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

The Yellow Perch Task Group (YPTG) was charged with describing yellow perch stock status, producing population size estimates and recommending allowable harvest for 1991 in each of four management units (Figure 1). For 1991, the task group was charged with the review of methodologies including exploitation policies. This report summarizes yellow perch status, population size and recommended allowable harvests (RAH) for 1991. A joint report with the Statistics and Modeling Task Group is planned for release later this year that details the methodology review.

Fisheries Review

The reported harvest of yellow perch from lake Erie in 1990 totaled 4,367 t (Table 1), which was 41% less that the 1989 harvest. All agencies reported declines in perch catches in 1990. The largest reductions were in New York (-69%) and Ohio (-49%) waters, which were followed by Ontario (-39%), Michigan (-30%) and Pennsylvania (-12%). Ontario harvested 73% of the lakewide reported catch, while Ohio accounted for 22%, and Michigan, Pennsylvania and New York caught the remaining 5%.

The reported harvest did not exceed the RAH in 1990 for Units 1 and 4. However, the RAH was exceeded in Unit 2 by 6% and in Unit 3 by 26% (Table 2). RAHs are meant to be achieved on a Unit basis (i.e. the harvest of all agencies combined for a Unit should not exceed the RAH for that Unit). Individual agency RAHs are calculated using a surface are sharing formula. However, Ontario determines internal quotas based on the task group recommendations and historical harvest levels. The Ontario commercial fishery adheres to internal quotas set by the agency. In 1990, the fishery harvested

only 60% of the Ontario internal quota in both Units 1 and 2, and reached its quota in Units 3 and 4.

Catch, fishing effort, and catch rate are summarized by Unit,year, agency, and gear type in Tables 3a-d. Commercial gillnet effort increased in all Units. Increases in effort were 44%, 23%, 78% and 49% respectively for Units 1 to 4. Total trapnet effort increased by 16%, with most of the increase in Unit 2 as a result of re-direction of effort from Units 1 and 3. Dramatic declines in 1990 yellow perch sport fishing effort in all Units were attributed to seasonally prolonged foul weather, which in part accounted for the significant reductions in perch sport catches. The reduction in sport harvest can also be attributed to declines in yellow perch stock abundance. Commercial and sport catch rates declined in all Units. 1990 catch rates have returned to levels comparable to those found prior to the recruitment of the 1984 year class to the fisheries.

The 1986 year class of yellow perch contributed strongly to the harvest in all Units (32% to 52% of the harvest) (Table 4). The 1984 year class was well represented in the catches in all Units (12% to 36% of the harvest). No previous year class has had such a significant contribution to the harvest as age-6 fish. Recruitment of the 1987 and 1988 year classes (age-2 and 3 fish) was relatively weak and will not support harvest levels observed in the late 1980s.

Stock Assessment

Catch-at-Age-Analysis (CAGEAN) - To estimate 1990 population size, a three gear version of the CAGEAN model was used. In the past, a one gear model was

used and all harvest and effort reported using a standardized effort. The three gear model allows inputs into the model such as catchabilities and selectivities to be entered as gear specific values.

CAGEAN estimates (based upon M=.2) of yellow perch stocks differed from the 1990 stock size projections presented in last year's report (Table 5). There are two sources of error accounting for these differences. First, trawl indices of recruitment apparently overestimated the strength of the 1988 year class. Second, catch rates in the fisheries in 1990 impact the trend of age-specific catch per unit effort for previously recruited year classes and therefore the estimated abundance. CAGEAN estimates revealed the 1990 stock size was lower in Unit 1 and higher in Unit 3 and Unit 4.

Traditionally, a value of 0.2 was used as a natural mortality (M) rate when estimating population size. Based on our review, a value of 0.4 appears to be more reasonable for yellow perch in Lake Erie. Trends in stock size were similar for both values on M. Stock size estimates were higher at M=0.4 but less than the proportional change from M=0.2 to M=0.4 (i.e. a doubling of M did not produce a doubling of stock size). Only results from M=0.4 will be presented in this report.

Stock size estimates are approaching historical low levels (Table 6 Fig. 2). Age composition of the stock size estimates for 1982-1991 are summarized in Table 7. Stock size estimates were totaled for age-2 and older, and age-3 and older fish. Although age-3 and older stock size represents the fully

vulnerable population, age-2 is included because it represents a portion of the stock that is exploited by the fisheries. Age-2 exploitation is determined by gear selectivity and the relative size of the year class.

Population parameters such as survival rate and exploitation rate are more conservative if age-2 fish are included in the population description. Survival and exploitation rates are presented for age-2 and older fish (Table 6 and Figure 3). Yellow perch survival rates are less than 50% in all Units and in general show a decline from the mid-1980s. Rates are approaching 40% in Units 1, 2 and 4, and approaching 20% in Unit 3. The corollary is that exploitation rates have been increasing in all Units (Table 6 and Figure 4). Exploitation values from each Unit are 30%, 45%, 59% and 26% respectively.

Recruitment - A strategy similar to previous years was used for estimating age-2 population size from index trawling values. Updates to the method included: an expanded data series (more years and more trawling projects), the use of geometric mean index values (number per trawl-hour), regressing CAGEAN age-2 population size estimates of age-2 abundance (Table 8).

There has been poor to fair recruitment of yellow perch in all Units subsequent to the 1986 year class (Figure 5). The 1987 and 1988 year classes were poor. Based on recruitment regressions, it appears that the 1989 and 1990 year classes are fair (Table 9).

Population Size Projection - Stock size estimates for 1991 (age-3 and older) were projected by simulating the effect of fishing and natural mortality on

the CAGEAN estimates of stock size for 1990. Recruitment of the 1989 year class in 1991 (age-2 fish) was estimated from various agency trawling indices of age-0 and age-1 yellow perch.

Projections of stock size for 1991 indicate significant decline in the stock size of age-2 and older fish in all units (Table 10). The declines in stock size were due to high mortality rates and low estimates of recruitment for the 1989 year class. Projections of age-3 and older stock size decreased from 1990 levels in all units except Unit 4. These declines ranged from 40% - 77% in Units 1 - 3 and increased by 57% in Unit 4.

The large perch stock size that supported relatively robust catches in Units 1, 2 and 3 from 1986 through 1989 were composed primarily of the 1982, 1984 and 1986 year classes. Only remnants of these year classes will be available in 1991. The 1991 population size estimates in all Units are largely comprised of age-2 fish.

Recommended Allowable Harvest

Recommended allowable harvests were calculated from the 1991 stock size for three exploitation policies; optimal yield, 1990 rate of fishing, and target effort rate of fishing. The optimal yield exploitation model balances natural mortality and growth rates to calculate the fishing mortality level (F_{opt}) necessary to achieve the "best" use of each year class (See Appendix). It assumes there is no spawner-recruit relationship. A scaled F_{opt} was used to determine a RAH for each Unit. The second option explored was harvesting the 1991 population at the 1990 exploitation rate. The third policy reported, target effort, was fishing the 1991 population at exploitation rates equal to

an effort level 20% less than that observed in 1981. The exploitation policies were applied to the 1991 population size estimate in numbers to produce harvest in number-at-age. This was converted to harvest weight by using mean weight-at-age in the harvest averaged for years 1986-1990.

The 1991 recommended allowable harvests derived from exploitation at the various policies are summarized in Table 11. Also in Table 11 is a comparison of exploitation rates derived from the three policies. The task group is recommending adoption of optimal yield as an exploitation policy. The optimal yield exploitation rates are similar to recent levels.

A summary of 1991 recommended allowable harvests by agency was based on the relative percentage of water surface are within each Unit (Table 13).

Recommendations and Conclusion

We recommend that a natural mortality rate of M=0.4 be adopted as a more realistic value for Lake Erie yellow perch. All stock size predictions and exploitation values were based on this value.

An initial exploitation strategy was established in 1985 to attain a reduction in fishing mortality by 1990. This objective has been reached. More reasonable exploitation strategies associated with sustainable yields are recommended for implementation in 1991 because of declining perch stock sizes and projected high exploitation rates. The recommended allowable harvest was calculated based on an exploitation strategy, defined as an optimum sustainable yield, described by the appropriate fishing rate, F_{opt}. The use of the optimum yield exploitation strategy is recommended.

