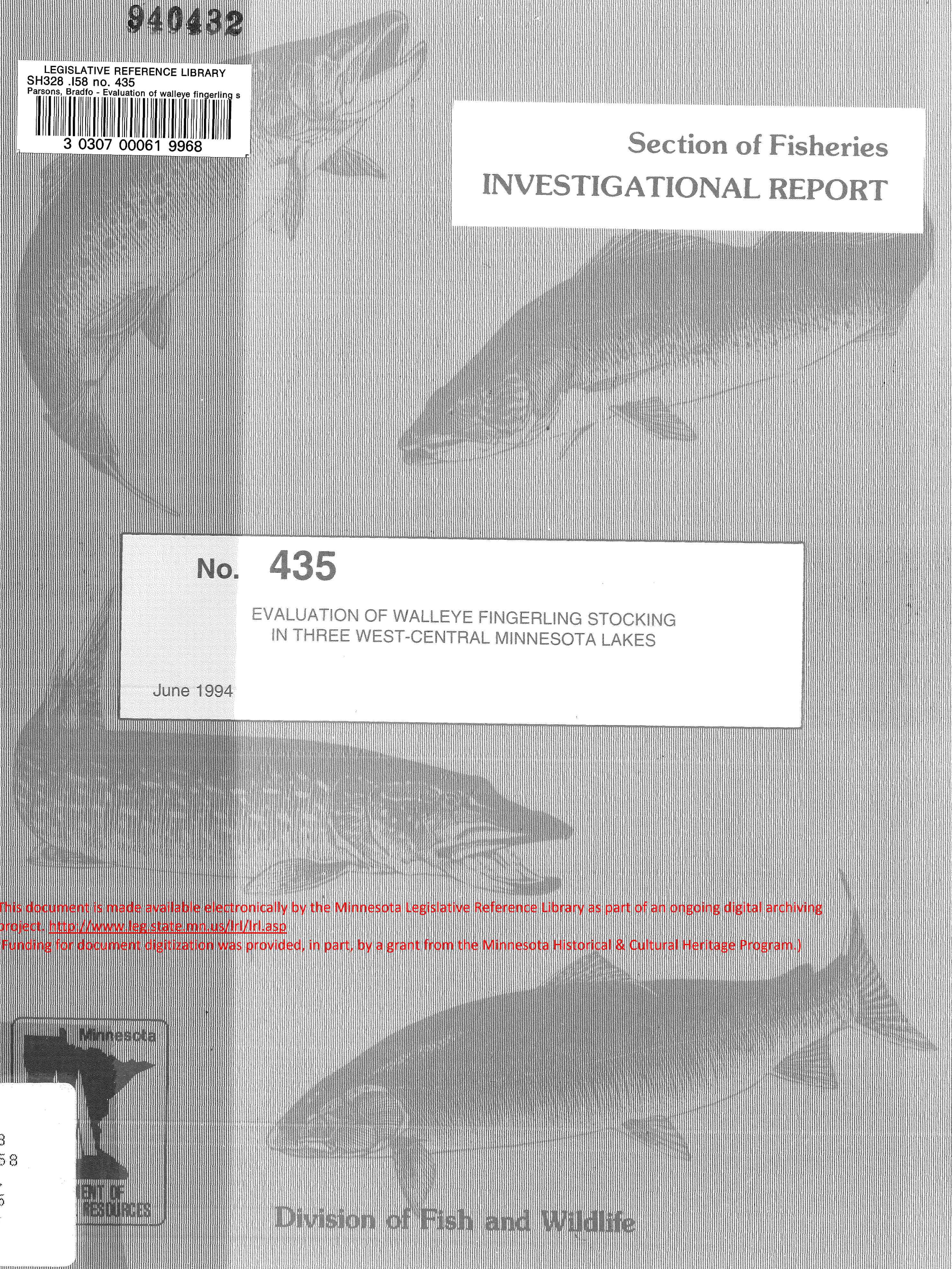

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EVALUATION OF WALLEYE FINGERLING STOCKING IN THREE WEST-CENTRAL MINNESOTA LAKES[1]

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Abstract.--Three years of high density walleye fingerling stocking from 1986 through 1988 in two west central Minnesota lakes, Mary and Ida, yielded mixed results in improving the walleye fisheries. Lake Miltona was stocked at normal densities as a reference lake during the same years. Walleye from each stocking survived and appeared in the angler's catch from 1989 through 1991. Naturally hatched walleye of the 1986-1988 cohorts also appeared in the angler's catch. One of the six high density stockings established a strong year class that improved walleye fishing for two years in one lake.

The walleye fishery in Lake Mary did not improve as a result of high density stocking. Stocked fish contributed to the walleye population and angler harvest. Gill net CPUE, however, did not improve over catches observed in earlier periods of no stocking. Angling success and walleye yields were lower three to five years after the high density stockings than in earlier years. An average of 1.8% of the stocked walleye were returned to the creel. The cost per stocked walleye returned to the creel was estimated to be $16.35. There were no changes in the fish community that could be attributed to the fingerling stocking. Yellow perch abundance increased during the study which may have been related to a decline in northern pike abundance.

Stocking established a strong 1986 year class in Lake Ida that improved walleye angling success and yield for two years. Gill net CPUE did not improve commensurately. Subsequent high density fingerling stockings in 1987 and 1988, however, did not prevent a decline in walleye angling success and yields to earlier levels by 1991. An average of 7.0% of the stocked walleye were returned to the creel. The cost per stocked walleye returned to the creel was $4.27. The 1979 and 1982 year classes, resulting from either fry stocking or natural reproduction, were probably as strong as 1986, thus challenging the true efficiency of high density fingerling stockings. Yellow perch abundance declined during the study period which may have been related to the high density walleye stocking.

A strong natural year class in 1986 was responsible for the unusually high abundance of walleye in Lake Miltona during the study years. Cost per stocked walleye returned to the creel was $4.02. The investment of $44,000 for fingerlings stocked during this study is difficult to justify, however, since only 25% of total harvest was due to stocking. The walleye fishery at

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Lake Miltona appears to be dependent on strong natural year classes similar to those of other large, natural walleye lakes in Minnesota.

There was evidence that stocked fingerlings did not fully disperse from stocking sites, and did not mix randomly with native walleye for two to three years.

Introduction

The rearing and stocking of walleye *Stizostedion vitreum* fingerlings is one the major activities of the Section of Fisheries, Minnesota Department of Natural Resources. The cost-effectiveness of the program has never been definitively evaluated. Until recently, reliable permanent marks that could be used to identify stocked walleye caught by anglers have not been available. Thus it was not possible to separate stocked walleye from wild fish.

Minnesota's large natural walleye lakes (>60,000 hectares) have continued to yield large walleye harvests amid increases in fishing pressure through natural reproduction (Schupp 1972, 1974; Osborn and Schupp 1985; Bruesewitz 1993). Walleye fry or fingerlings are commonly stocked in small and medium-size lakes (400 to 4,000 hectares) in an attempt to augment harvest of wild fish (supplemental stocking), or to maintain stocks that would not otherwise offer a walleye fishery (maintenance stocking).

Walleye fingerling stockings appear to be most effective in lakes with little or no natural reproduction (maintenance stocking). Laarman (1978) reviewed 40 evaluations of walleye maintenance stockings from across North America and reported that 32.5% were judged to be successful. In a similar survey of 41 Michigan lakes, Schneider (1969) reported that stocking of summer walleye fingerlings made a strong contribution to the fishery in 4 lakes, provided a limited amount of fishing in 20 lakes, and contributed nothing in 17 lakes. The strength of 3 of 6 walleye year classes studied in 13 north-central Minnesota bass-panfish lakes increased due to midsummer stocking of small (< 50 mm) fingerlings at an average rate of 400 per littoral hectare (Johnson 1971).

Stocking programs to augment natural reproduction by walleye (supplemental stocking) have been less successful. Laarman (1978) reported that only 13.8% of 58 supplemental stockings showed limited to good success. Johnson (1971) found no increase in relative abundance of walleye year classes supplemented by summer fingerling stockings in 28 natural walleye lakes in northern Minnesota.

Despite its dubious effectiveness in many situations, supplemental and maintenance walleye fingerling stockings are still very popular with anglers. Quinn (1992) found that 22% of anglers surveyed on walleye management viewed supplemental stocking as very important in producing good walleye fishing. Factors that fisheries managers take into account when determining walleye fingerling stocking rates include the extent of natural reproduction, prey abundance, and fishing pressure (Minnesota Department of Natural Resources 1983). Public pressure, however, has still led to many stockings based on social and political factors rather than on sound biological principles.

