Yield (million pounds)

Age 2+ Estimated RAH - Traditional

	Mean	Min.	Max.
Unit 1	2.701	2.447	2.954
Unit 2	2.694	2.402	2.985
Unit 3	0.721	0.622	0.820
Unit 4	0.154	0.105	0.240
Total	**6.269**	**5.575**	**7.000**

Age 2+ Estimated RAH - Averaged

	Mean	Min.	Max.
Unit 1	1.132	0.975	1.289
Unit 2	1.499	1.181	1.818
Unit 3	0.590	0.446	0.734
Unit 4	0.079	0.054	0.104
Total	**3.300**	**2.657**	**3.946**

Age 3+ Estimated RAH

	Mean	Min.	Max.
Unit 1	0.747	0.688	0.805
Unit 2	1.067	0.938	1.197
Unit 3	0.526	0.446	0.605
Unit 4	0.073	0.054	0.091
Total	**2.413**	**2.127**	**2.698**

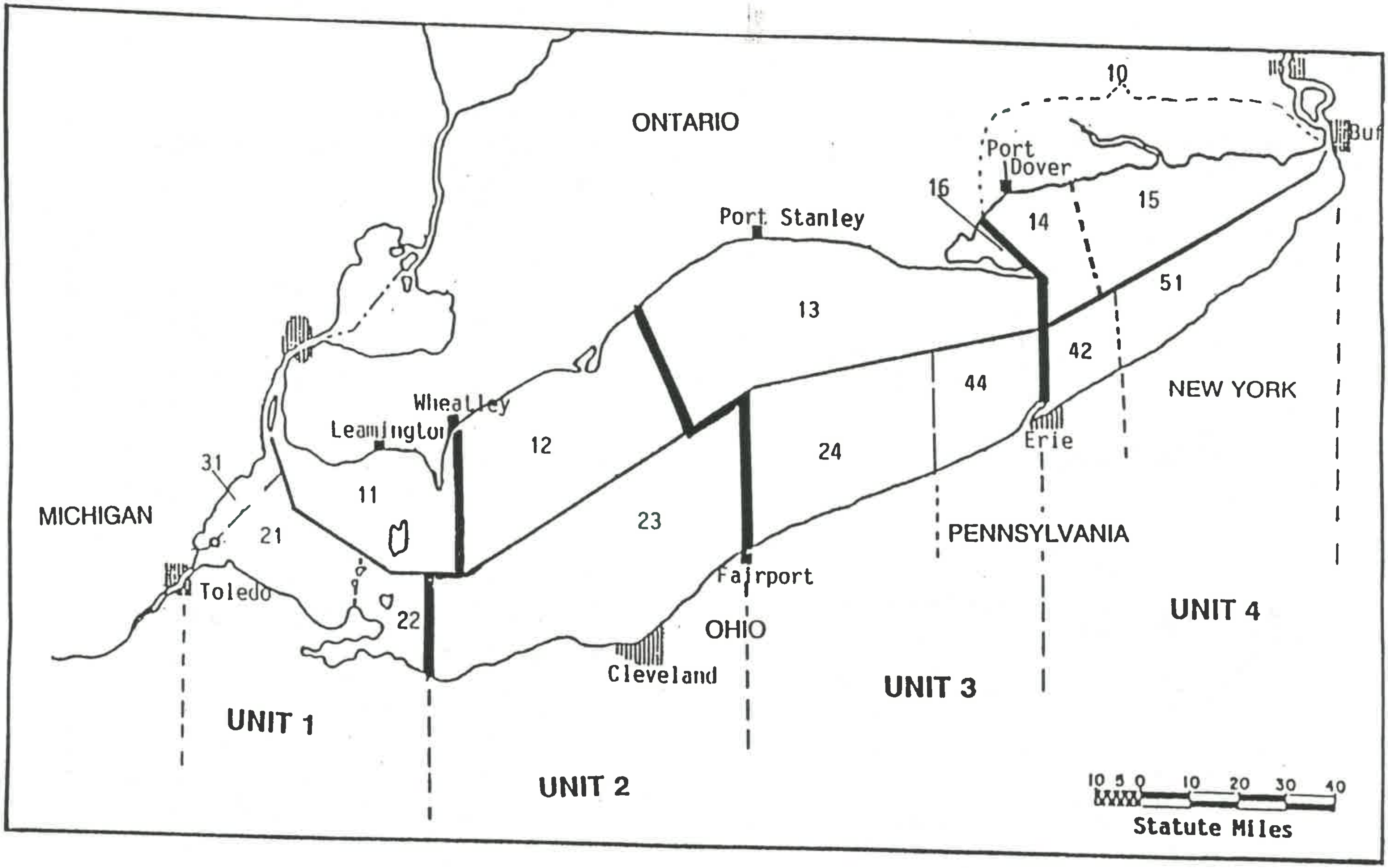

Figure 1. Lake Erie Management Units defined and used by the Yellow Perch Task Group.