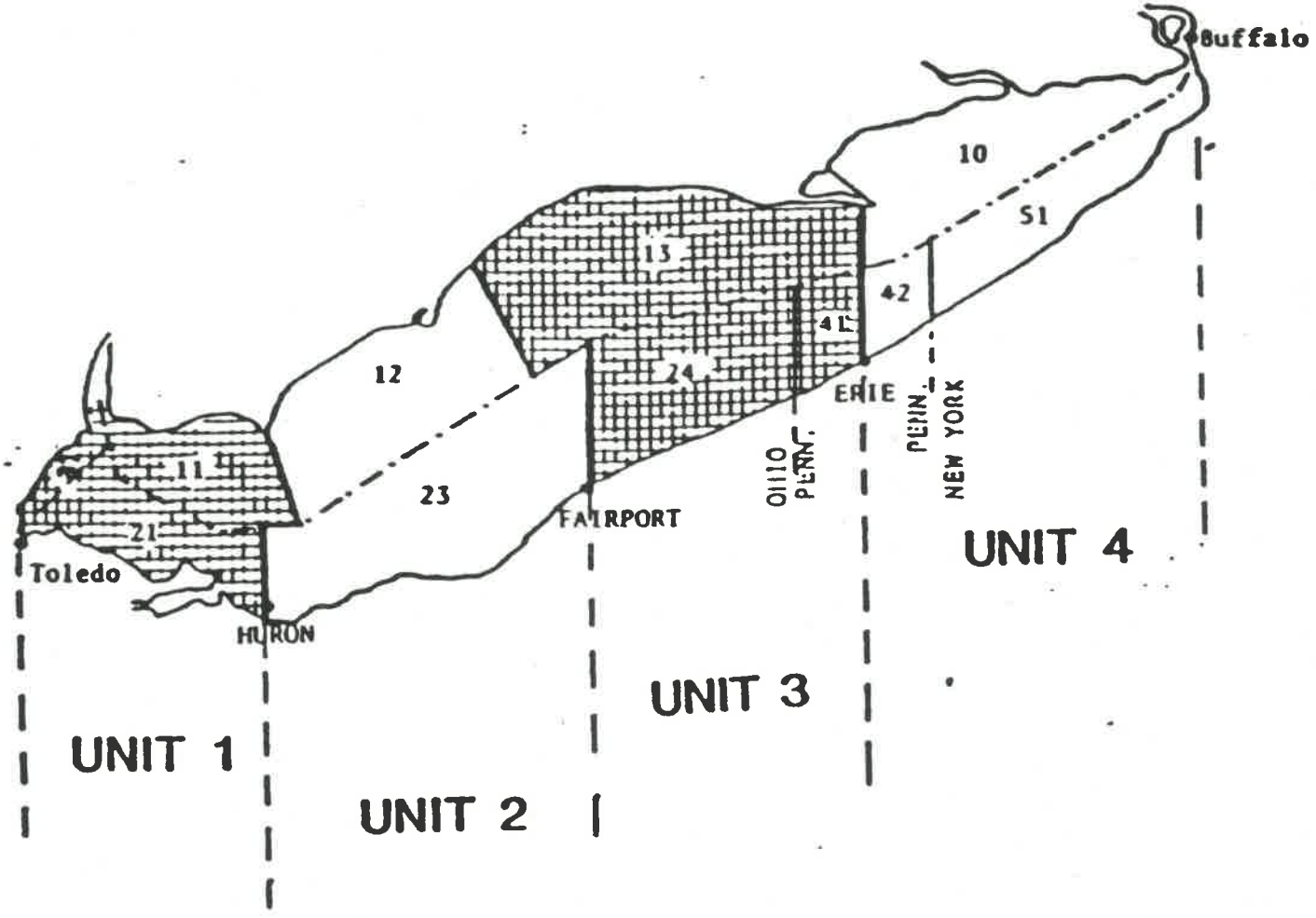


Figure 1. Geographical boundaries of mangement units for yellow perch task group.

Year classes entering the fishery since 1989 have not been impressive in size. The trend of declining perch stock sizes indicates that sustaining exploitation rate at levels as high as the ones observed in the past few years will likely foster further deterioration of yellow perch stocks and fisheries. The coincidental high abundance of white perch at a time of low yellow perch population levels is also a cause for concern when examining yellow perch status.

Finally, we continue to encourage agencies to adopt some form of standardized assessment practice for juvenile and adults to reduce the impact of variability which induces a background of higher risk management, especially when perch stocks exhibit historically low levels.

Table 1. Summary of total catch* of yellow perch by management unit and agency, Lake Erie 1980-90.

Unit	Year	Ontario Catch	(%)	Ohio Catch	(%)	Michigan Catch	(%)	Pennsylvania Catch	(%)	New York Catch	(%)	Total
1	1980	1,873	(56)	1,326	(41)	74	(02)	--	--	--	--	3,323
	1981	1,180	(55)	924	(43)	34	(02)	--	--	--	--	2,138
	1982	983	(49)	972	(49)	46	(02)	--	--	--	--	2,001
	1983	326	(47)	358	(51)	17	(02)	--	--	--	--	701
	1984	1,208	(65)	608	(33)	30	(02)	--	--	--	--	1,846
	1985	1,347	(73)	476	(26)	22	(01)	--	--	--	--	1,845
	1986	1,360	(61)	775	(35)	82	(04)	--	--	--	--	2,217
	1987	1,298	(59)	785	(36)	102	(05)	--	--	--	--	2,185
	1988	1,445	(61)	846	(36)	76	(03)	--	--	--	--	2,367
	1989	1,432	(59)	862	(35)	151	(06)	--	--	--	--	2,445
	1990	808	(67)	296	(24)	105	(09)	--	--	--	--	1,209
2	1980	2,877	(71)	1,175	(29)	--	--	--	--	--	--	4,052
	1981	1,603	(67)	784	(33)	--	--	--	--	--	--	2,387
	1982	2,162	(86)	356	(14)	--	--	--	--	--	--	2,518
	1983	1,466	(85)	258	(15)	--	--	--	--	--	--	1,724
	1984	2,117	(85)	378	(15)	--	--	--	--	--	--	2,495
	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	(07)	--	--	--	--	--	--	2,729
	1989	2,530	(84)	486	(16)	--	--	--	--	--	--	3,016
	1990	1,303	(75)	432	(25)	--	--	--	--	--	--	1,735
3	1980	478	(68)	144	(20)	--	--	86	(12)	--	--	708
	1981	505	(68)	131	(18)	--	--	103	(14)	--	--	739
	1982	615	(80)	89	(12)	--	--	64	(08)	--	--	768
	1983	519	(94)	21	(04)	--	--	15	(03)	--	--	555
	1984	466	(86)	44	(08)	--	--	32	(06)	--	--	542
	1985	370	(81)	43	(09)	--	--	43	(09)	--	--	456
	1986	1,101	(92)	60	(05)	--	--	30	(03)	--	--	1,191
	1987	908	(84)	108	(10)	--	--	64	(06)	--	--	1,080
	1988	1,128	(78)	239	(17)	--	--	81	(06)	--	--	1,448
	1989	1,095	(63)	544	(31)	--	--	96	(06)	--	--	1,735
	1990	965	(76)	229	(18)	--	--	84	(06)	--	--	1,278
4	1980	303	(78)	--	--	--	--	42	(11)	42	(11)	387
	1981	355	(80)	--	--	--	--	33	(07)	53	(12)	441
	1982	253	(76)	--	--	--	--	29	(09)	52	(16)	334
	1983	175	(81)	--	--	--	--	13	(06)	28	(13)	216
	1984	365	(78)	--	--	--	--	35	(07)	67	(14)	467
	1985	190	(75)	--	--	--	--	14	(05)	51	(20)	255
	1986	143	(88)	--	--	--	--	16	(11)	2	(01)	161
	1987	260	(90)	--	--	--	--	23	(08)	6	(02)	289
	1988	258	(98)	--	--	--	--	1	(<1)	4	(02)	263
	1989	199	(78)	--	--	--	--	0	(00)	55	(22)	254
	1990	128	(88)	--	--	--	--	0	(00)	17	(12)	145

*Catch is in tonnes.
Values in parentheses represent each agency's percentage of management unit catch.

Table 2. Lake Erie 1990 recommended allowable harvests (RAH) and measured harvest of yellow perch by Management Unit and Agency.

UNIT	AGENCY	RAH (t)	HARVEST (t)	DIFFERENCE (t)	DIFFERENCE (%)
1	Ontario	1,193	808	-385	-32.2
	Ohio	1,399	296	-1,103	-78.8
	Michigan	228	105	-123	-53.9
	TOTAL	2,820	1,209	-1,611	-57.1
2	Ontario	693	1,303	+610	+88.0
	Ohio	937	432	-505	-53.9
	TOTAL	1,630	1,735	+105	+6.4
3	Ontario	570	965	+395	+69.3
	Ohio	324	229	-95	-29.3
	Pennsylvania	121	84	-37	-30.6
	TOTAL	1,015	1,278	+263	+25.9
4	Ontario	96	128	+32	+33.3
	Pennsylvania	30	0	-30	-100.0
	New York	52	17	-35	-67.5
	TOTAL	178	145	-33	-18.5

Table 3a. Catch and effort summaries for Lake Erie yellow perch fisheries in Management Unit 1, 1981-90.

	Year	Ohio		Michigan	Ontario	
		Trap	Sport	Sport	Gill Net	Sport
CATCH (tonnes)	1981	93	831	34	1180	--[a]
	1982	54	922	46	983	--
	1983	26	330	17	327	--
	1984	14	594	30	1208	--
	1985	27	449	24	1206	--
	1986	73	704	82	1361	--
	1987	139	646	102	1298	--
	1988	284	562	76	1447	--
	1989	392	470	151	1432	--
	1990	210	86	105	808	--
EFFORT[b]	1981	9,830	2,676,326	271,000	24,908	--
	1982	5,272	3,036,979	151,900	27,627	--
	1983	5,086	1,302,203	74,914	11,456	--
	1984	3,451	1,159,599	57,980	28,746	--
	1985	4,141	935,645	46,782	16,139	--
	1986	5,279	1,404,286	469,368	20,909	--
	1987	7,078	1,046,115	452,460	14,730	--
	1988	6,900	1,153,182	494,158	9,616	--
	1989	8,418	1,028,551	696,937	12,716	--
	1990	6,299	400,676	634,255	18,305	--
CATCH RATE[c]	1981	9.46	0.31	0.13	47.37	--
	1982	10.24	0.30	0.30	35.58	--
	1983	5.11	0.25	0.23	28.54	--
	1984	4.06	0.51	0.51	42.02	--
	1985	6.52	0.48	0.51	74.73	--
	1986	13.83	0.50	0.17	65.09	--
	1987	19.64	0.62	0.23	88.12	--
	1988	41.16	0.49	0.15	150.48	--
	1989	46.57	0.46	0.22	112.61	--
	1990	33.34	0.21	0.17	44.14	--

[a] Not measured.

[b] Sport effort in angler-hours; gill net effort in km; trapnet effort in lifts.

[c] Sport (kg/hour), gill net (kgs/km), trap net (kgs/lift).

Table 3b. Catch and effort summaries for Lake Erie yellow perch fisheries in Management Unit 2, 1981-90.