Effects of walleye introductions on native fish communities are poorly understood and often confounded by changes in abundance or introductions of other species. Introduction of walleye and northern pike *Esox lucius* suppressed smallmouth bass *Micropterus dolomieui* and panfish *Lepomis* spp. in Escanaba Lake, Wisconsin, and a decline in fishing pressure followed because panfish were most desired (Kempinger et al. 1975; Kempinger and Carline 1977). Eschmeyer (1950) also reported a decline of smallmouth bass in Goegebic Lake, Michigan, after successful walleye introductions.

In contrast, Forney (1977) reported little change in centrarchid populations after walleye abundance increased substantially in Oneida Lake, New York. Oneida Lake, however, is much larger than lakes where changes in the fish community have been reported. The increased abundance of walleye in Oneida Lake occurred as northern pike and American eel *Anguilla* *rostrata* abundance declined. The total standing stock of top predators may not have changed appreciably. Size of creeled yellow perch *Perca flavescens* in Oneida Lake increased with little change in abundance of perch following increased walleye abundance.

There is no clear relationship between the abundance of walleye and northern pike in lakes as we may expect from a relationship based on direct competition and predation (Colby et al. 1987). Examination of 3,500 Minnesota lake surveys indicated that walleye abundance was inversely correlated with pike abundance, and that the average walleye size increased as northern pike numbers increased (unpublished data). These correlations, though statistically significant, were low (< 0.25). Yellow perch is usually the most common prey species for both northern pike and walleye in Minnesota lakes, but pike eat larger perch than walleye. The difference in sizes of prey eaten may mask the relationship between pike and walleye. Walleye may also compete with yellow perch for benthic food resources (Colby et al. 1987).

Objective evaluations of the walleye fingerling stocking program in Minnesota are rare. Evaluations by standard lake surveys are tenuous due to the confounding factors of stocking carryover fingerlings (walleye that have survived one or more winters in rearing ponds), and the inability to differentiate between natural and stocked walleye. The lack of valid assessments can lead to stocking walleye in lakes that may not benefit from it.

Evaluation of the stocking contribution requires that stocked fish be distinguished from naturally reproduced fish. Most previous studies used some form of fin-clipping to mark stocked fish, while Schweigert et al. (1977) used a genetic marker. Mitzner (1992), and McWilliams and Larscheid (1992) used a combination of fin clips and coded wire tags. Early tags were implanted in the nasal cartilage but later other anatomical locations were tried (Klar and Parker 1986; Fletcher et al. 1987). Two groups of walleye with mean total lengths of 51 and 75 mm tagged in the cheek musculature had only 3% tag loss (Heidinger and Cook 1988).

The purpose of this study was to provide information on the effectiveness of Minnesota's walleye fingerling stocking program. Our primary objective was to evaluate the contribution and benefit:cost ratio of high density walleye fingerling stocking in lakes with natural walleye reproduction at rates above the standard Minnesota stocking density of 1.1 kg/littoral hectare. Additional objectives were to identify lake conditions that influence stocking success, and to determine if high density walleye fingerling stocking would lead to fish communities changes.

Study Area

The study was conducted in Douglas County in west-central Minnesota. Lakes Mary and Ida were designated for high density fingerling stocking primarily because high density stockings had occurred in 1984. Lake Miltona was picked as a reference lake due to its history as a productive walleye lake.

Lakes Mary and Miltona are in Lake Class 27, and Lake Ida is in Lake Class 22 (Schupp 1992) (Table 1). These lake classes have similar fish community structure with northern pike, bluegill *Lepomis macrochirus*, and walleye being the primary species. Lake Class 22 lakes are, on average, larger and deeper, and have a lower percent littoral area, a higher shoreline development factor, and lower morphoedaphic index than Lake Class 27.

The shores of all three lakes are heavily developed with private homes and resorts. Walleye is the species sought most often by anglers (Schalekamp and Nelson 1986; Parsons and Pereira, in prep). Each lake has been

Table 1. Physical and chemical characteristics of lakes Mary, Ida, and Miltona, Minnesota.

Characteristic	Mary	Ida	Miltona
Area (hectare)	960	1,736	2,363
Littoral Area (hectare)	413	676	1,141
Maximum Depth (m)	12.2	32.3	32.0
Total Alkalinity (ppm)	155	172	171
Total Dissolved Solids (ppm)	312	212	212
Total Phosphorus (ppm)	0.055	0.011	0.017
Chlorophyl a (ppb)	6.8	4.2	4.6
Secchi (m), May 1991	4.3	5.8	4.0
Secchi (m), August 1991	1.2	2.7	2.0

stocked frequently with walleye fry or fingerlings during the past 40 years. Northern pike and various centrarchids have also been stocked over the years. In addition, Lake Miltona received approximately 1,000 muskellunge *Esox masquinongy* fingerlings annually from 1982-1985, and in 1987 and 1989.

Methods

Stocking and Tagging

Intensive evaluation of high density walleye stocking began in 1986. The study design included stocking lakes Mary and Ida with at least triple the normal stocking density of 1.1 kg/littoral hectare from 1986 through 1988, a year of no stocking in 1989, and a normal density stocking in 1990. The stocking schedule for Lake Miltona was normal density stockings from 1986 through 1988, and no stocking in 1989 or 1990.

Walleye fingerlings were harvested from rearing ponds in September and October with seines or trap nets in 1986, and with trap nets in 1987 and 1988. No stocking or tagging was conducted before 15 September, and water temperatures were never above 19°C. Fingerlings to be tagged were harvested, transported to the lake and placed in 3 m X 3 m mesh cribs at the tagging site. Whenever possible, fingerlings were tagged the following morning so that fish injured or severely stressed during harvest or transport would die overnight and not be tagged. When pond harvest exceeded tagging capacity, fingerlings were stocked directly into the lake without cribbing. Obviously dead or dying fish were collected at the stocking site and not counted as stocked, but no allowance was made for delayed mortality.

A subsample of fingerlings of each lot stocked from each pond was measured and weighed. The mean length of the lot was assigned to all fingerlings of the lot, whether tagged or untagged. Mean length of all stocked fingerlings was estimated by weighting the pond mean lengths by the number of fingerlings stocked from each pond.

Fingerlings were lightly anesthetized with tricaine methanesulfonate (MS-222) before tagging. Fingerlings were tagged in the cheek musculature with 1 mm X 0.25 mm binary coded wire tags (Nielsen 1992) and discharged into the lake. Tag codes in 1986 were unique for lake, year, and method of pond harvest (seine or trap). Tag codes in 1987 and 1988 represented lake, year, and fingerling size (small < 130 mm, medium 130-170 mm, and large > 170 mm).

Tagging mortality was estimated at each lake by holding samples of 100 tagged and 100 untagged fingerlings from the same pond in divided 1.8 m X 1.8 m cribs for 3 days each year at each lake. In 1986, 10 of these tests extended between 11 and 18 days. Short term tag retention was tested by sending the 200 tagged mortality test fish through the quality control device in 1990. Longer term tag retention was estimated in 1986 by stocking 2,770 tagged fingerlings into a pond at the New London, Minnesota hatchery and holding them over the winter.

The relative contributions of seined versus trapped (1986), and small, medium and large fingerlings (1987 and 1988) were tested by χ^2 analysis. Total numbers of tags recovered during community assessments and creel surveys for each lake and year were multiplied by the proportion of each tag code stocked to generate expected values. The assumption was that the proportion of each tag code collected was equal to the proportion of each tag code stocked.

Chi-square analysis was also used to determine if naturally reproduced walleye contributed to a year class. The assumption was that the proportion of collected tagged fish from a cohort was equal to the proportion of stocked fingerlings tagged. For example, if 10% of the walleye fingerlings stocked in a lake in a year were tagged, we would expect 10 from a sample of 100 from that cohort would have tags if no natural reproduction took place that year.