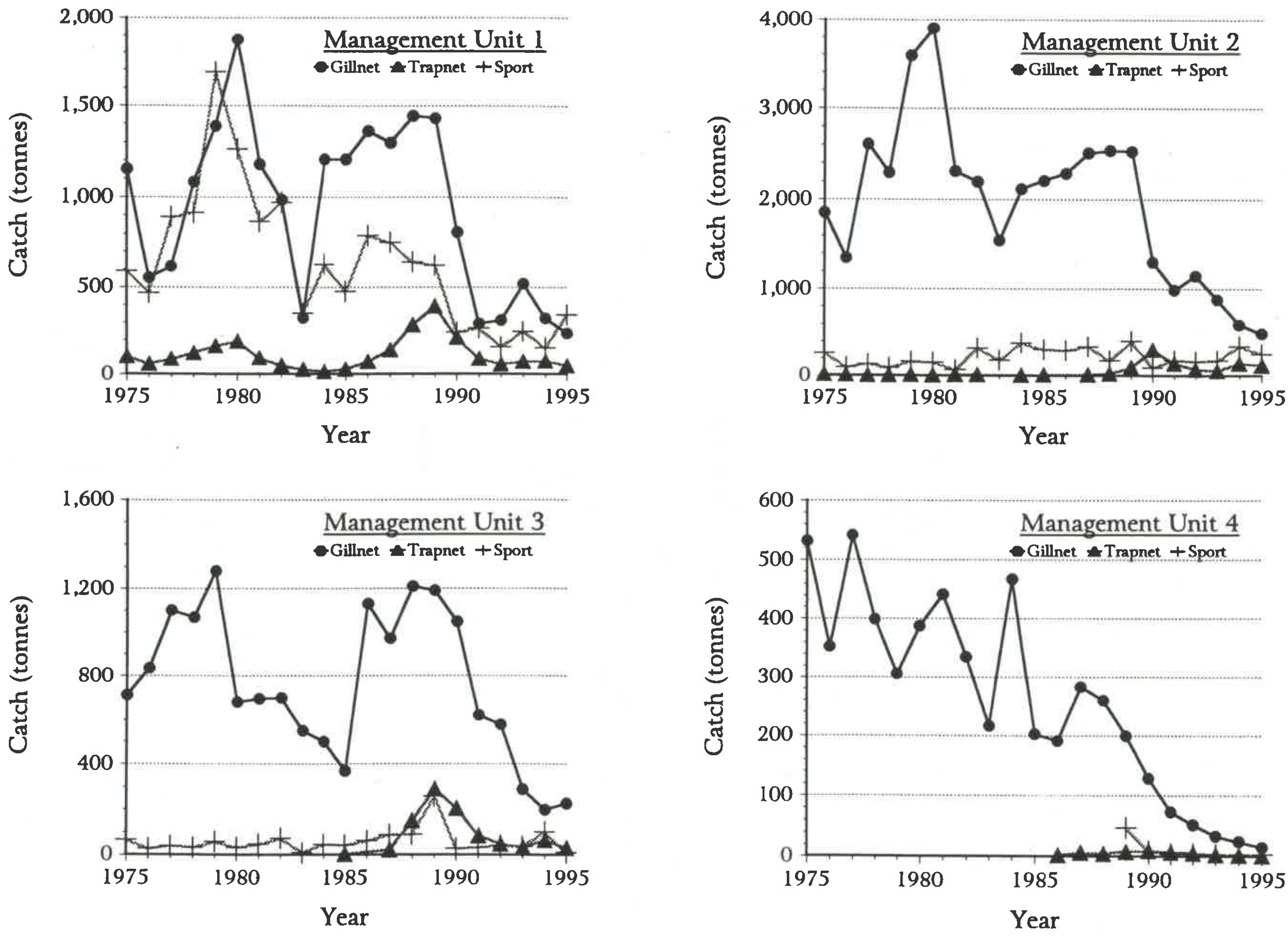

Figure 2. Lake Erie yellow perch harvest by management unit and gear type.

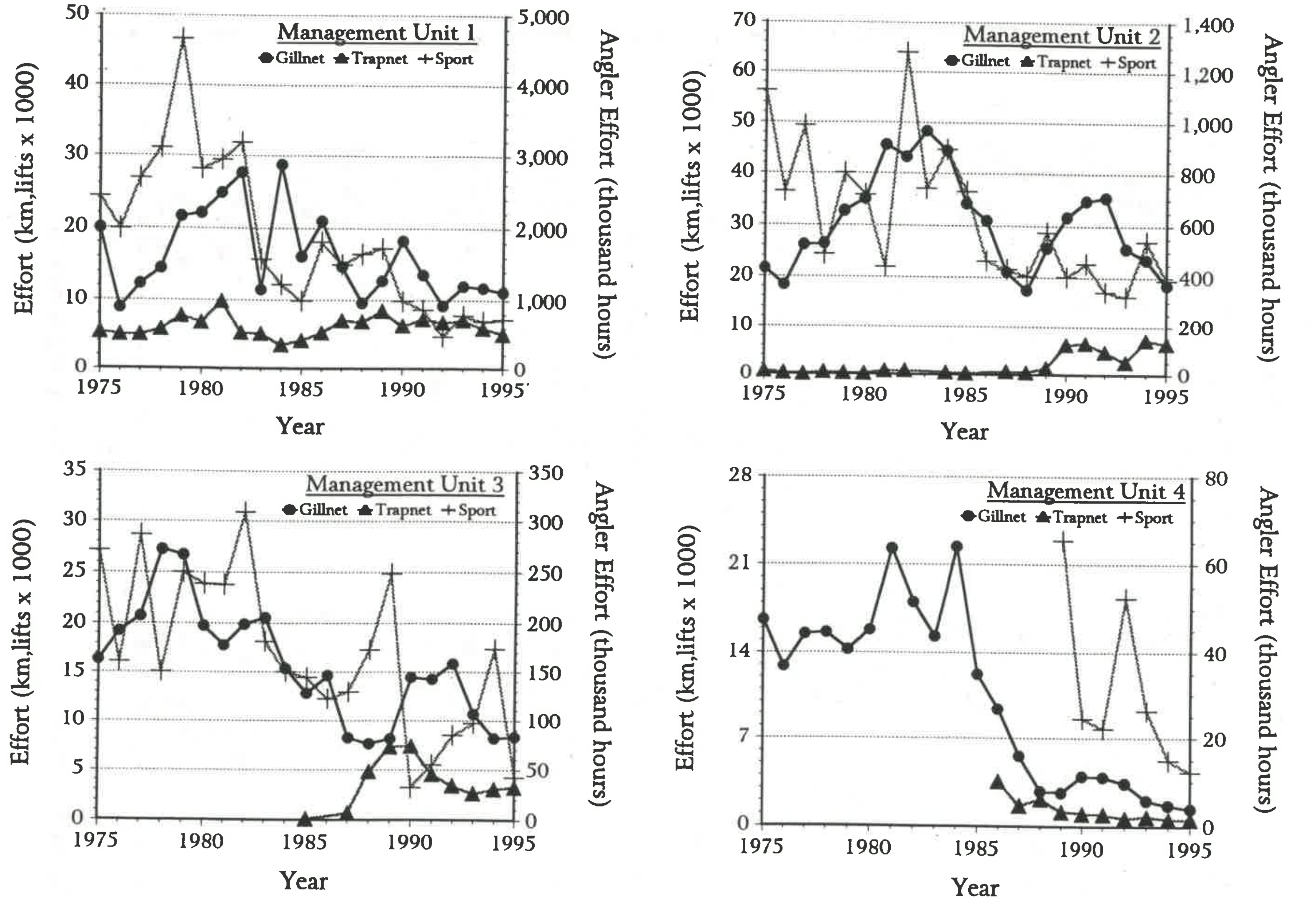

Figure 3. Lake Erie yellow perch effort by management unit and gear type.