	Year	Ohio			Ontario	
		Gill Net	Trap Net	Sport	Gill Net	Sport
CATCH (tonnes)	1981	711	12	65	1,603	--[a]
	1982	35	10	314	2,163	--
	1983	82	0	176	1,466	--
	1984	0	5	373	2,118	--
	1985	0	8	300	2,208	--
	1986	0	0	289	2,291	--
	1987	0	11	334	2,512	--
	1988	0	21	170	2,538	--
	1989	0	91	395	2,530	--
	1990	0	309	137	1,303	--
EFFORT[b]	1981	17,810	713	437,816	27,782	--
	1982	1,400	801	1,277,417	41,868	--
	1983	3,632	0	739,325	44,692	--
	1984	0	466	894,109	44,524	--
	1985	0	212	728,763	34,187	--
	1986	0	0	461,273	30,920	--
	1987	0	630	429,239	20,940	--
	1988	0	448	402,180	17,315	--
	1989	0	1,403	702,976	25,679	--
	1990	0	6,238	349,775	31,613	--
CATCH RATE[c]	1981	39.92	16.83	0.15	57.70	--
	1982	25.00	12.48	0.25	51.66	--
	1983	22.58	0	0.24	32.80	--
	1984	--	10.73	0.42	47.57	--
	1985	--	37.74	0.41	64.59	--
	1986	--	0	0.63	74.09	--
	1987	--	17.46	0.78	119.96	--
	1988	--	46.88	0.42	146.58	--
	1989	--	64.86	0.56	98.52	--
	1990	--	47.29	0.39	41.22	--

[a] Not measured.

[b] Sport effort in angler-hours; gill net effort in km; trapnet effort in lifts.

[c] Sport (kg/hour), gill net (kgs/km), trap net (kgs/lift).

Table 3c. Catch and effort summaries for Lake Erie yellow perch in Management Unit 3, 1981-90.

	Year	Ohio			Ontario		Pennsylvania	
		Gill Net	Trap Net	Sport	Gill Net	Sport	Gill Net	Sport
CATCH (tonnes)	1981	86	0	45	506	--[a]	103	--[a]
	1982	19	0	71	616	--	64	--
	1983	14	0	7	519	--	15	--
	1984	0	0	44	466	--	32	--
	1985	0	2	42	325	--	43	--
	1986	0	0	60	1,102	--	30	--
	1987	0	21	87	908	--	64	--
	1988	0	150	89	1,128	--	81	--
	1989	0	288	256	1,095	--	96	--
	1990	0	203	26	965	--	84	--
EFFORT[b]	1981	2,377	0	237,691	12,685	--	2,735	--
	1982	710	0	308,826	16,438	--	2,737	--
	1983	802	0	181,030	18,199	--	1,521	--
	1984	0	0	149,602	14,153	--	1,197	--
	1985	0	136	144,309	10,635	--	2,175	--
	1986	0	0	122,007	12,440	--	2,185	--
	1987	0	668	129,316	6,667	--	1,538	--
	1988	0	4,781	172,490	6,203	--	1,418	--
	1989	0	7,281	248,530	7,098	--	1,037	--
	1990	0	7,376	31,881	12,472	--	1,978	--
CATCH RATE[c]	1981	36.18	0	0.19	39.89	--	37.66	--
	1982	26.76	0	0.23	37.47	--	23.38	--
	1983	17.46	0	0.04	28.52	--	9.86	--
	1984	--	0	0.29	32.93	--	26.73	--
	1985	--	14.71	0.29	30.56	--	19.77	--
	1986	--	0	0.49	88.59	--	13.73	--
	1987	--	31.44	0.67	136.19	--	41.61	--
	1988	--	31.37	0.52	181.85	--	57.12	--
	1989	--	39.56	1.03	154.27	--	92.57	--
	1990	--	27.52	0.82	77.37	--	42.47	--

[a] Not measured.

[b] Sport effort in angler-hours; gill net effort in km; trapnet effort in lifts.

[c] Sport (kg/hour), gill net (kgs/km), trap net (kgs/lift).

Table 3d. Catch and effort summaries for Lake Erie yellow perch in Management Unit 4, 1981-90.

	Year	Ontario		Pennsylvania		New York		
		Gill Net	Sport	Gill Net	Sport	Gill Net	Trap Net	Sport
CATCH (tonnes)	1981	357	--[a]	0	--	86	0	--
	1982	254	--	0	--	81	0	--
	1983	178	--	13	--	28	0	--
	1984	365	--	36	--	68	0	--
	1985	139	--	14	--	52	0	--
	1986	143	--	48	--	--	2	--
	1987	260	--	23	--	--	6	--
	1988	260	--	1	--	--	4	--
	1989	199	--	0	--	--	8	47
	1990	128	--	0	--	--	9	8
EFFORT[b]	1981	19,130	--	0	--	3,142	0	--
	1982	14,637	--	0	--	3,430	0	--
	1983	12,832	--	1,329	--	1,160	0	--
	1984	19,368	--	1,211	--	1,826	0	--
	1985	8,582	--	486	--	3,133	0	--
	1986	8,797	--	569	--	--	3,513	--
	1987	4,908	--	632	--	--	1,602	--
	1988	2,719	--	8	--	--	2,132	--
	1989	2,628	--	0	--	--	1,136	65,370
	1990	3,924	--	0	--	--	981	24,463
CATCH RATE[c]	1981	18.66	--	0	--	27.37	0	--
	1982	17.35	--	0	--	23.62	0	--
	1983	13.87	--	9.78	--	24.14	0	--
	1984	18.85	--	29.73	--	37.24	0	--
	1985	16.20	--	28.81	--	16.60	0	--
	1986	16.26	--	84.36	--	--	0.57	--
	1987	52.97	--	36.39	--	--	3.75	--
	1988	95.62	--	125.00	--	--	1.88	--
	1989	75.72	--	0	--	--	7.04	0.72
	1990	32.62	--	0	--	--	9.17	0.33

[a] Not measured.

[b] Sport effort in angler-hours; gill net effort in km; trapnet effort in lifts.

[c] Sport (kg/hour), gill net (kgs/km), trap net (kgs/lift).

Table 4. Harvest of yellow perch (millions of fish) from Lake Erie by management unit, 1990.

YEAR CLASS	UNIT 1		UNIT 2		UNIT 3		UNIT 4	
	No.	(%)	No.	(%)	No.	(%)	No.	(%)
1989	0.047	0.5	0.034	0.3	0.000	0.0	0.000	0.0
1988	0.257	3.0	0.865	7.6	0.070	0.9	0.014	1.2
1987	0.659	7.7	1.003	8.8	1.034	13.3	0.056	5.0
1986	4.365	51.1	5.951	52.1	2.518	32.4	0.589	52.4
1985	2.101	24.6	1.481	13.0	1.278	16.5	0.203	18.0
1984	1.059	12.4	1.689	14.8	2.821	36.3	0.252	22.4
1983	0.062	0.7	0.390	3.4	0.026	0.3	0.007	0.6
1982	0.000	0.0	0.008	0.1	0.010	0.1	0.003	0.3
1981	0.000	0.0	0.000	0.0	0.005	0.1	0.001	0.1
TOTAL	8.550		11.421		7.762		1.125	

Table 5. Comparison of 1990 yellow perch stock size estimates generated by simulated projection of stocks for 1989 versus CAGEAN estimates of stock size.

UNIT	YEAR CLASS	STOCK PROJECTION	CAGEAN ESTIMATE	DIFFERENCE (No.)	DIFFERENCE (%)
1	1988	11.98	5.46	-6.52	-54
	1987	1.04	1.30	0.26	+25
	1986	20.88	10.56	-10.32	-49
	1985	8.46	4.45	-4.01	-47
	1984	7.43	3.10	-4.33	-58
	TOTAL	49.79	24.87	-24.92	-50
2	1988	6.30	5.29	-1.01	-16
	1987	1.19	1.19	-0.00	*0
	1986	11.94	10.34	-1.60	-13
	1985	1.91	1.97	0.06	+ 3
	1984	2.50	2.93	0.43	+17
	TOTAL	23.84	21.73	-2.11	-9
3	1988	5.52	0.91	-4.61	-84
	1987	0.09	0.96	0.87	+970
	1986	0.81	2.52	1.71	+212
	1985	0.74	2.16	1.42	+191
	1984	3.85	6.70	2.85	+74
	TOTAL	11.01	17.01	6.00	+55
4	1988	3.82	0.58	-3.24	-85
	1987	0.19	0.36	0.17	+90
	1986	0.29	0.83	0.54	+184
	1985	0.13	0.29	0.16	+120
	1984	0.42	0.77	0.35	+84
	TOTAL	4.85	2.82	-2.03	-42

Table 6. Lake Erie yellow perch population parameters estimated by 3-GEAR CAGEAN (assuming M=0.4).
N is stock size abundance in millions of fish, S is annual survival rate, u is annual exploitation rate.