Community Assessment

Three phase 230 V AC electrofishing for age 1 and 2 walleye, and adult largemouth and smallmouth bass was conducted at night in the spring (Figures 1-3). Sampling began when water temperatures reached approximately 10°C

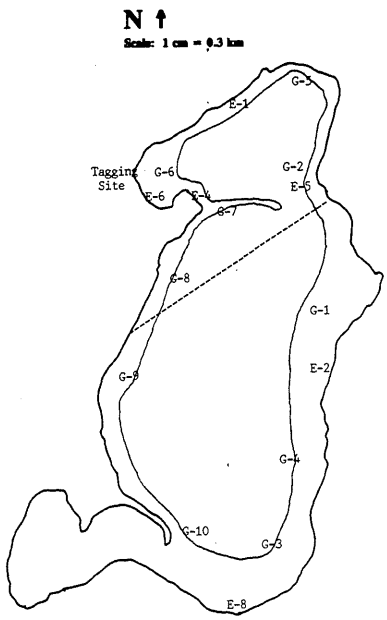


Figure 1. Lake Mary

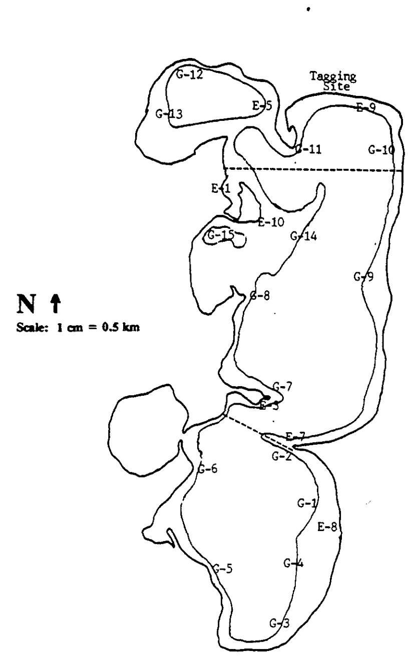


Figure 2. Lake Ida

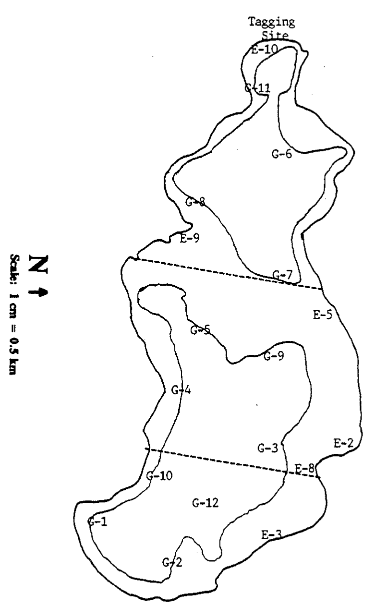


Figure 3. Lake Miltona

Figures 1-3. Location of gill net (G) and electrofishing (E) stations. Dashed line divides station designated "near" and "away" for walleye fingerling disposal.

in late April or early May. Each lake was sampled once per week up to six weeks at five permanent stations established in 1986. One additional station was selected primarily to catch largemouth bass, and this station was sampled first at sunset. Catch per unit effort (CPUE) was calculated as number of fish per hour. Lengths, weights, and scale samples were taken from all collected walleye. Walleye were checked for coded wire tags (CWT) with a field sampling device (FSD). All collected largemouth bass and smallmouth bass were measured, and weights and scales were collected from a subsample of five fish per cm length group. Age structure of the entire largemouth bass sample was calculated from age-length keys.

Assessment netting was conducted during late July on Lake Miltona and early August on lakes Mary and Ida. Nets were set at standard lake survey net locations (Schlagenhaft 1993). Overnight sets of 76.2 m experimental gill nets and 19.1 mm mesh double frame trap nets were used. Each walleye and northern pike caught in the gill nets was measured, weighed, sexed by examination of the gonads, examined for stomach contents, and a scale removed for aging. Opercles were taken from walleye and cleithra from northern pike to assist aging from scales. Scales were taken from smallmouth bass and a subsample of yellow perch. All bluegill captured in trap nets were measured, and weights and scales were taken from a representative subsample. Walleye in both gears were checked with the FSD for presence of a CWT. All other species in both gears were measured individually and weighed collectively by species.

Shoreline seining was conducted in late August and early September at 9 stations per lake with a 15.2 m X 1.8 m bag seine with 6.3 mm mesh (Figures 1-3). Scale samples and weights were taken from a representative subsample of yellow perch, bluegill, and largemouth bass. All fish were measured, except cyprinids and darters, which were counted by species.

We fit the following linear model to test variation in walleye year class strength and estimate least square means for each year class:

$$Y_{ij} = \mu + \alpha_i * Age(i) + \beta_j * YearClass(j) + \epsilon_{ij},$$

where Y_{ij} is the log of gill net CPUE (number of fish age i from year class j caught divided by number of nets, plus 1 to allow log of zero values), and Age(i) and Year Class(j) are vectors of dummy variables for the main effects in the model. Only ages one through six were used to remove potential aging errors for older walleye (Campbell and Babaluk 1979). Data for all three lakes included gill netting from 1986 through 1991. Lake Mary also included surveys conducted in 1982 and 1985, and Lake Miltona included one additional survey in 1984. All least square means and approximate 95% confidence intervals from the model are reported after back-transforming.

Since the linear year class strength model (YCSM) does not include replication, we were not able to test for lack of fit due to interaction of the two main effects, age and year class. However, we examined lack of fit qualitatively by plotting the dependent variable against age for each year class. A high degree of interaction would have been indicated if the plots for separate year classes did not follow similar patterns relative to age. For all three lakes, strong and weak year classes were consistently above and below the mean CPUE for each age. Therefore, we felt the YCSM was an appropriate measure of year class strength.

Total mortality rates (Z) of walleye were estimated from age structured catch curves developed from the combined 1986 through 1991 gill net data for each lake. Combining samples was necessary to reduce irregularities caused by fluctuations in recruitment (Ricker 1975).

Gill net CPUE's of walleye, northern pike, and yellow perch were compared to CPUE quartiles for the appropriate Lake Class developed by Schupp (1992). He indicated that catches below the first quartile or above the third quartile merited more detailed examination.

Age structure and growth rates were determined by reading acetate impressions of collected scales. Results were digitized and back-calculated growth was computed using DISBCAL (Frie 1982). A body-scale constant of 55.0 mm was used for walleye. Other collected bony structures were used to check the reliability of scale ages. Ages of tagged walleye were verified by the tag codes.

We analyzed growth of walleye using the linear model of Weisberg (1993). The marginal lengths model adjusted lengths at capture for seasonal growth, and estimated length increments for cohorts of fish sampled sequentially over time. Thus, each individual fish contributed only one observation that consisted of an estimate of its last full season of growth. Walleye up to and including age six were used to minimize effects of aging errors. Analysis of scale growth increments by age indicated that larger fish during their second growing season may be selected by assessment gill nets. We therefore feel that estimates of age one increments from the marginal lengths model were biased positively. We also suggest that estimates of growth for the first growth year were influenced by the amount and effectiveness of stocking. Stocked fingerling walleye spend most of their first growing season in rearing ponds that have different temperature and feeding conditions than the lakes. For these reasons, we discounted the use of this growth analysis for drawing inferences about first year growth.

Creel Survey

Completed trip daytime creel surveys were conducted on the three lakes. The surveys began on opening day of the walleye season in mid-May and continued through mid-October each year from 1986 through 1991. Results were analyzed separately for three periods within the year. The spring period was from the walleye season opener in mid-May to 30 June, the summer period ran from 1 July through Labor Day, and the fall period began after Labor Day. An incomplete trip winter creel survey was also conducted from 14 December 1990 (safe ice) through 15 February 1991 (walleye closing date). Walleye harvest rates discussed in this report are for anglers seeking walleye. Parsons and Pereira (in preparation) describe methodology and computation formulas for the creel surveys.

A walleye head collection program was initiated in 1987 to increase sample sizes of harvested walleye and to increase returns of coded wire tags (Parsons et al. 1991). Pearson correlation coefficients were calculated to determine any relationship between angler catch rates of walleye and CPUEs of population assessment gears.

Age of harvested walleye was determined from scales collected by the creel clerk and from opercles recovered from a subsample of walleye heads. Age-length keys were developed for each period (spring, summer, and fall) for each year and lake to determine the age structure of the walleye harvest observed from head collections. Proportions of each age were multiplied by total estimated harvest to determine the contribution of each year class to the creel.

Estimates of harvests by cohort for years when there were no creel surveys were made to assess a cohort's contribution to the fisheries from ages 2 through 8. We assumed that the harvest of a cohort at a particular age would be related to the strength of the cohort. Therefore, we used the year class least square mean (LSM) from the linear model developed from the gill nets. The LSM for the cohort to be estimated was divided by the LSM for each cohort where a harvest estimate for that particular age existed. This was multiplied by the estimated number harvested by age. For example, we needed estimates for the harvest of the 1982 year class at age 3 in 1985. The first step would be: (LSM1982/LSM1983)X(1983 cohort harvest at age 3 in 1986). Because harvest estimates at age 3 were also available for the 1984 through 1988 cohorts, estimates of harvest of the 1982 year class at age 3 were generated from each of those cohorts by replacing 1983 in the equation. The six values were then averaged to give a final harvest estimate for the 1982 year class at age 3. This method allowed for comparison among the 1981 through 1988 year classes.

We also estimated the cost per fingerling returned to the creel. Total harvest for a cohort was multiplied by the proportion of the cohort attributed to stocking from the tag return data. This gave the number of stocked fish harvested from each tagged cohort. Cost of stocked fish was set at $0.30 per fingerling (KMPG Peat Marwick 1990). The total cost of stocking was divided by the number of stocked fish harvested to yield the cost of fish returned to the creel.

Significant walleye winter harvest occurred on lakes Mary and Miltona. The ratio of the winter harvest to the open water harvest was used to adjust the total harvest of marked walleye. This figure was used to calculate the cost of each stocked fish in the creel.