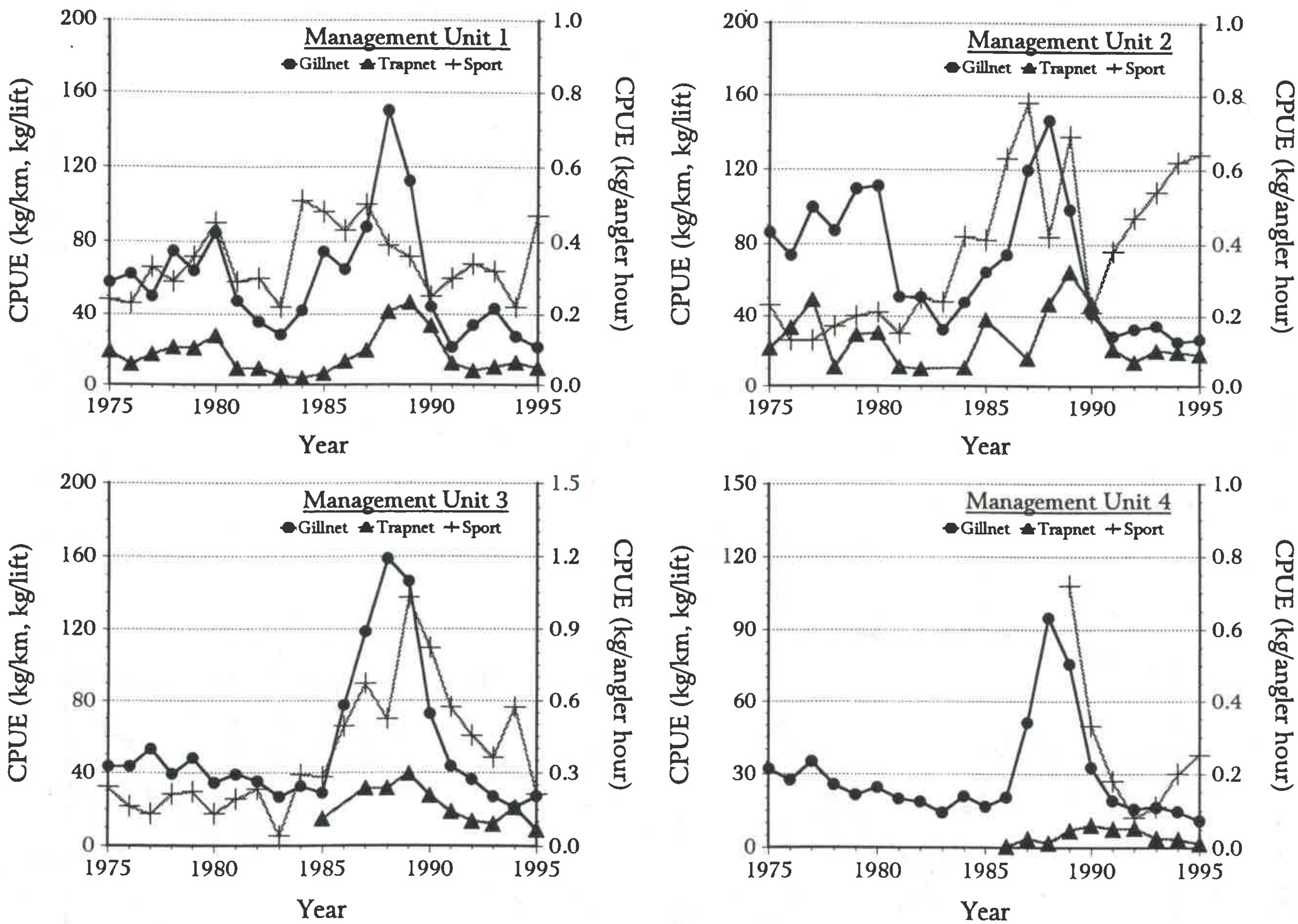

Figure 4. Lake Erie yellow perch catch per unit effort by management unit and gear type.