	UNIT 1			UNIT 2			UNIT 3			UNIT 4		
YEAR	N	S	u	N	S	u	N	S	u	N	S	u
76	54.44	0.53	0.179	44.32	0.42	0.308	19.84	0.37	0.382	8.09	0.45	0.276
77	102.06	0.57	0.123	49.55	0.41	0.328	27.33	0.34	0.415	9.98	0.44	0.292
78	86.87	0.46	0.262	38.59	0.38	0.371	15.14	0.22	0.583	7.73	0.41	0.326
79	147.32	0.52	0.191	77.63	0.44	0.291	15.27	0.42	0.306	12.44	0.49	0.222
80	101.74	0.49	0.227	51.34	0.25	0.535	11.84	0.33	0.428	11.94	0.47	0.252
81	75.68	0.39	0.362	40.15	0.28	0.493	9.91	0.28	0.503	11.08	0.39	0.352
82	70.73	0.41	0.331	66.40	0.46	0.264	13.08	0.41	0.320	9.08	0.43	0.297
83	65.41	0.56	0.139	65.04	0.45	0.278	12.03	0.34	0.417	8.76	0.45	0.274
84	112.92	0.58	0.110	71.52	0.46	0.270	14.29	0.55	0.155	8.96	0.46	0.271
85	77.30	0.52	0.184	38.28	0.34	0.423	10.00	0.41	0.331	6.31	0.47	0.254
86	137.26	0.55	0.147	153.03	0.54	0.165	121.76	0.63	0.045	18.32	0.58	0.114
87	124.32	0.54	0.159	114.49	0.50	0.211	90.46	0.60	0.093	12.81	0.50	0.215
88	110.29	0.53	0.177	103.76	0.49	0.223	61.88	0.54	0.162	9.07	0.53	0.175
89	61.12	0.42	0.317	53.49	0.37	0.384	35.08	0.34	0.420	5.51	0.48	0.240
90	35.21	0.43	0.301	27.53	0.32	0.446	12.99	0.21	0.594	3.49	0.46	0.262
91	37.14			27.48			9.39			4.34		

TABLE 7. Yellow perch stock size (millions of fish) at the beginning of the year) estimated from CAGEAN for 1982-90, and 1991 projections based on stock survival estimates and recruitment estimates from agency trawl indices. (NATURAL MORTALITY RATE M=0.40)

UNIT	AGE	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	2	41.58	36.27	76.39	11.65	96.89	48.41	42.89	2.90	9.69	21.99
	3	16.16	24.01	23.13	49.42	7.60	62.17	31.40	27.90	1.88	6.29
	4	6.38	4.20	11.71	11.43	26.17	3.53	31.40	16.27	13.84	0.91
	5	6.17	0.57	1.43	4.21	4.71	8.25	1.31	12.25	5.73	4.61
	6	0.43	0.35	0.27	0.58	1.87	1.97	3.30	1.80	4.05	3.34
Total	(2+)	70.72	65.41	112.92	77.30	137.25	124.32	110.29	61.12	35.20	37.14
Total	(3+)	29.15	29.14	36.53	65.65	40.36	75.91	67.41	58.22	25.51	15.15
2	2	54.97	34.56	42.41	5.69	140.18	32.11	46.43	2.48	8.00	18.65
	3	10.15	27.36	18.58	24.67	3.31	80.05	19.90	29.07	1.51	4.69
	4	0.91	2.90	9.76	6.26	8.21	1.01	36.67	9.49	12.18	0.51
	5	0.32	0.15	0.70	1.51	0.98	1.05	0.30	12.11	2.34	1.98
	6	0.06	0.07	0.07	0.16	0.35	0.28	0.47	0.35	3.50	1.65
Total	(2+)	66.41	65.05	71.52	38.28	153.03	114.49	103.76	53.50	27.53	27.48
Total	(3+)	11.44	30.48	29.11	32.60	12.84	82.38	57.33	51.02	19.53	8.83
3	2	10.35	6.61	10.21	2.19	117.69	13.32	8.05	1.69	1.16	6.68
	3	2.17	4.72	2.80	6.40	1.37	75.51	8.78	5.30	1.10	0.71
	4	0.40	0.61	1.17	1.06	2.33	0.63	44.21	5.00	2.67	0.34
	5	0.15	0.08	0.10	0.33	0.28	0.88	0.34	22.76	2.09	0.55
	6	0.01	0.02	0.01	0.03	0.08	0.12	0.50	0.34	5.98	1.11
Total	(2+)	13.09	12.03	14.30	10.00	121.76	90.46	61.88	35.09	12.99	9.39
Total	(3+)	2.73	5.42	4.09	7.81	4.07	77.15	53.83	33.39	11.83	2.71
4	2	4.74	4.83	5.01	2.22	15.37	2.19	2.70	0.71	0.86	2.73
	3	2.86	2.57	2.65	3.14	1.43	9.82	1.43	1.78	0.47	0.57
	4	1.11	1.09	1.02	0.84	1.33	0.56	4.73	0.82	0.98	0.25
	5	0.33	0.22	0.23	0.10	0.17	0.22	0.16	2.11	0.33	0.37
	6	0.04	0.07	0.06	0.03	0.03	0.03	0.07	0.09	0.86	0.43
Total	(2+)	9.08	8.76	8.97	6.32	18.33	12.82	9.08	5.52	3.50	4.34
Total	(3+)	4.34	3.94	3.96	4.10	2.96	10.63	6.38	2.39	1.03	1.62

Table 8. Regression equations of year class abundance (ln number of age-2 recruits) on agency trawl indices (ln geometric mean). Abundance estimates are based on 3-gear CAGEAN assuming M=0.4.

Agency	Area	Season	Group	Intercept	Slope	Prob>F	r^2 value	SE_b	Sign.
Unit 1 Regression Parameters									
OMNR	11	Summer	YOY	15.3555	0.4233	0.0013	0.7470	0.0871	**
			YRL	16.5204	0.2385	0.1483	0.2174	0.1508	
ODNR	21	Summer	YOY	16.1529	0.5081	0.0035	0.4937	0.1427	*
		Fall	YOY	15.3912	0.3572	0.0141	0.3819	0.1260	*
			YRL	15.1581	0.4681	0.0012	0.4288	0.1140	*
USFWS	21	Summer	YOY	16.0629	0.3316	0.0181	0.3599	0.1227	*
			YRL	15.6914	0.4970	0.0108	0.4045	0.1673	*
		Fall	YOY	15.8881	0.4617	0.0130	0.3887	0.1606	*
			YRL	15.8158	0.6326	0.0022	0.5268	0.1663	*
Unit 2 Regression Parameters									
OMNR	12	Summer	YOY	16.6432	0.6299	0.0522	0.6515	0.2304	*
			YRL	17.7373	-0.2420	0.7218	0.0352	0.6333	
ODNR	23	Fall	YOY	15.6512	0.4376	0.0009	0.5833	0.1026	*
			YRL	14.7486	0.5705	0.0001	0.8142	0.0756	**
OMNR	11	Summer	YOY	14.9319	0.4932	0.0006	0.7877	0.0905	*
			YRL	16.1551	0.3243	0.0750	0.3104	0.1611	
ODNR	21	Summer	YOY	15.7716	0.5672	0.0016	0.5462	0.1434	*
		Fall	YOY	15.0575	0.3730	0.0162	0.3698	0.1350	*
			YRL	15.0149	0.4446	0.0060	0.4522	0.1357	*
USFWS	21	Summer	YOY	16.0468	0.2681	0.0867	0.2089	0.1447	
			YRL	15.5281	0.4700	0.0276	0.3212	0.1895	*
		Fall	YOY	15.7289	0.4317	0.0339	0.3018	0.1821	*
			YRL	15.3798	0.7128	0.0008	0.5939	0.1635	*
Unit 3 Regression Parameters									
ODNR	24	Fall	YOY	15.3825	0.2785	0.1983	0.1456	0.2035	
			YRL	13.3119	0.8384	0.0003	0.7036	0.1640	**
PFC	41	Fall	YOY	14.9477	0.2259	0.1321	0.1787	0.1398	
			YRL	15.2032	0.2425	0.2318	0.1168	0.1925	
OMNR	11	Summer	YOY	14.0541	0.4071	0.0303	0.4634	0.1549	*
			YRL	14.8021	0.3753	0.0511	0.3597	0.1669	*
ODNR	21	Summer	YOY	14.8844	0.4058	0.0585	0.2486	0.1957	
		Fall	YOY	14.3991	0.2620	0.1366	0.1623	0.1651	
			YRL	14.2969	0.3282	0.0784	0.2192	0.1718	
USFWS	21	Summer	YOY	15.4296	0.0972	0.5782	0.0244	0.1704	
			YRL	14.8688	0.2867	0.2356	0.1063	0.2306	
		Fall	YOY	14.6709	0.3694	0.0980	0.1964	0.2072	
			YRL	14.3049	0.6389	0.0085	0.4243	0.2064	*
Unit 4 Regression Parameters									
OMNR	14	Fall	YOY	14.2169	0.3085	0.3736	0.1334	0.3209	
			YRL	14.4518	0.3196	0.3841	0.1096	0.3443	
	16	Fall	YOY	13.5798	0.3451	0.0367	0.4865	0.1340	*
			YRL	13.3307	0.6246	0.0157	0.5897	0.1969	**
PFC	42	Fall	YOY	14.9755	0.0651	0.6481	0.0165	0.1393	
			YRL	14.7638	0.1982	0.3623	0.0642	0.2099	
OMNR	11	Summer	YOY	13.7116	0.2972	0.0220	0.5009	0.1049	*
			YRL	14.3850	0.2521	0.0723	0.3152	0.1238	
ODNR	21	Summer	YOY	14.2442	0.4016	0.0062	0.4255	0.1247	*
		Fall	YOY	13.5161	0.3156	0.0064	0.4224	0.0986	*
			YRL	13.6028	0.3494	0.0017	0.4463	0.1040	*
USFWS	21	Summer	YOY	14.4378	0.1923	0.1159	0.1671	0.1147	
			YRL	14.1304	0.3235	0.0590	0.2318	0.1574	
		Fall	YOY	14.0279	0.3742	0.0171	0.3430	0.1384	*
			YRL	14.0672	0.4695	0.0097	0.3899	0.1570	*

* Significant at 0.05 ** Index with highest r^2

Table 9. Estimates of yellow perch abundance (number of age-2 recruits) for the 1989 and 1990 year classes derived from agency trawl indices (at M=0.40).