Results

Stocking and Tagging

High density fingerling stocking quotas of 3.3 kg/littoral hectare for lakes Mary and Ida were met in all years (Table 2). Extra fingerlings were available in 1986, so the stocking rate was increased to 4.8 kg/littoral hectare in Lake Mary and 7.7 kg/littoral hectare in Lake Ida. Every effort was made to assure that only age 0 fingerlings were stocked from 1986 to 1988. Although a few older fish were undoubtedly stocked, the number was minute compared to the number of stocked fingerlings .

The high numbers of fingerlings needed for the stockings precluded tagging all of them. The numbers of stocked fish, tagged and untagged, varied from year to year (Table 3). An average of 16,500 fingerlings were tagged each year from 1986-1988 at each lake. This was 16% of all fingerlings stocked and ranged from 5% at Lake Ida in 1986 to 63% at Lake Miltona in 1988.

Mortality and Tag Retention

There were no differences in 3-day mortalities between tagged and untagged fingerlings in any year (Table 4). Mortality of tagged fish held for over 10 days, however, was higher ($\chi^2=15.78$, $P < 0.001$). The increase in mortality from 3 days to over 10 days suggests that holding fingerlings in cribs for an extended time period added stress. The higher mortality of tagged fish noted in the longer tests was probably compensated for by tagging mainly fingerlings that had survived one night. Untagged fingerlings were generally stocked directly into the lakes with no holding time. No adjustments of numbers of untagged fish stocked were made for mortality associated with the normal harvest and transportation stresses, which can be substantial (Lound and Dobie 1958; Schreiner 1985).

Table 2. Walleye stocking history for lakes Mary, Ida, and Miltona, 1978 through 1990.

	Lake Mary			Lake Ida			Lake Miltona		
Year	Size	Number	kg	Size	Number	kg	Size	Number	kg
1978	FNG[2]	17,732	NA	FNG	3,463	NA	FNG[1]	8,050	NA
1979	NONE			FRY	1,800,000		FNG	9,690	NA
1980	NONE			FNG[1]	756	515	FNG	1,290	NA
1981	FRY	2,370,000		FNG	12,196	355	FRY	5,786,000	
1982	NONE			FRY	4,000,000		NONE		
1983	NONE			NONE			FNG	24,250	NA
1984	FNG[1]	49,131	1,584	FNG[1]	133,947	2,609	FNG[1]	4,420	559
							FRY	2,819,000	
1985	FNG	7,353	328	FNG	31,399	802	FNG	29,326	838
1986	FNG	132,648	1,968	FNG	325,389	5,192	FNG	135,383	1,321
1987	FNG	38,498	1,363	FNG	84,165	2,599	FNG	39,745	1,319
1988	FNG	50,696	1,413	FNG	107,948	2,439	FNG	25,788	978
1989	NONE			NONE			FNG[1]	8,080	1,185
1990	FNG	18,497	1,044	FNG	38,705	1,631	NONE		

[1] Includes some stocked yearling walleye.

2 FNG = fingerling.

Table 3. Number, weight (kg), and mean total length (mm) of tagged and untagged walleye fingerlings by tag code stocked into lakes Mary, Ida, or Miltona, 1986-1988.

		Tagged			Untagged			All		
Lake	TagCode	kg	Number	mm	kg	Number	mm	kg	Number	mm
Mary 1986	Trap	178	10,687	128	485	31,842	121	663	42,529	123
	Seine	147	5,804	147	1,158	84,315	118	1,305	90,119	120
	Both	325	16,491	135	1,643	116,157	119	1,968	132,648	121
Mary 1987	Small	33	3,681	110	78	5,901	110	111	9,582	110
	Medium	186	6,055	148	470	13,375	147	656	19,430	147
	Large	370	6,468	187	226	3,017	193	596	9,485	189
	All	589	16,204	155	774	22,293	144	1,363	38,497	149
Mary 1988	Small	92	6,729	123	160	15,042	113	241	21,771	116
	Medium	291	7,871	152	409	14,749	147	710	22,620	149
	Large	84	2,040	196	78	4,255	208	462	6,295	204
	All	467	16,640	146	947	34,046	139	1,413	50,686	141
Ida 1986	Trap	119	8,297	126	3,042	191,420	125	3,161	119,717	125
	Seine	356	8,077	148	1,675	117,595	118	2,031	125,672	120
	Both	475	16,374	137	4,717	309,015	122	5,192	325,389	123
Ida 1987	Small	61	1,931	114	253	23,792	110	314	25,723	110
	Medium	203	8,418	144	963	37,223	141	1,166	45,641	142
	Large	377	5,540	201	742	7,557	198	1,119	13,097	199
	All	641	15,889	152	1,958	68,572	136	2,599	84,461	139
Ida 1988	Small	113	9,333	119	924	74,304	118	1,037	83,635	118
	Medium	291	7,871	152	409	14,749	147	710	22,620	149
	Large	309	3,739	202	817	10,163	205	1,126	13,902	204
	All	553	17,471	145	1,886	90,477	144	2,439	107,948	144
Miltona 1986	Trap	186	10,048	133	335	36,425	111	522	46,473	116
	Seine	180	8,679	134	620	80,231	104	800	88,910	107
	Both	366	18,727	133	955	116,656	106	1,321	135,383	110
Miltona 1987	Small	97	5,454	109	14	1,712	110	111	7,166	109
	Medium	185	7,002	146	608	20,219	135	793	27,221	138
	Large	216	2,481	225	199	2,877	227	415	5,358	226
	All	498	14,937	146	821	24,808	144	1,319	39,745	145
Miltona 1988	Small	91	5,633	117	23	1,789	121	114	7,422	118
	Medium	186	6,988	155	198	6,335	155	383	13,323	155
	Large	293	3,497	205	128	1,548	205	421	5,045	205
	All	570	16,118	152	349	9,672	156	978	25,788	154

We observed no tag loss in either the short-term or long-term tests. All 200 fish tagged for mortality tests in 1990 retained their tags through 3 and 14 days. Samples of 200 fish 149 days after tagging, and 150 fish 250 days after tagging had 100% tag retention.

Dispersal of Tagged Fingerlings

Most tagged walleye remained near the tagging sites through the following spring. This was most apparent at Lake Miltona due to its large size and longer distance between electro fishing stations (Table 5, Figure 3). A few fish moved long distances by the following spring. A tagged walleye stocked in Lake Miltona during October 1988 was captured the following spring by electrofishing at Station 3, a linear distance of 7.9 km. A tagged walleye stocked in Lake Ida during October 1986 was caught by electrofishing at Station 8, a linear distance of 5.8 km.

The rate of dispersal appeared to be related to lake size. In Lake Mary, stocked walleye were fully dispersed by age 2+ (Table 5). Mixed results were evident from Lake Ida

Table 4. Results of 3 and 10+-day coded wire tagging mortality tests from all three lakes combined, expressed as percent dead or moribund. Number indicates total number each of tagged and untagged fish held. Asterisk indicates a significant difference from Chi-square test.

	3-day			10+-Day		
	Number	Tag	Untag	Number	Tag	Untag
1986	1,350	2.1	2.7	1,000	25.4	17.2*
1987	500	16.0	15.4			
1988	575	12.2	11.7			
1990	200	10.5	10.5			

Table 5. Capture location by age of tagged fingerling walleye in relation to the tagging site and gear (electrofishing and gill nets). Electrofishing stations indicated "Away" and gill net groups indicated by superscript were at least 1 km from the tagging site on Lake Mary, 2 km on Lake Ida, and 4 km on Lake Miltona.[1]

Lake Mary

	Electrofishing		Gill Nets	
	Near	Away	North[2]	South
Age 1	31	9	6	2
Age 2	37	9	10	12
Age 3	4	5	2	4
Age 4	0	1	0	0

Lake Ida

	Electrofishing		Gill Nets		
	Near	Away	North[1]	Mid	South
Age 1	21	6	0	0	1
Age 2	29	19	7	2	4
Age 3	2	9	13	6	2
Age 4	1	0	1	2	2
Age 5	1	0	1	3	0

Lake Miltona

	Electrofishing		Gill Nets		
	Near	Away	West[2]	Mid	East
Age 1	76	9	4	2	1
Age 2	46	23	7	2	2
Age 3	15	11	15	7	4
Age 4	0	1	2	0	1
Age 5	0	1	0	0	0

[1] See Figures 1-3 for netting locations.
[2] Denotes gill net group closest to tagging site.

where electrofishing indicated complete dispersal by age 2. However, tagged walleye were more common in gill nets at age 3 near the tagging site (χ^2=8.86, P=0.012) than in those away from it. More tagged walleye were caught near the tagging site in gill nets (χ^2=11.24, P=0.004) at Lake Miltona than away from it through age 3. The same was true for electrofishing, but the differences were not significant.