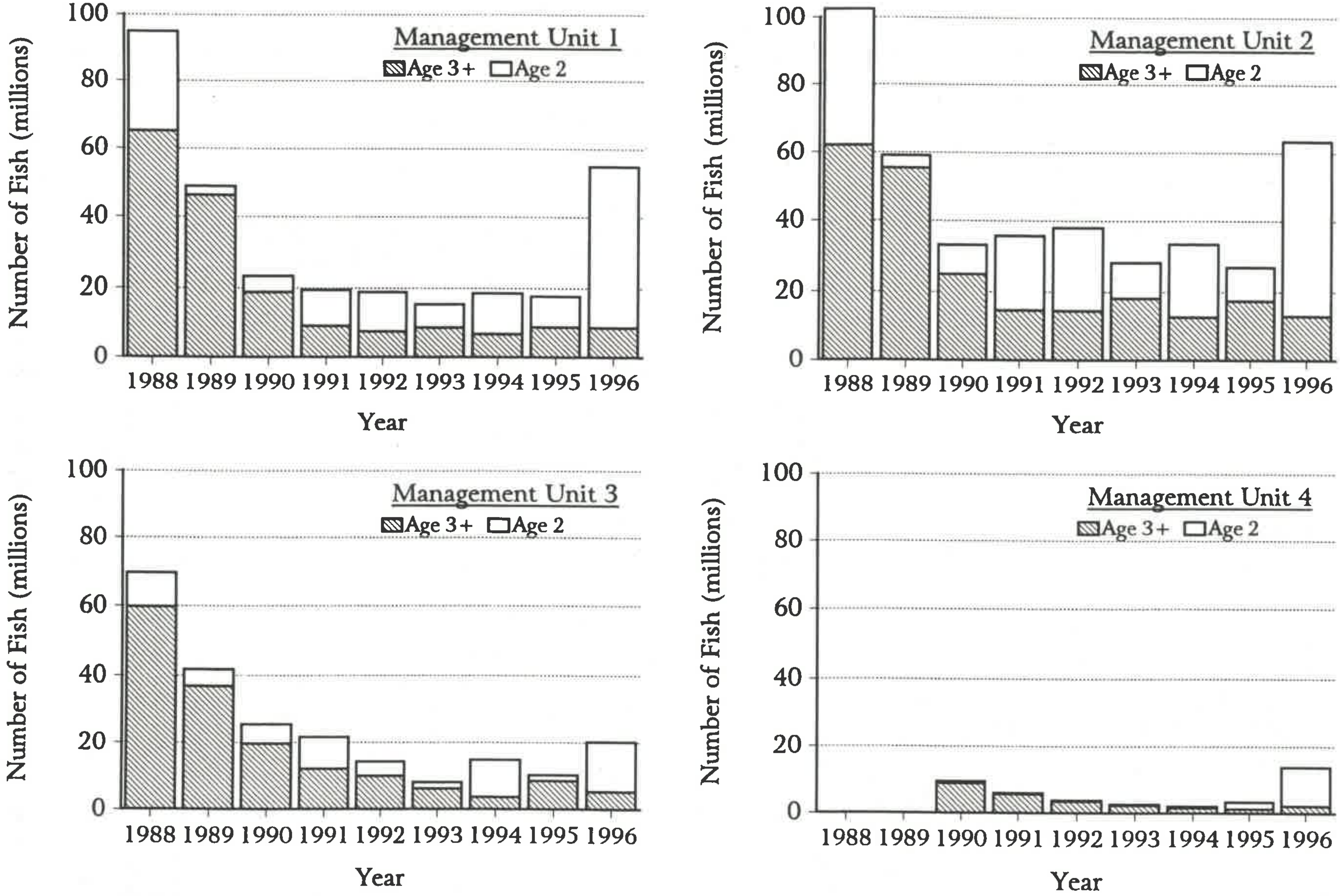

Figure 5. Lake Erie yellow perch population estimates by management unit. 1996 age 2 estimates are from regressions of CAGEAN estimates against YOY and yearling trawl indices.

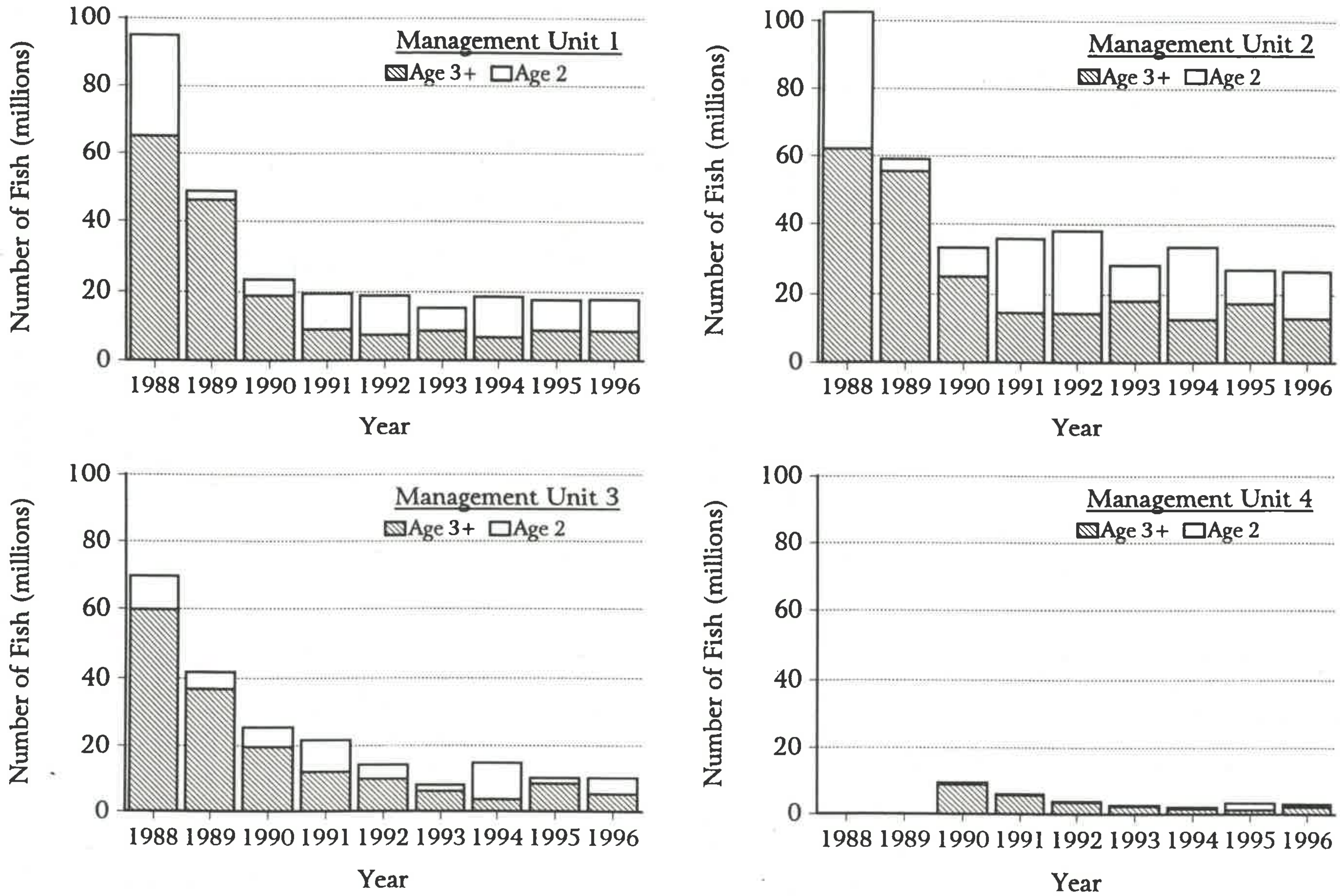

Figure 6. Lake Erie yellow perch population estimates by management unit. 1995 age 2 estimates are the average of CAGEAN age 2 estimates 1993-95.