Regression				1989 Year Class			1990 Year Class		
					95% Confidence Limits			95% Confidence Limits	
Agency	Area	Season	Group	Mean Estimate	Lower	Upper	Mean Estimate	Lower	Upper
MANAGEMENT UNIT 1									
OMNR	11	Summer	YOY	28,289,464	26,151,053	30,602,737	28,120,236	26,012,819	30,398,384
ODNR	21	Summer	YOY	12,347,942	6,888,749	22,133,437	17,948,193	12,529,545	25,710,242
ODNR	21	Fall	YOY	24,652,774	19,804,109	30,688,545	36,899,184	32,142,831	42,359,361
ODNR	21	Fall	YRL	27,001,420	24,196,051	30,132,052	--	--	--
USFWS	21	Summer	YOY	30,355,856	27,442,405	33,578,616	29,282,482	26,064,896	32,897,262
USFWS	21	Summer	YRL	17,985,924	11,709,371	27,626,886	--	--	--
USFWS	21	Fall	YOY	31,102,539	28,436,952	34,017,988	52,709,170	35,937,792	77,307,387
USFWS	21	Fall	YRL	14,931,744	9,623,321	23,168,404	--	--	--
			Weighted	21,992,801	17,032,454	28,397,744	29,841,540	24,382,162	36,523,321
MANAGEMENT UNIT 2									
ODNR	23	Fall	YOY	34,969,961	29,130,608	41,979,837	47,550,364	34,103,139	66,299,970
ODNR	23	Fall	YRL	21,151,048	19,995,144	22,373,773	--	--	--
OMNR	11	Summer	YOY	24,940,412	22,917,239	27,142,193	24,766,438	22,773,315	26,934,000
ODNR	21	Summer	YOY	8,607,978	4,788,846	15,472,890	13,068,300	9,104,688	18,757,421
ODNR	21	Fall	YOY	18,976,274	14,963,134	24,065,745	28,915,837	24,835,881	33,666,034
ODNR	21	Fall	YRL	21,212,475	18,457,844	24,378,204	--	--	--
USFWS	21	Summer	YRL	14,457,155	8,867,469	23,570,347	--	--	--
USFWS	21	Fall	YOY	24,276,030	21,649,653	27,221,019	39,749,189	25,666,572	61,558,592
USFWS	21	Fall	YRL	10,554,892	6,853,705	16,254,819	--	--	--
			Weighted	18,650,415	14,692,394	23,675,193	27,081,931	21,104,469	34,753,745
MANAGEMENT UNIT 3									
ODNR	24	Fall	YRL	9,668,657	8,590,779	10,881,776	--	--	--
OMNR	11	Summer	YOY	7,185,675	5,648,497	9,141,180	7,144,119	5,619,201	9,082,863
USFWS	21	Fall	YRL	3,318,754	1,917,437	5,744,193	--	--	--
			Weighted	6,668,305	5,097,013	8,722,895	7,144,119	5,619,201	9,082,863
MANAGEMENT UNIT 4									
OMNR	16	Fall	YOY	2,798,516	2,428,781	3,224,537	2,275,249	1,753,633	2,952,019
OMNR	16	Fall	YRL	2,323,999	1,865,239	2,895,592	--	--	--
OMNR	11	Summer	YOY	3,195,008	2,855,621	3,574,729	3,181,617	2,845,644	3,557,256
ODNR	21	Summer	YOY	1,764,539	1,049,789	2,965,926	2,371,421	1,715,302	3,278,511
ODNR	21	Fall	YOY	3,126,735	2,701,722	3,618,608	4,465,537	3,979,632	5,010,769
ODNR	21	Fall	YRL	3,473,940	3,205,568	3,764,780	--	--	--
USFWS	21	Fall	YOY	3,737,771	3,509,205	3,981,225	5,731,570	4,141,216	7,932,668
USFWS	21	Fall	YRL	2,167,533	1,434,605	3,274,907	--	--	--
			Weighted	2,724,577	2,209,162	3,360,428	3,265,717	2,619,267	4,071,903

Table 10. Projection of Lake Erie yellow perch stock size estimates (millions of fish) to 1991. Stock size estimates derived from CAGEAN assuming a natural mortality rate of M=0.4.

		1990 PARAMETERS									1991 PARAMETERS		
		STOCK SIZE (NUMBERS)				MORTALITY RATES				SURV RATE	STOCK SIZE (NUMBERS)		
UNIT	AGE	MEAN	SE	MIN	MAX	(F)	(Z)	(A)	(u)	(S)	MEAN	MIN	MAX
1	2	9.694	2.423	7.270	12.117	0.033	0.433	0.352	0.027	0.648	21.993	17.032	28.398
	3	1.882	0.471	1.412	2.353	0.327	0.727	0.517	0.233	0.483	6.285	4.714	7.856
	4	13.845	3.461	10.383	17.306	0.699	1.099	0.667	0.424	0.333	0.909	0.682	1.137
	5	5.734	1.434	4.301	7.168	0.855	1.255	0.715	0.487	0.285	4.613	3.459	5.766
	6	4.051	1.013	3.039	5.064	0.467	0.867	0.580	0.312	0.420	3.338	2.503	4.172
	TOTAL	35.206	8.801	26.404	44.007	0.444	0.844	0.570	0.300	0.430	37.138	28.391	47.329
	(3+)	25.512				0.658	1.058	0.653	0.406	0.347	15.145		
2	2	8.002	2.000	6.001	10.002	0.134	0.534	0.414	0.104	0.586	18.650	14.692	23.675
	3	1.509	0.377	1.132	1.886	0.687	1.087	0.663	0.419	0.337	4.692	3.519	5.865
	4	12.180	3.045	9.135	15.225	1.418	1.818	0.838	0.653	0.162	0.509	0.382	0.636
	5	2.343	0.586	1.757	2.928	1.335	1.735	0.824	0.634	0.176	1.978	1.484	2.473
	6	3.499	0.875	2.624	4.374	0.642	1.042	0.647	0.399	0.353	1.647	1.236	2.059
	TOTAL	27.533	6.883	20.650	34.416	0.738	1.138	0.679	0.441	0.321	27.477	21.312	34.709
	(3+)	19.531				1.153	1.553	0.788	0.585	0.212	8.827		
3	2	1.157	0.289	0.867	1.446	0.085	0.485	0.384	0.068	0.616	6.683	5.097	8.723
	3	1.096	0.274	0.822	1.370	0.779	1.179	0.692	0.458	0.308	0.712	0.534	0.890
	4	2.669	0.667	2.002	3.336	1.183	1.583	0.795	0.594	0.205	0.337	0.253	0.421
	5	2.093	0.523	1.570	2.616	1.585	1.985	0.863	0.689	0.137	0.548	0.411	0.685
	6	5.977	1.494	4.482	7.471	1.585	1.985	0.863	0.689	0.137	1.108	0.831	1.386
	TOTAL	12.991	3.248	9.744	16.239	1.169	1.569	0.792	0.590	0.208	9.389	7.126	12.105
	(3+)	11.835				1.381	1.781	0.832	1.242	0.168	2.706		
4	2	0.862	0.216	0.647	1.078	0.020	0.420	0.343	0.016	0.657	2.725	2.209	3.360
	3	0.469	0.117	0.352	0.586	0.223	0.623	0.464	0.166	0.536	0.567	0.425	0.708
	4	0.983	0.246	0.737	1.229	0.585	0.985	0.626	0.372	0.374	0.251	0.188	0.314
	5	0.329	0.082	0.246	0.411	0.620	1.020	0.639	0.389	0.361	0.367	0.276	0.459
	6	0.857	0.214	0.643	1.071	0.620	1.020	0.639	0.389	0.361	0.427	0.321	0.534
	TOTAL	3.500	0.875	2.625	4.375	0.375	0.775	0.539	0.261	0.461	4.337	3.419	5.376
	(3+)	2.638	0.659	1.978	3.297	0.525	0.925	0.603	0.342	0.397	1.613		

Table 11. Yield and exploitation rates for Lake Erie yellow perch by Management Unit for three exploitation policies based on 1991 stock size projections assuming M=0.4. Exploitation rates are depicted for the population of age-2 and older (2+) and age-3 and older (3+)

UNIT	EXPLOITATION POLICY	YIELD (t)	YIELD (lbs)	EXPLOITATION RATE (2+)	EXPLOITATION RATE (3+)
1	Optimal Yield[a]	839	1,849,676	0.165	0.362
	1990 Exploitation[b]	761	1,677,716	0.154	0.339
	Target effort[c]	637	1,404,343	0.125	0.276
2	Optimal Yield	501	1,104,515	0.125	0.297
	1990 Exploitation	811	1,787,947	0.224	0.477
	Target effort	674	1,485,914	0.171	0.395
3	Optimal Yield	190	418,878	0.113	0.342
	1990 Exploitation	353	778,231	0.226	0.616
	Target effort	206	454,152	0.123	0.370
4	Optimal Yield	69	152,119	0.105	0.267
	1990 Exploitation	79	174,165	0.125	0.308
	Target effort	242	533,518	0.431	0.637

[a] $F_{opt} = F_{0.1}$ for ages 2 - 6 adjusted for relative age selectivity.

[b] 1990 Exploitation = age specific exploitation rates observed in 1990.

[c] Target Effort = age specific exploitation rates equivalent to fishing at an effort 20% less than observed in 1981.