Return by Harvest Method or Size

More tagged fish harvested by seining were recovered than expected from each lake (Table 6). Since three χ^2 tests (one for each lake) were performed, the level of significance was reduced to 0.02 (Zar 1984), and thus the differences were not significant. Two factors may have favored survival of the seined fingerlings. Seined fingerlings stocked in lakes Mary and Ida averaged about 20 mm longer than the trap netted fingerlings (Table 3). The two groups were of equal length at Lake Miltona, but the trap netted fingerlings were all from Otter Tail County. The longer hauling time may have stressed these fingerlings more.

Small sized fingerlings stocked during 1987 appeared to have lower survival rates than medium or large fingerlings, and were underrepresented in the tag collections from all three lakes (Table 6). The differences were significant (significance = 0.01 for six tests) for Lake Ida (χ^2= 14.23, P < 0.001) and Lake Miltona (χ^2=151.3, P < 0.001), but not for Lake Mary (χ^2=6.61, P = 0.039). Small stocked fingerlings of the 1988 year class were significantly underrepresented from Lake Miltona (χ^2=12.98, P = 0.002), but not from lakes Mary or Ida.

Contribution of Stocked and Natural Fingerlings

Tag returns from all gears and years were combined to reduce biases that samples from any one gear or year might introduce to evaluation of the contribution of stocking to year class strength. Head collections provided the largest samples of age 2 and older tagged fish from all three lakes (Table 7). Electrofishing samples provided mostly age 1 walleye. A high percentage of fish caught by electrofishing had

Table 6. Number observed and expected returns from all gear types of tag codes indicating harvest method or size at stocking from lakes Mary, Ida, and Miltona. P is from a x^2 test.

	Lake Ida		Miltona Lake		Lake Mary	
	Observed	Expected	Observed	Expected	Observed	Expected
1986						
Seine	22	15.8	56	45.4	56	45.4
Trap	23	29.2	36	46.6	42	52.6
	P = 0.056		P = 0.027		P = 0.033	
1987						
Small	7	15.6	3	9.6	5	35.9
Medium	27	25.2	34	42.4	31	45.6
Large	34	27.2	43	28.0	61	16.5
	P = 0.039		P < 0.001		P < 0.001	
1988						
Small	27	30.8	30	27.8	57	74.2
Medium	37	36.2	6	13.1	88	91.2
Large	13	9.2	16	11.1	67	46.6
	P = 0.386		P = 0.047		P = 0.002	

tags due to the incomplete dispersal discussed earlier, and the location of electrofishing stations at or near the tagging sites. This introduced some bias to first year post-tagging samples from Lake Miltona and, to a lesser extent, Lake Mary (Figure 4).

Natural reproduction was evident in all study lakes from 1986 through 1988. Fingerling stocking and natural reproduction contributed equally to the 1986 year class in Lake Mary, while natural reproduction accounted for approximately 60% of the 1987 and 1988 year classes (Table 7). In Lake Ida, natural reproduction contributed approximately 10% to the 1986, 60% to the 1987, and 40% to the 1988 year classes. Natural reproduction was most evident in Lake Miltona where it comprised 80% of the 1986, 70% of the 1987, and 60% of the 1988 year classes.

Walleye Year Class Strength

The relative strengths of year classes during the years tagged fingerlings were stocked were similar in all the study lakes. Each lake had a strong year class in 1986, weak in 1987, and moderate in 1988. The influence of fingerling stocking on year class strengths, however, varied greatly among lakes.

The variation in year class strength in Lake Mary was relatively low and the F-test for year class effect from the YCSM was not significant (Figure 5). The 1986, 1984, and 1979 walleye year classes were strongest in Lake Mary, while 1989 and 1988 were moderate (Figure 5). There was no stocking in 1979 or 1989, and high density fingerling stockings in 1984, 1986, and 1988 (Table 2).

No trends in walleye gill net CPUE occurred on Lake Mary during the study (Figure 6). This was consistent with the low variation in year class strength. Individual year classes did, however, influence gill net catches in some years. The highest walleye catch was 23.3/lift in 1988, and consisted mainly of the 1986 year class (Table 8). The lowest catch was 10.4/lift in 1987 which reflected the poor 1983 and 1985 year classes. CPUE from Lake Mary was always above the third quartile (9.7) for Lake Class 27 and always among the highest 15% of all statewide walleye catches.

Mean weights of walleye from gill nets in Lake Mary were consistent during the study and similar to those of previous surveys (Figure 6). The 1988 and 1991 samples were exceptions. During 1988, a high catch of the 1986 year class caused the mean weight to decline to 440 g. Mean weight was highest in 1991 due to a scarcity of age 1 fish and excellent growth by the 1987-1989 cohorts (Table 8).

Electrofishing data supported the YCSM showing strong 1984 and 1986 year classes

Table 7. Number of walleye observed, number with tags from various assessment methods, percent of fish stocked with tags, and the estimated contribution of natural reproduction to the cohort from lakes Mary, Ida, and Miltona.

1986 Cohort

	Lake Mary			Lake Ida			Lake Miltona		
	Observed	Tagged	% Tagged	Observed	Tagged	% Tagged	Observed	Tagged	% Tagged
Electrofishing	458	42	9.2	612	26	4.3	975	42	4.3
Gill nets	247	7	2.8	449	14	3.1	730	8	1.1
Creel	93	5	5.4	287	9	3.1	504	8	1.6
Heads	712	35	4.9	1,458	72	4.9	3,026	86	2.8
Total	1,510	89	5.9	2,806	121	4.3	5,235	144	2.8
Stocked			12.4			5.0			13.8
Contribution[1]									
Stocked			48%			86%			20%
Natural Reprod.			52%			14%			80%

1987 Cohort

	Lake Mary			Lake Ida			Lake Miltona		
	Observed	Tagged	% Tagged	Observed	Tagged	% Tagged	Observed	Tagged	% Tagged
Electrofishing	116	32	27.6	200	23	11.5	204	36	17.7
Gill nets	75	21	28.0	160	15	9.4	83	10	12.1
Creel	32	10	31.3	76	8	10.5	96	10	10.4
Heads	376	38	10.1	861	56	6.5	938	78	8.3
Total	599	101	16.9	1,297	102	7.9	1,321	134	10.1
Stocked			42.1			18.8			37.6
Contribution[1]									
Stocking			40%			42%			27%
Natural Reprod.			60%			58%			73%

1988 Cohort

	Lake Mary			Lake Ida			Lake Miltona		
	Observed	Tagged	% Tagged	Observed	Tagged	% Tagged	Observed	Tagged	% Tagged
Electrofishing	203	23	11.3	328	41	12.5	331	100	30.2
Gill nets	126	8	6.4	209	19	9.1	137	30	21.9
Creel	38	6	15.8	83	7	8.4	105	25	23.8
Heads	353	64	18.1	290	23	7.9	627	162	25.8
Total	720	101	14.0	910	90	9.9	1,200	317	26.4
Stocked			32.8			16.2			62.5
Contribution[1]									
Stocking			43%			61%			42%
Natural Reprod.			57%			39%			58%

[1] Percent stocked contribution = Total percent/stocked percent.

and a poor 1987 year class in Lake Mary (Figure 7). Electrofishing, however, also indicated a strong 1985 year class and mixed results for the 1988 and 1989 year classes. These results were not consistent with the YCSM. Low water levels beginning in 1988 changed habitat conditions at electrofishing stations.

Lake Ida had the most variable year class strength ($F = 9.54$, $P < 0.001$). The strongest year classes occurred in 1982 and 1986, and the 1988 year class was also good (Figure 5). Fry were stocked in 1982, and high density fingerling stocking occurred in 1986 and 1988 (Table 2). Tag returns indicated the 1986 year class was due almost exclusively to fingerling stocking, while natural reproduction contributed about 40% to the 1988 year class (Table 7). No stocking was conducted in Ida Lake in the years with weakest year classes (1983 and 1989).

Despite high variation in year class strength at Lake Ida, walleye gill net CPUE and mean weight were fairly stable during the study. Except in 1987, walleye gill net CPUE was consistently between 15 and 23/lift (Figure 6). The lower CPUE in 1987 appeared to be an

Table 8. Age distribution and mean length (mm) at capture by age of walleye caught by gill net in lakes Mary, Ida, and Miltona, July and August, 1986 - 1991.