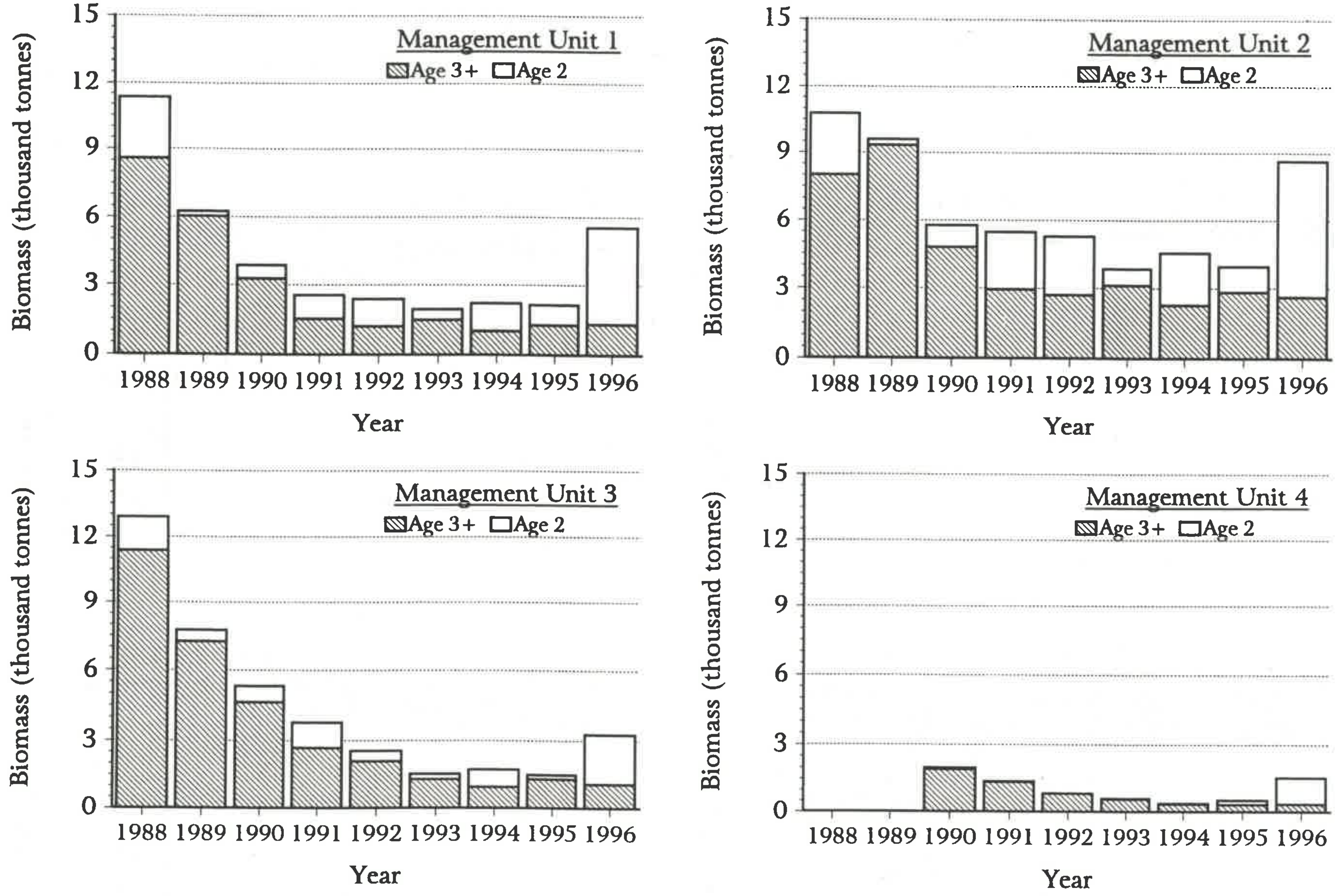

Figure 7. Lake Erie yellow perch biomass estimates by management unit. 1995 age 2 estimates are from regressions of CAGEAN estimates against YOY and yearling trawl indices.

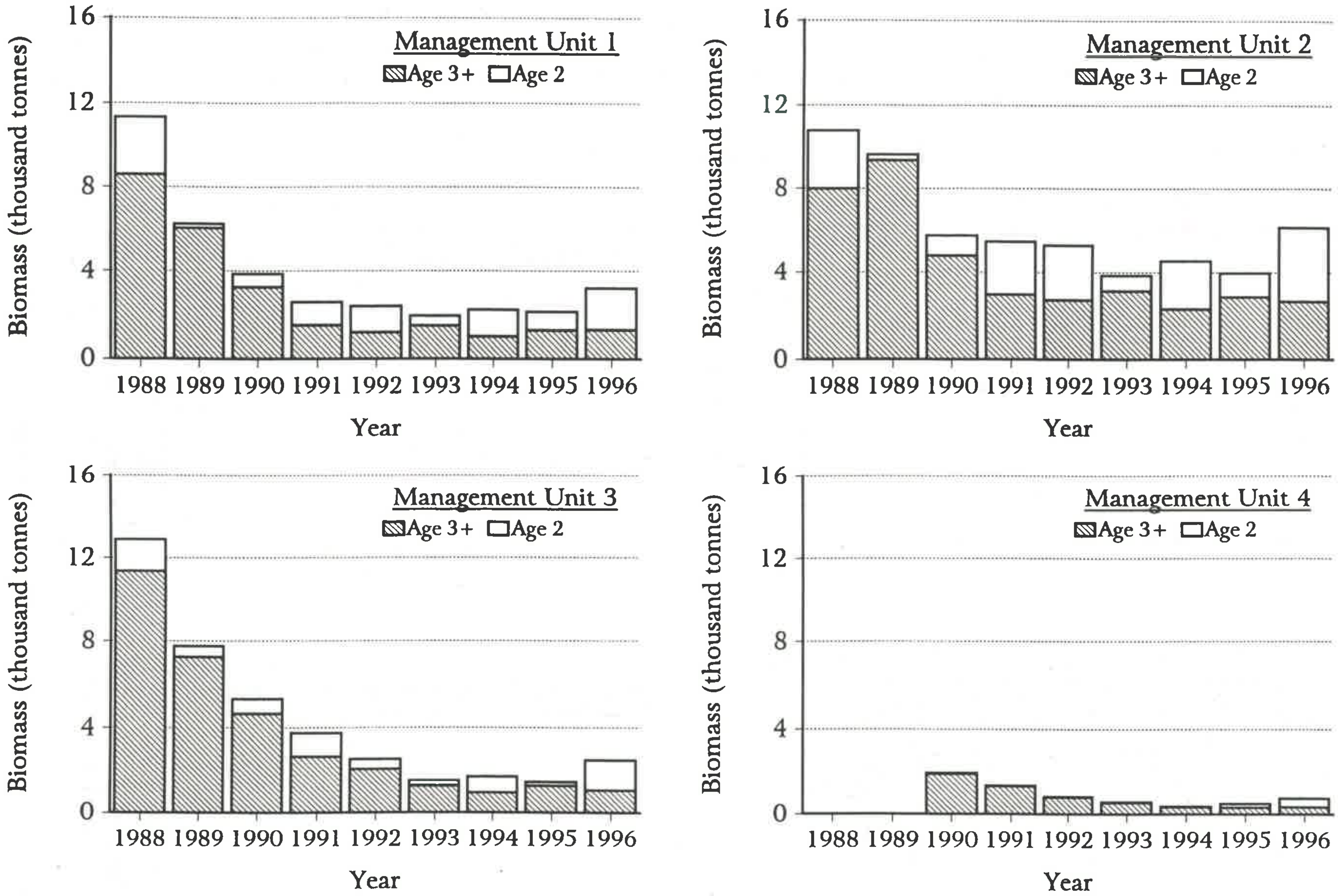

Figure 8. Lake Erie yellow perch biomass estimates by management unit. 1995 age 2 estimates are the average of CAGEAN age 2 estimates 1993-95.