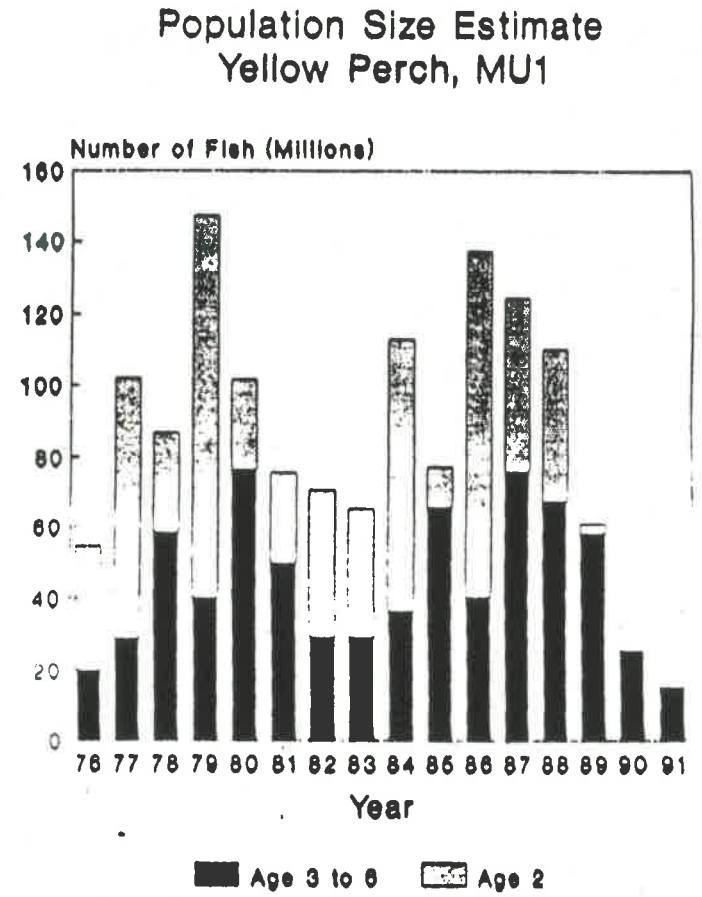
Table 12. Recommended allowable harvest (RAH) of Lake Erie yellow perch for 1991. Exploitation rate is derived from optimal yield policy and stock size estimates are derived from CAGEAN assuming M=0.40.

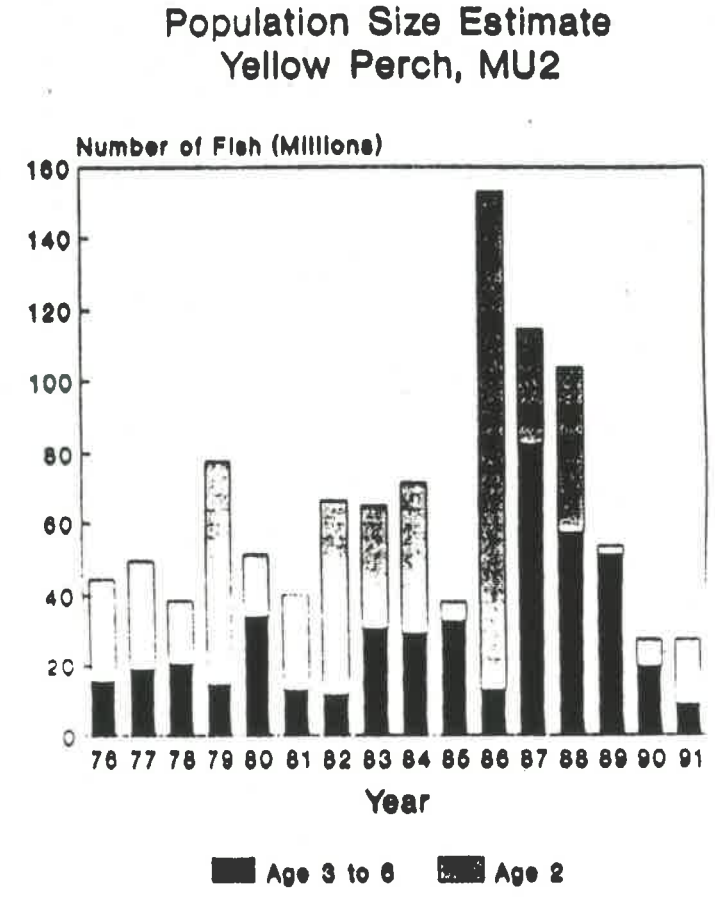
UNIT	AGE	STOCK NUMBER (MILLIONS)	EXPLOIT RATE (u)	CATCH NUMBER (MILLIONS)	WEIGHT @AGE (g)	CATCH WEIGHT (t)	CATCH WEIGHT (POUNDS)
1	2	21.993	0.030	0.660	88	58	128,004
	3	6.285	0.207	1.301	107	139	306,897
	4	0.909	0.378	0.344	121	42	91,659
	5	4.613	0.517	2.385	141	336	741,356
	6	3.338	0.436	1.455	181	263	580,745
	Total	37.138	0.165	6.145	136	839	1,848,661
2	2	18.650	0.044	0.821	92	75	166,438
	3	4.692	0.178	0.835	120	100	220,949
	4	0.509	0.394	0.201	136	27	60,129
	5	1.978	0.466	0.922	167	154	339,361
	6	1.647	0.401	0.660	218	144	317,416
	Total	27.476	0.125	3.439	146	501	1,104,294
3	2	6.683	0.021	0.140	118	17	36,510
	3	0.712	0.157	0.112	122	14	30,066
	4	0.337	0.248	0.084	147	12	27,085
	5	0.548	0.440	0.241	181	44	96,216
	6	1.108	0.440	0.488	213	104	228,932
	Total	9.388	0.113	1.064	178	190	418,808
4	2	2.725	0.009	0.025	105	3	5,677
	3	0.567	0.105	0.060	106	6	13,913
	4	0.251	0.258	0.065	121	8	17,275
	5	0.367	0.385	0.141	157	22	48,906
	6	0.427	0.385	0.164	184	30	66,687
	Total	4.337	0.105	0.455	152	69	152,457

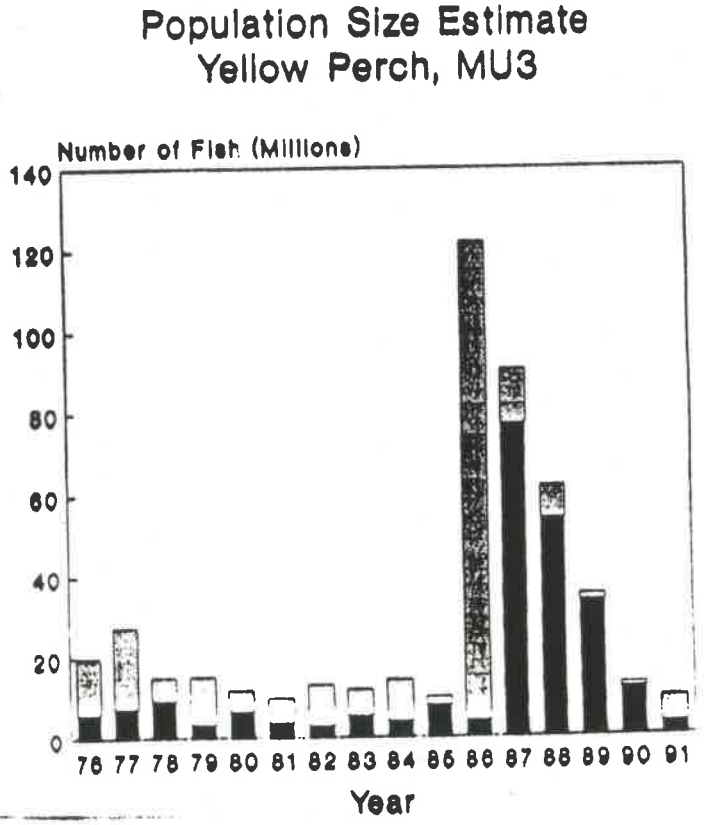
Table 13. Agency allocation of 1991 RAH (tonnes and 1000's of pounds) for different exploitation policies. Yields derived from projections of CAGEAN estimates of abundance at M=0.40.

Agency	Unit	Water Area (%)	OPTIMAL YIELD F_{OPT} (t)	OPTIMAL YIELD F_{OPT} (lbs)	1990 EXPLOITATION (t)	1990 EXPLOITATION (lbs)	TARGET EFFORT EXPLOITATION (t)	TARGET EFFORT EXPLOITATION (lbs)
Ontario	1	42.3	355	782	322	710	269	594
	2	42.5	213	469	345	760	286	632
	3	56.1	107	235	198	437	116	255
	4	55.2	38	84	44	96	134	295
Total			713	1,571	908	2,002	805	1,775
Ohio	1	49.6	416	917	377	832	316	697
	2	57.5	288	635	466	1,028	388	854
	3	31.9	61	134	113	248	66	145
Total			765	1,686	956	2,108	769	1,696
Pennsylvania	3	11.9	23	50	42	93	25	54
	4	17.2	12	26	14	30	42	92
Total			34	76	56	123	66	146
Michigan	1	8.1	68	150	62	136	52	114
New York	4	29.6	20	45	23	52	72	158

Figure 2. Lake Erie stock size estimates for age-2 and older fish, by Management Unit for years 1976-1991.