Lake Mary

Age	1986 No.	1986 mm	1987 No.	1987 mm	1988 No.	1988 mm	1989 No.	1989 mm	1990 No.	1990 mm	1991 No.	1991 mm
1	6	275	3	211	15	249	15	255	16	277	7	253
2	95	337	19	310	124	314	32	339	65	356	46	380
3	17	446	41	373	42	387	59	379	16	411	32	430
4	16	459	9	478	25	429	11	438	39	439	12	472
5	13	468	6	499	6	478	8	452	12	489	18	483
6	8	483	5	552	4	471	2	491	15	482	4	544
7	9	529	8	529	2	568	2	539	2	525	1	514
8	6	500	3	573	3	536	4	521	1	485	1	604
9	3	546	3	526	3	585	2	548	1	480	1	503
10	2	509	4	493	0	-	1	536	1	619	1	644
>10	4	678	3	513	0	-	3	676	3	550	5	540

Lake Ida

Age	1986 No.	1986 mm	1987 No.	1987 mm	1988 No.	1988 mm	1989 No.	1989 mm	1990 No.	1990 mm	1991 No.	1991 mm
1	14	225	34	215	24	233	36	231	5	215	13	235
2	84	287	25	284	109	279	67	274	53	282	23	314
3	21	362	44	349	74	344	147	334	50	344	121	354
4	126	405	1	441	37	401	20	399	87	385	19	416
5	12	430	35	449	4	426	20	447	8	456	72	444
6	5	511	5	483	44	477	6	486	13	510	9	469
7	10	526	2	471	7	500	30	512	0	-	11	524
8	7	577	3	527	3	488	5	516	8	517	2	469
9	1	693	1	530	1	471	5	522	1	455	11	531
10	3	633	3	525	1	582	0	-	0	-	0	-
>10	2	709	3	510	0	-	4	600	2	516	8	589

Lake Miltona

Age	1986 No.	1986 mm	1987 No.	1987 mm	1988 No.	1988 mm	1989 No.	1989 mm	1990 No.	1990 mm	1991 No.	1991 mm
1	14	232	42	227	9	253	6	227	2	214	13	237
2	41	360	106	318	214	297	21	295	47	295	23	325
3	43	424	30	406	107	385	251	345	34	350	84	381
4	10	442	24	463	15	458	44	434	151	395	20	426
5	69	494	14	438	11	480	1	446	10	436	68	447
6	7	480	44	512	4	481	5	539	3	483	8	467
7	4	493	5	541	11	545	2	513	0	-	3	528
8	7	511	5	516	6	510	3	531	0	-	1	490
9	6	520	3	587	4	528	1	624	4	558	0	-
10	4	548	2	556	1	497	0	-	1	561	2	567
>10	8	560	12	547	2	677	0	-	1	562	1	526

anomaly, possibly caused by a combination of less fish movement at the time of netting and the very weak 1983 year class (Table 8). Even the 1987 CPUE, however, was above the third quartile of 8.2 for Lake Class 22 and statewide among the highest 15%.

Mean weight increased markedly in 1991 (Figure 6). This was caused by a high catch of age 5 fish from the 1986 year class (4.8/lift) combined with the lowest catch of age 2 fish (1.5/lift) during the study. Comparisons with historical data were not possible because previous Lake Ida nettings were done in June or July.

Electrofishing catch at age 2 agreed more closely with the YCSM than did catch at age 1 (Figure 7). The strength of the 1984 year class, however, was greatly overestimated and the 1986 year class was underestimated.

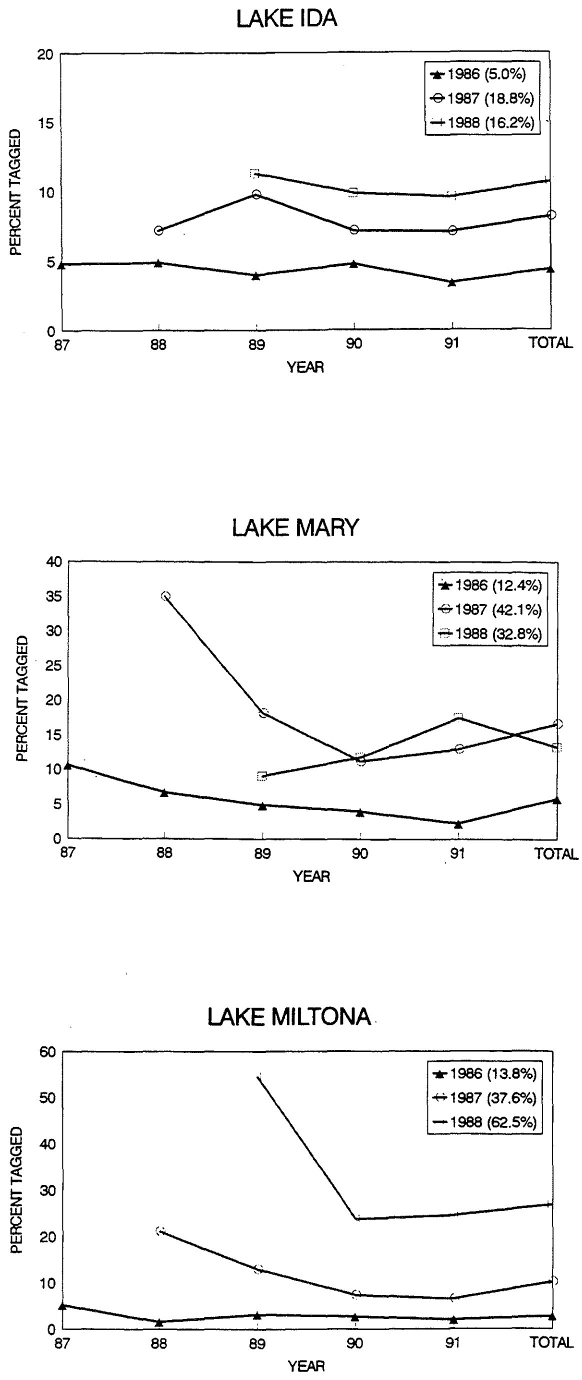


Figure 4. Percent of walleye sampled with tags by year class, for all years combined and all assessment methods from lakes Mary, Ida, and Miltona. Number in parenthesis in the legend is the percent of fish from that year class stocked with tags.

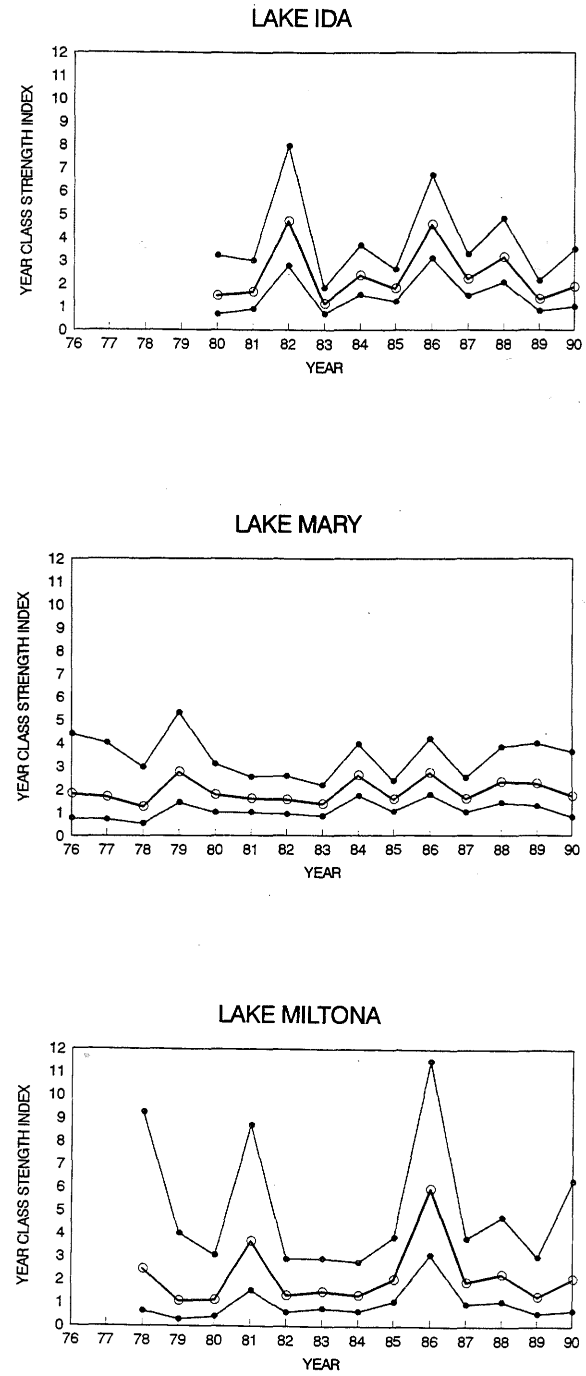


Figure 5. Plot of walleye year class strength index from linear model using Ln(gill net CPUE + 1) for ages 1 - 6. Outer lines indicates +/- two standard errors.