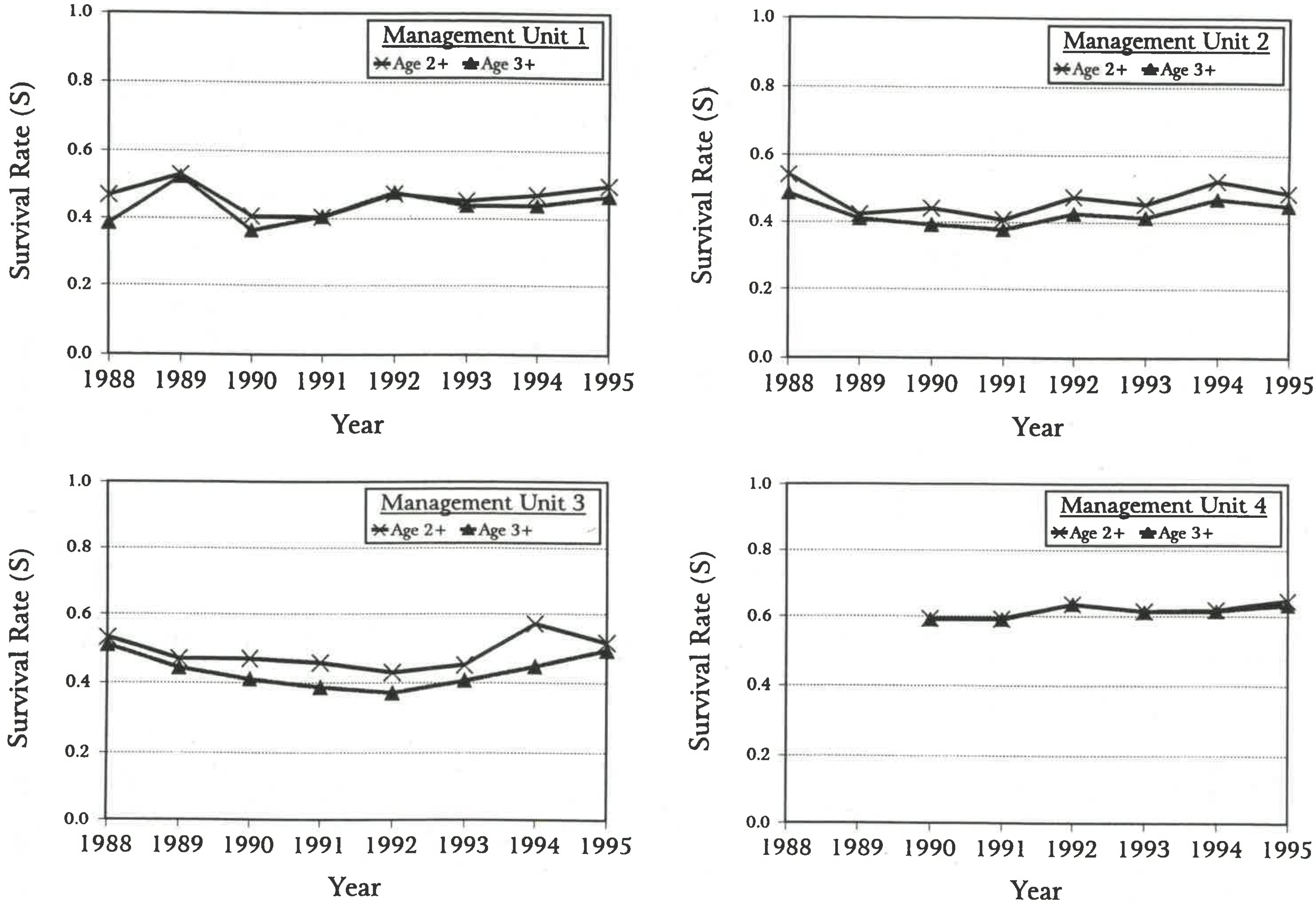

Figure 9. Survival rates of age 2 and older and age 3 and older yellow perch, Lake Erie, 1988 - 1995. Estimates are derived from CAGEAN.