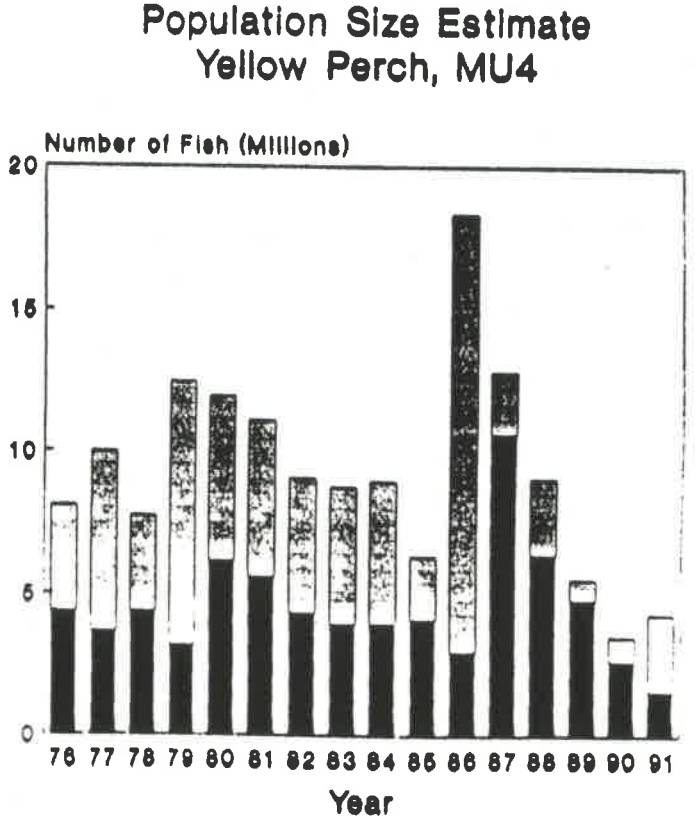
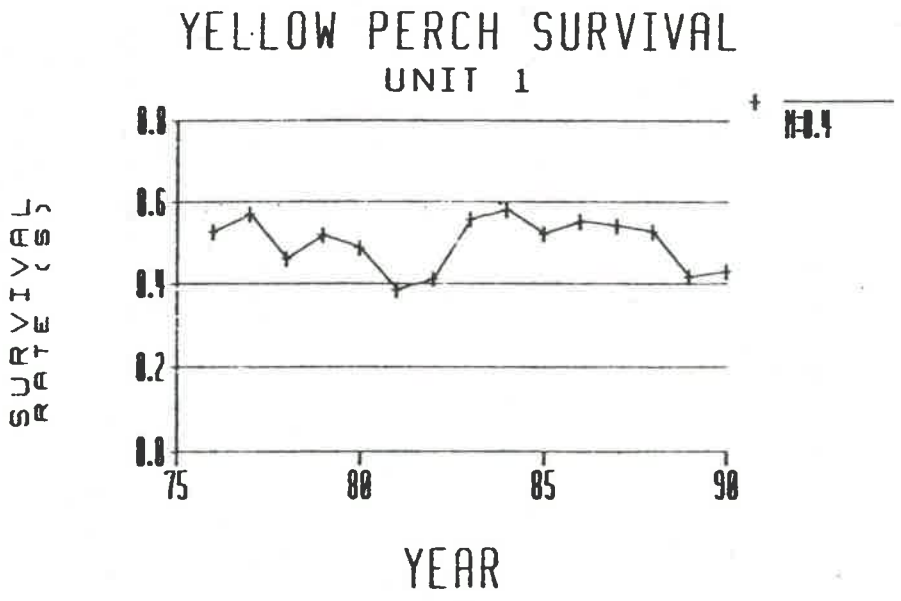
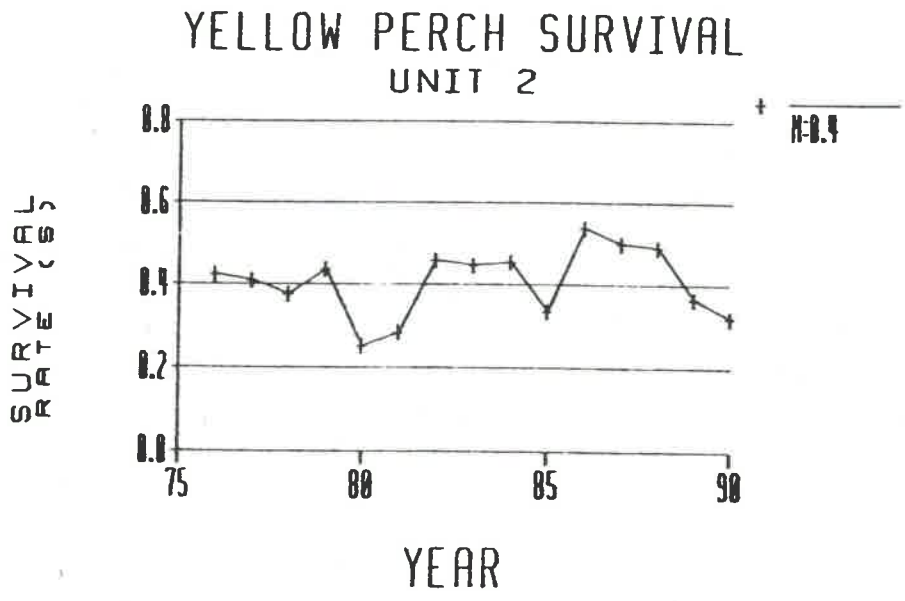
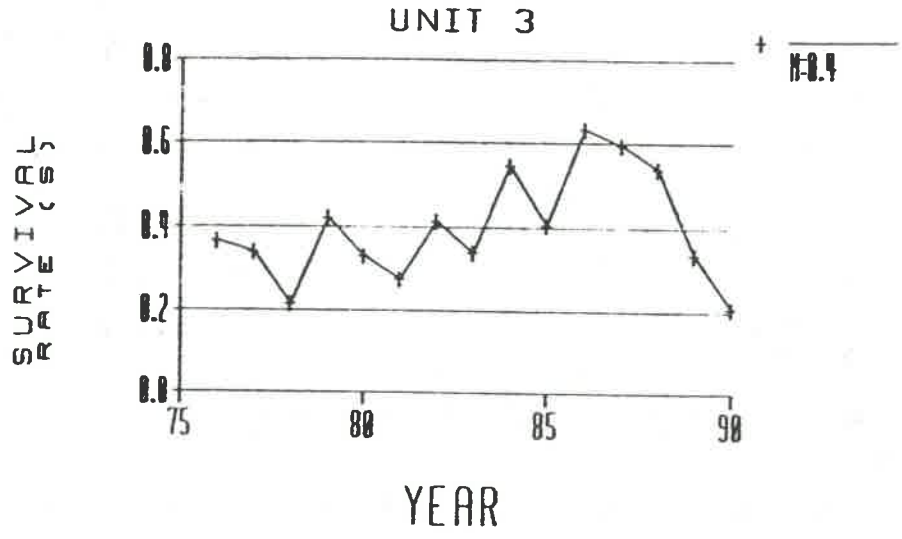


Figure 3. Survival rates of Lake Erie yellow perch exhibited by Management Units, 1975-1990.







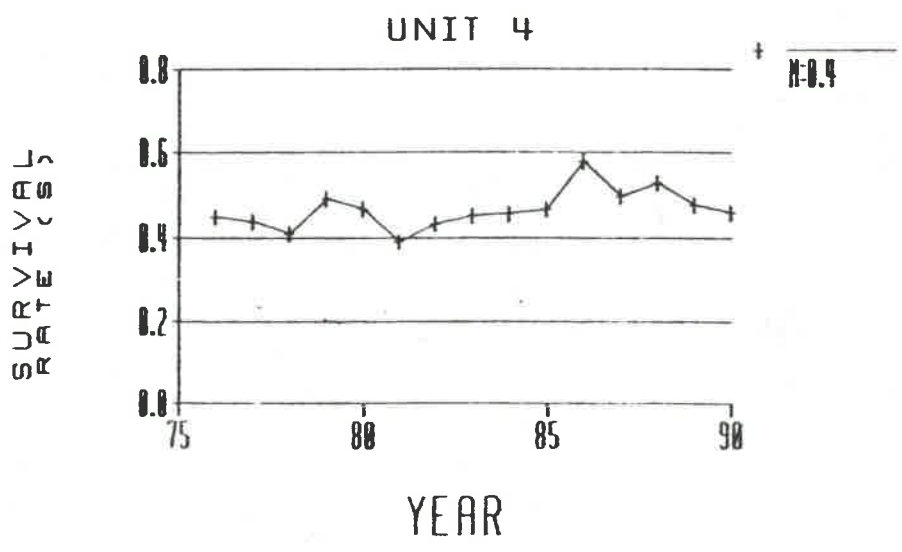


Figure 4. Exploitation rates of Lake Erie yellow perch exhibited by Management Units, 1975-1990.