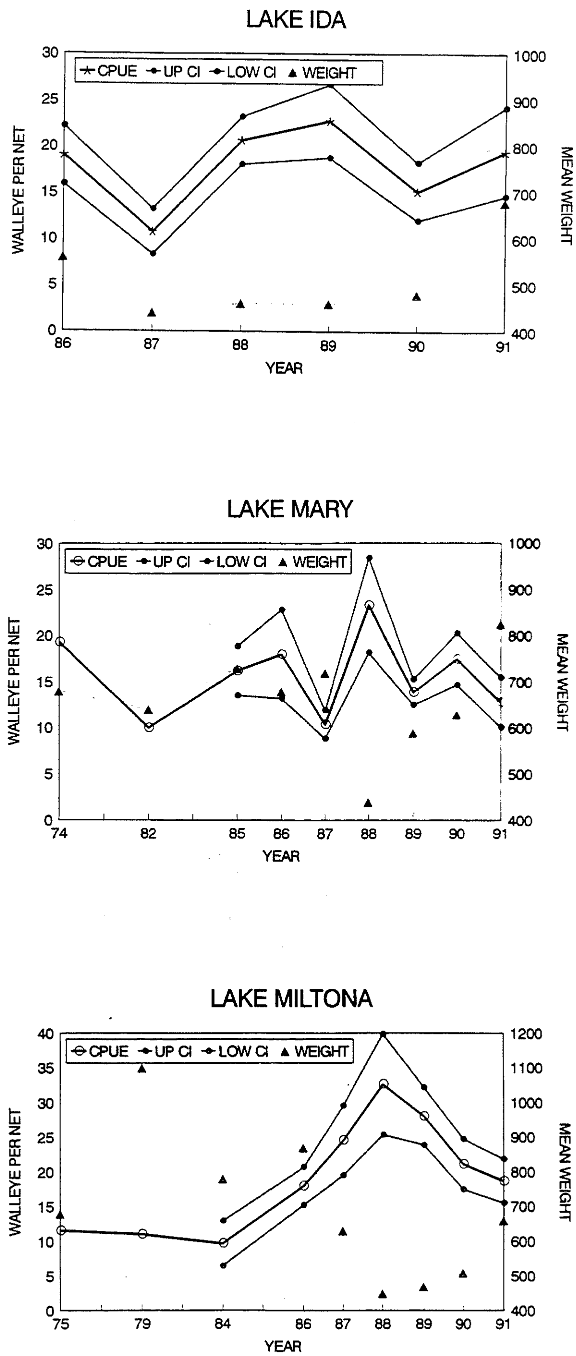


Figure 6. Gill net CPUE with 80% confidence intervals and mean weight of gill netted walleye from lakes Mary, Ida, and Miltona.

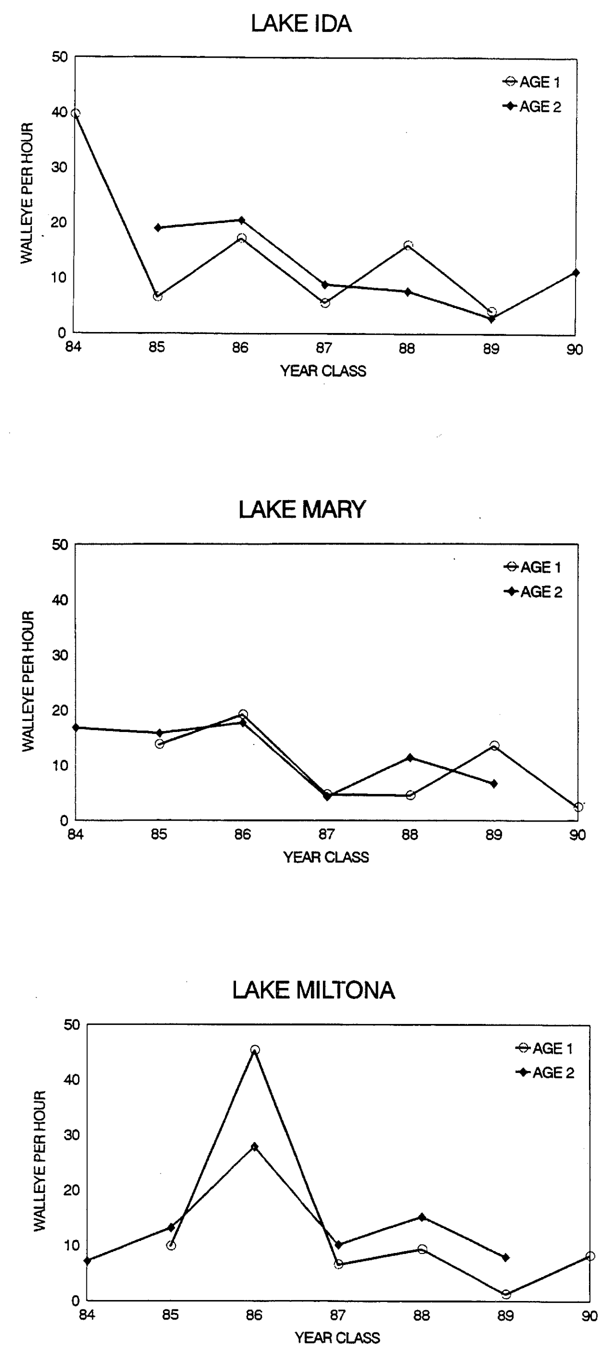
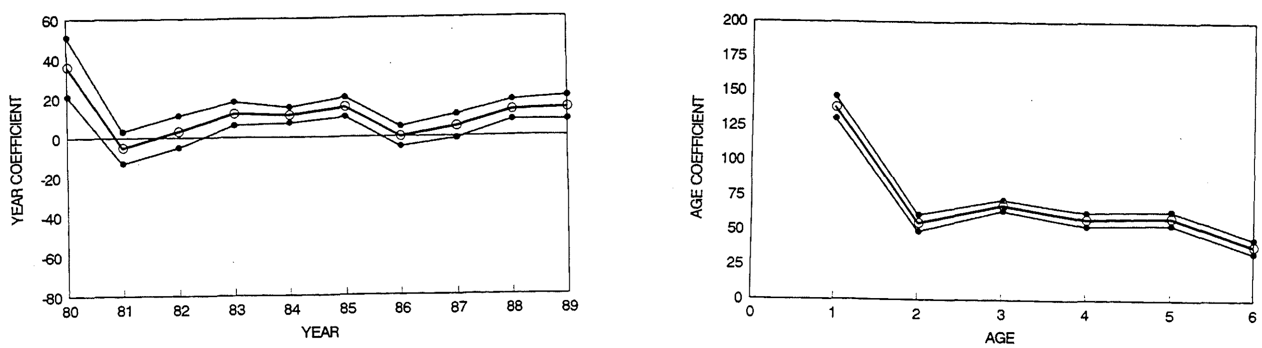
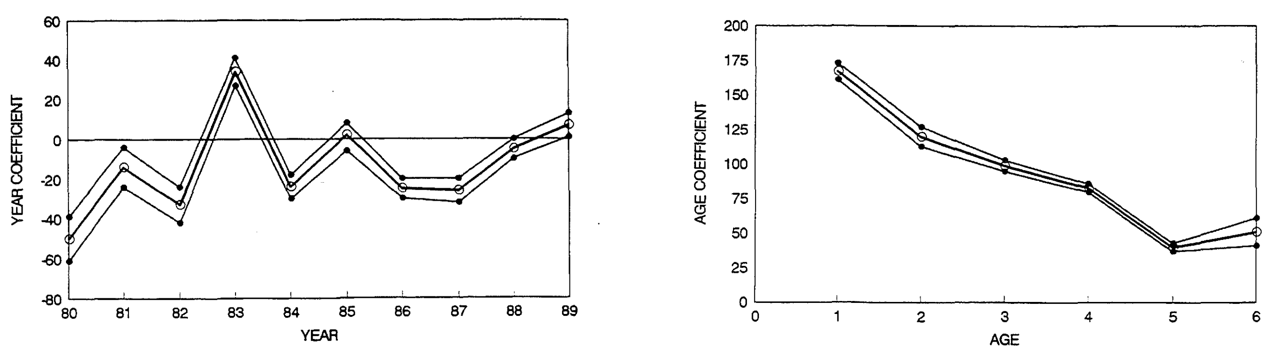


Figure 7. Spring electrofishing CPUE of age 1 and age 2 walleye from lakes Mary, Ida, and Miltona.