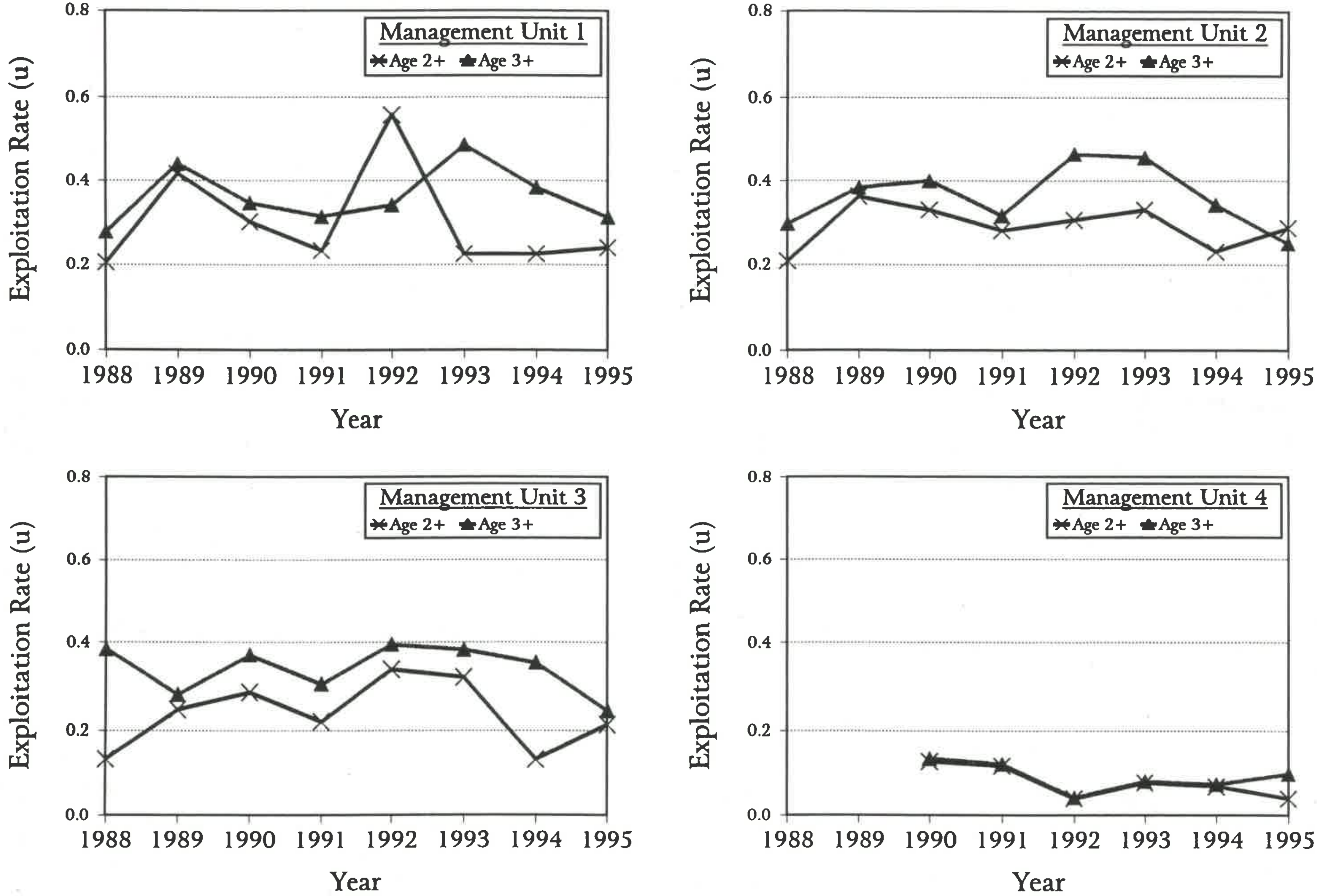

Figure 10. Exploitation rates of age 2 and older and age 3 and older yellow perch, Lake Erie, 1988 - 1995. Estimates are derived from catch data and CAGEAN estimates

Appendix A. Updating yellow perch yield per recruit and optimal fishing mortality, F_{opt}.

A Beverton-Holt yield model has been used by the YPTG since 1985 to target a recommended or managed annual harvest for the Lake Erie perch fisheries. The strategy has been to optimize the return in weight per recruit by allowing a conservative fishing mortality, F, which is less than that associated with the dome (or maximum) of a yield per recruit-fishing mortality curve. The conservative F value is actually $F_{0.1}$ [1] as described by Hilborn and Walters (1992), Gulland (1993) and Gulland and Boerema (1972). F_{opt} is an age-specific fishing mortality, derived from scaling $F_{0.1}$ by the selectivity of the fishing gear at that age.

In addition to fishing and natural mortality, the yield per recruit function requires estimates of von Bertalanffy growth coefficients. Changes in Lake Erie perch growth have been documented (YPTG 1995 Report). Changes in growth are suspected to be related to density-dependent dynamics in the community of benthic organisms, including colonization by Dreissenid mussels as well as successional, interbasin trophic changes. Yield per recruit and $F_{0.1}$ evaluations are sensitive to changes in growth. Recent changes in the Lake Erie ecosystem and biota were examined with this in mind and updates of perch growth parameters deemed a prudent exercise.

Von Bertalanffy growth parameters that were used since 1992 and updated values are listed in Table A-1. F_{opt} values similarly revised are presented in Table A-2. These values were estimated by the program "FOPTMAXX" (R. Lorantas, Pa. Fish and Boat Commission, personal communication). Updated Y/R estimates are calculated with the F_{opt} value as first derivative of the Y/R function with respect to F. Input to FOPTMAXX included von Bertalanffy growth coefficients, as well as age at entry and age at recruitment to the fisheries and the estimate of perch natural mortality. Natural mortality (M) is 0.40, while 3.0 years was used as age at entry and age at recruitment for both periods, 1992 and 1996. Details of the computation formulations used here can be found in Henderson et al. (1990).

F_{opt} values are initially considered to act equally across all age groups considered

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[1]The "$F_{0.1}$" strategy is a constant exploitation rate induced policy where F is set where the slope of the yield per recruit is one-tenth the initial slope.

vulnerable to the fisheries. The actual performance of fishing gear in the fisheries tells us this is not true. In fact, the selectivity of the various fishing gear applies fishing mortality differentially across vulnerable age groups. A modification of F_{opt} was devised to allow for different fishing mortalities across age groups, relative to the age group(s) that receive full force from the gear. The latter are scaled at 1.0 with the remaining age group F values represented by some fraction of full selectivity. Individual age group selectivity values, s(age), were computed as the ratio of age group fishing force, F_i, to the maximum fishing force of all age groups, F_{max}. These values were then used to scale F_{opt} across age groups by multiplying s(age) times the ratio of the cumulative F_{opt}; *i.e.* the sum of F_{opt} across all age groups, to the cumulative s(age), the sum of s(age) across all age groups. These products represent scaled F_{opt}, or in the Estimated Harvest portion of this report's spreadsheets, F at age. These in turn are used to produce age specific exploitation rates of the projected, exploitable perch stock. This explanation of factors that calculate F_{opt} is graphically represented in Figure A-1.

Table A-1. Yellow Perch von Bertalanffy parameter estimates for Lake Erie yellow perch management units. 1992 - 95, 1996.

1992-95				
	MU-1	MU-2	MU-3	MU-4
W inf	667.3	852.2	548.6	1353.1
K	.191	.214	.292	.126
t(0)	-.814	-.816	-.440	-1.272

1996				
	MU-1	MU-2	MU-3	MU-4
W inf	908	712	794	1353
K	.17	.26	.20	.12
t(0)	-.79	-.67	-1.08	-1.27

Figure A-1. Inputs and sequence of yellow perch F(opt) derivations by management unit.