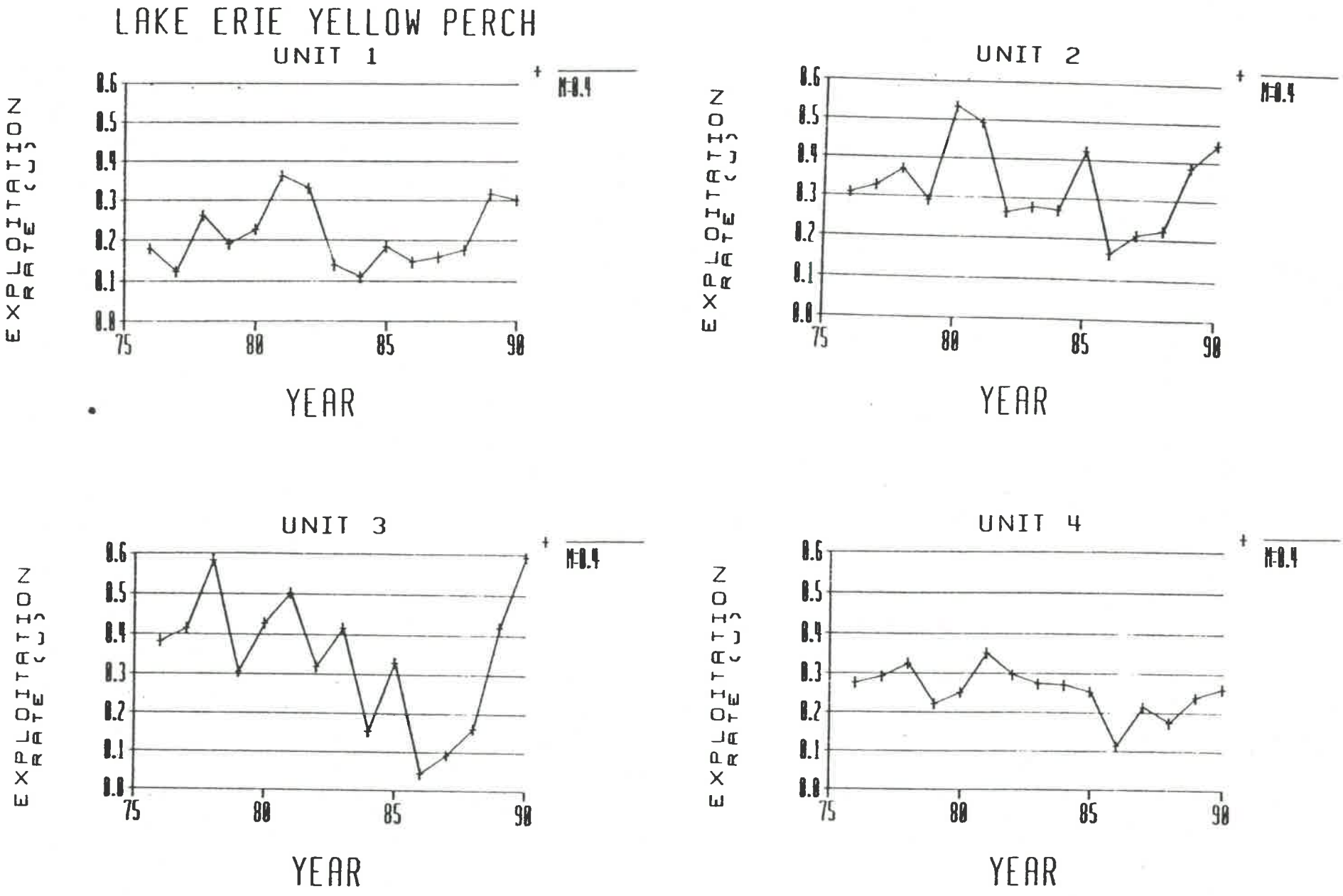
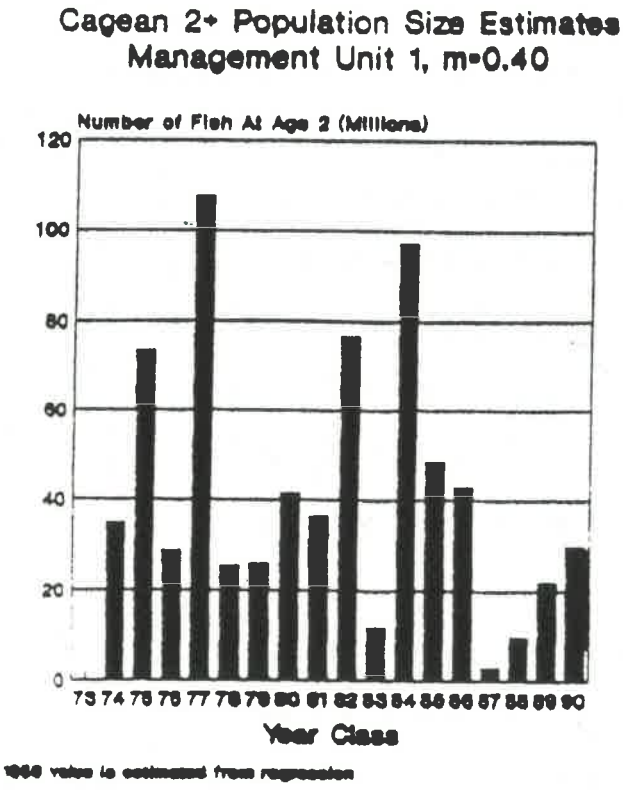
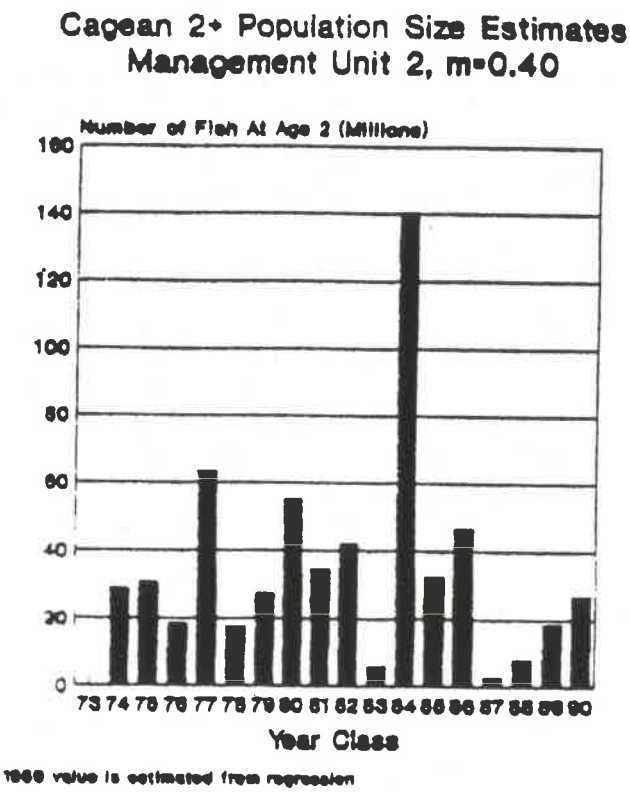
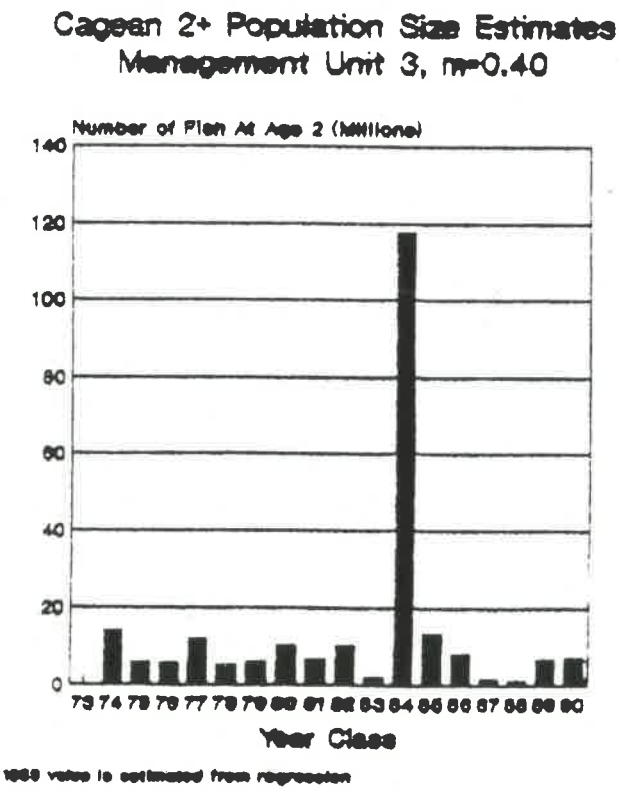
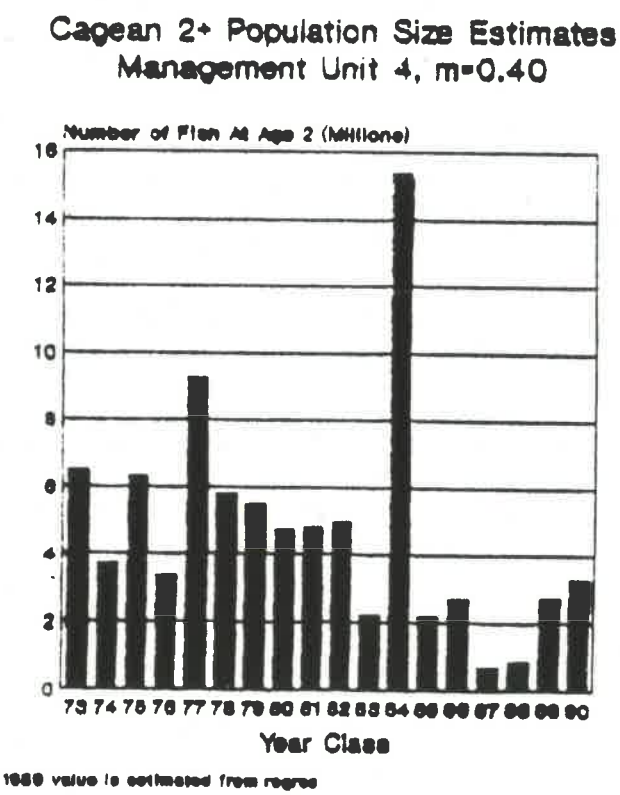


Figure 5. Recruitment for Lake Erie yellow perch (age-2) by Management Unit for years 1975-1990.









"Appendix"

Derivation of Optimal F policy options prepared as exploitation strategies for Lake Erie yellow perch harvest management.

Optimum fishing mortality (F_{opt}) is used to calculate an optional yield for each Management Unit. $F_{0.1}$ is arbitrarily defined as that level of fishing mortality beyond which the instantaneous rate of change in yield per recruit is less than 10% of the rate produced by an instantaneous fishing mortality rate of zero. Derivation of the F_{opt} option recommended by the YPTG for use in computing yield may be needed and is provided below.

The optional exploitation strategy implies the fishable perch stock (ages 2 - 6) is fished at a rate $F_{0.1}$ across all age groups as depicted schematically in Figure 2. In reality, all age groups are subject to selectively different rates induced by gear selectivity, behavior, changes in distribution etc. Since catch allocations cannot be specified by age, the level of fishing mortality applied to a specific age group is not controlled. Therefore, those more vulnerable age groups may experience levels of fishing above $F_{0.1}$ and those less vulnerable below $F_{0.1}$ (Figure 1).

Using Management Unit 1 as an example (Figure 1) F_{opt} is the optimal yield fishing rate adjusted by age and $F_{0.1}$ equals 0.517. By adjusting $F_{0.1}$ to represent age-group vulnerability and selectivity, such that F_{opt} (A+B) equals F_{opt} (A+C) schematically in Figure 1, perch yields are allocated by a more realistic method, consistent with the actual practice within the fishery.

Figure 1. Appendix.