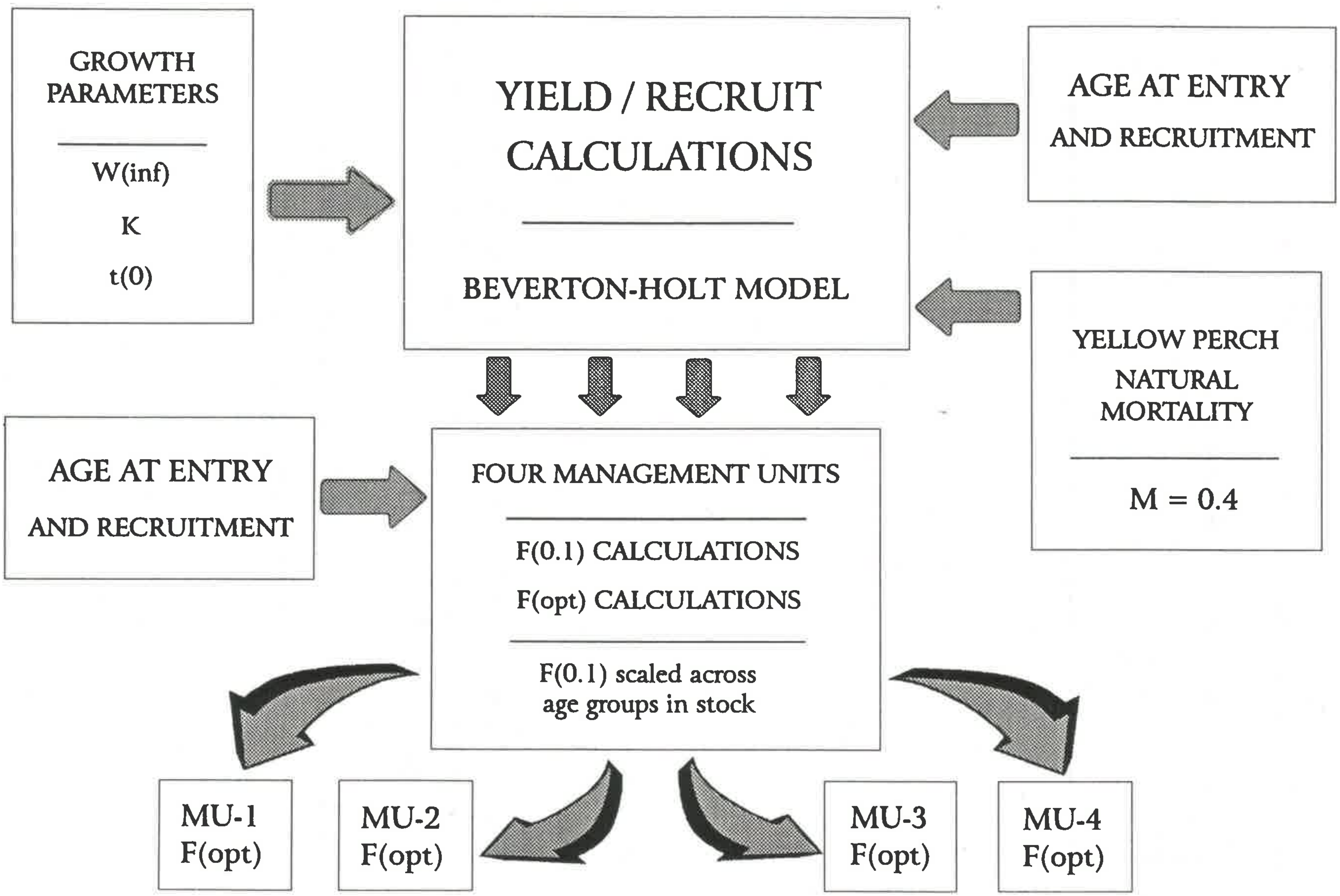

Table A-2. F_{opt} values for Lake Erie yellow perch, 1992-95 and 1996.

	MU-1	MU-2	MU-3	MU-4
1992-95	.453	.434	.523	.398
1996	.423	.515	.482	.398

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Henderson, B. A., R. Haas, R. Knight, R. Lorantas and M. Rawson. 1990. Quota estimation for Lake Erie walleye: model and results. Statistics and Modelling Task Group Report; Lake Erie Committee, Great Lakes Fishery Commission.

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Appendix B. Summary table of factors affecting yellow perch recruitment.

Parental Stock	*Egg*	*Sac Fry*	*Larvae*	*Juvenile/Young of Year*	*Overwinter/ Yearlings*
- spawning stock size ?, GOOD	- temperature: rate of warming, reversals STRONG, GOOD	- temperature: growth rate, mortality STRONG, POOR	- temperature,growth; climatic events STRONG,GOOD	- temperature, optimal growth; too high or low STRONG, GOOD	- climatic factors ice storms ?, GOOD
- fecundity - egg size - energy content of the egg ?, POOR	- storm events; - water quality, wave action, wind direction, sedimentation WEAK, GOOD	- water quality, turbidity WEAK, POOR	- productivity, food supply; quantity, type of food STRONG, GOOD	- productivity, food supply; quantity, type of food STRONG, GOOD	- productivity, food supply; quantity, type of food, esp. in early spring ?, GOOD
- size of mature female ?, GOOD	- physical habitat available WEAK, POOR	- current transport and drift ?, POOR	- current, water masses; transport and drift STRONG, POOR	- nearshore habitat ?, POOR	- competition WEAK, GOOD
- fall condition of females ?, GOOD	- water level fluctuation WEAK, POOR	- habitat, aquatic vegetation WEAK,POOR	- entrainment losses STRONG,GOOD	- size at end of growing season, fall condition STRONG, GOOD	- incidental fishing mortality WEAK, GOOD
- interference during spawning, distribution of eggs ?, POOR	- predation: abundance predators, abundance of alternative prey items, tempo-spatial overlap VARIABLE to STRONG, POOR	- predation: abundance predators, abundance of alternative prey items, tempo-spatial overlap VARIABLE to STRONG, GOOD	- predation: abundance predators, abundance of alternative prey items, tempo-spatial overlap VARIABLE to STRONG, GOOD	- predation: abundance predators, abundance of alternative prey items, tempo-spatial overlap VARIABLE to STRONG, GOOD	- predation: abundance predators, abundance of alternative prey items, tempo-spatial overlap VARIABLE to STRONG, GOOD
- temperature impacts on gonad development ?, POOR		- developmental size STRONG, POOR	- competition: (survival), zebra mussels, BC, fish ?, POOR	- competition: (growth) white perch, yellow perch STRONG, GOOD	

Status of two variables are given; the first one is whether the YPTG believed a variable to be strong, weak, or variable and the potential amount of data, good or poor. Note: data and information are distinguished herein. Data implies that data could be analyzed or information is available. Information refers to conclusions. We may not have good information; hence, conclusions about a particular topic.