LAKE IDA



LAKE MARY



LAKE MILTONA

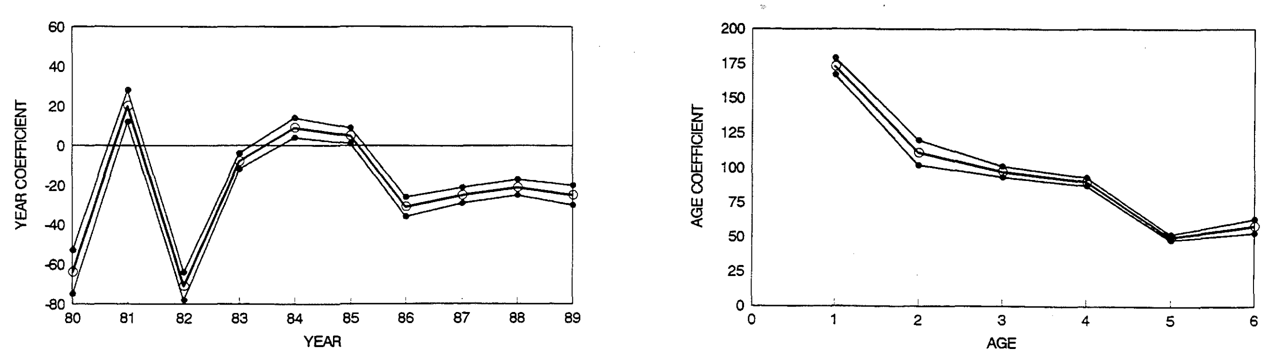


Figure 8. Year and age coefficients from the marginal lengths model for lakes Mary, Ida, and Miltona. Age coefficients are estimates of mean length increments in 1990. The year coefficients are a relative index of growth for each year with 1990 set to zero. Outer lines are 95% confidence intervals.

The strongest year classes in Lake Miltona occurred during 1986 and 1981 (Figure 5). Fingerlings were stocked at normal densities in 1986 (Table 2), but tag returns indicated that the year class was mainly due to natural reproduction (Table 7). Fry were stocked in 1981. These two strong year classes led to a significant year class effect (F = 3.34, P = 0.019) from the YCSM.

The gill net CPUE at Lake Miltona showed a clear pattern (Figure 6). CPUE began to increase in 1987 due to the 1985 year class, and peaked at 32.6/lift in 1988 due to the 1985 and 1986 year classes (Table 8). The CPUE then slowly declined through 1991 despite recruitment of the 1988 year class. CPUE was at least double the Lake Class 27 third quartile of 9.7/lift and exceeded values found in nettings done before this study (Figure 6).

Mean weight per gill netted walleye was inversely correlated with CPUE (r = -0.795, P = 0.034). The high mean weight in 1986 was due to the dominance of the 1981 year class, and low contributions from the 1983 and 1984 cohorts (Table 8).

Electrofishing also showed a strong 1986 walleye year class in Lake Miltona (Figure 7). Electrofishing CPUE, both at age 1 (r = 0.998, P < 0.001) and at age 2 (r = 0.978, P < 0.001) was strongly correlated with the YCSM for Lake Miltona.

Total mortality rates of walleye were similar among lakes. Annual mortality in Lake Mary was estimated to be 0.383 for ages 2-10 and 0.375 for ages 3-10. Mortality was slightly higher in lakes Ida and Miltona, 0.447 and 0.440, respectively, for ages 3-10.

Walleye Growth

No consistent trends in growth that could be related to intensive stocking from 1986 through 1988 were evident in the study lakes (Figure 8). Growth was less variable over time in Lake Ida (F_{year} = 19.6) than in either Lake Mary (F_{year} = 135.1) or Lake Miltona (F_{year} = 339.3). Annual growth coefficients were most similar between lakes Mary and Miltona. Walleye growth in both lakes was highly variable between 1980 and 1984. Growth in all three lakes during 1986 was relatively slower than during adjacent years. Strong walleye recruitment occurred in all three lakes in 1986.

Growth was considerably slower in Lake Ida, especially during the second year of life, than in lakes Mary and Miltona (Figure 8). Growth at age was similar in lakes Mary and Miltona. In both lakes there was a noticeable decline in length increments between ages four and five. A similar decline occurred between ages five and six in Lake Ida. These declines may be related to the onset of sexual maturity in female walleye. The slower second year growth in Lake Ida may have delayed sexual maturity by one year.

Age coefficients in Lake Ida declined sharply between ages 1 and 2 (Figure 8). The third growth increment was also larger than the second for most cohorts in Lake Ida. This suggests a low abundance of prey small enough to be eaten by walleye ≤ 200 mm. It further suggests a food bottleneck that may reduce survival between the time of stocking and the second growing season, thus limiting abundance.

Fish Community Changes

Changes in the fish community were noted in each lake during the study. The 1985 year classes of bluegill and largemouth bass were small in all three lakes. The summer of 1985 was cool and contributed to poor spawning success for bluegill and bass. There was no evidence that walleye stocking affected centrarchids.

Stomach contents from gill netted walleye and northern pike showed yellow perch were the primary prey in all three lakes (Tables 9 and 10). Any changes in the fish community related to walleye stocking should be evident in catches of northern pike or yellow perch.

Northern pike CPUE's from Lake Mary declined during the study. The decline, however, was not related to high density walleye fingerling stocking. Northern pike gill net CPUEs were normal for Lake Class 27 from 1988 through 1991, but less than one-half those from 1985 through 1987 (Figure 9). The lake level dropped 1.0 m in 1987 due to outlet channel maintenance, and remained low due to the

Table 9. Number of walleye stomachs examined and stomach contents of those with food from gill nets, lakes Mary and Miltona, 1987-1991, and Lake Ida, 1986-1991.

Lake Mary

	1987	1988	1989	1990	1991
Examined	104	227	136	172	126
With Food	25	109	61	59	64
Insects	4	2	0	1	0
Fish	21	108	61	58	64
Unknown	10	37	12	23	19
Adult Perch	6	15	14	6	26
Age 0 Perch	4	48	29	20	17
Darter[1]	0	1	1	1	0
Cyprinids[2]	1	9	5	6	2
Centrarchids[3]	2	15	2	2	5
Cisco[4]	0	0	1	0	0
Bullhead[5]	0	0	0	0	1
Carp[6]	0	0	1	0	0

Lake Ida

	1986	1987	1988	1989	1990	1991
Examined	275	158	305	328	214	290
With Food	130	68	142	115	67	106
Insects	27	40	34	26	3	22
Fish	114	35	113	99	64	88
Unknown	57	23	44	43	22	49
Adult Perch	15	2	25	11	12	9
Age 0 Perch	29	6	39	27	18	19
Darter[1]	0	1	5	8	0	3
Walleye	0	1	0	0	0	1
Cyprinids[2]	11	0	0	7	8	4
Centrarchids[3]	2	2	3	6	4	3
Cisco[4]	3	0	0	0	0	0
Bullhead[5]	0	1	1	0	0	0

Lake Miltona

	1987	1988	1989	1990	1991
Examined	271	389	336	247	216
With Food	128	194	180	131	108
Insects	24	9	8	2	1
Fish	113	185	177	129	107
Unknown	75	89	20	26	35
Adult Perch	12	23	22	10	6
Age 0 Perch	13	49	137	86	57
Darter[1]	0	1	1	1	0
Cyprinids[2]	13	27	4	9	1
Centrarchids[3]	0	1	6	0	4
Cisco[4]	1	1	0	0	3

[1]*Etheostoma* spp.
[2]Family Cyprinidal
[3]*Lepomis* spp.
[4]*Coregonus* artedi
[5]*Ameiurus* spp.
[6]*Cyprinus* carpia

Table 10. Number of northern pike stomachs examined and stomach contents of those with food from gill nets from lakes Mary, Ida, and Miltona, 1987-1991.

Lake Mary

	1987	1988	1989	1990	1991
Examined	135	67	45	46	42
With Food	19	20	12	14	18
Fish	19	20	12	14	18
Unknown	8	10	2	4	5
Adult Perch	5	4	7	3	8
Age 0 Perch	2	3	3	3	2
Darter[1]	0	0	1	0	0
Cyprinids[2]	0	0	0	1	2
Centrarchids[3]	4	3	0	2	1

Lake Ida

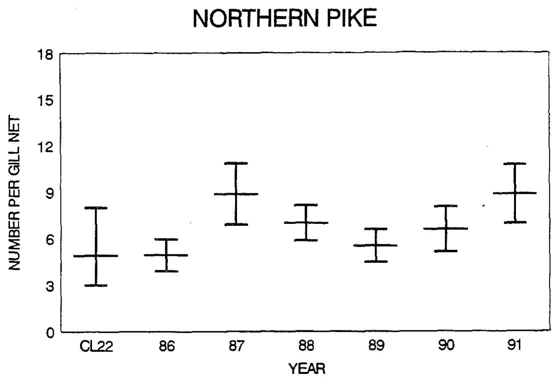
	1987	1988	1989	1990	1991
Examined	134	105	76	98	130
With Food	50	39	18	27	51
Insects	2	0	1	0	1
Crayfish	1	0	0	0	3
Fish	47	39	17	27	47
Unknown	14	11	3	4	21
Adult Perch	11	17	4	15	13
Age 0 Perch	6	6	1	3	0
Darter[1]	3	0	2	0	6
Walleye	4	2	3	0	0
Cyprinids[2]	1	0	0	3	0
Centrarchids[3]	5	5	3	1	6
Cisco[4]	6	0	0	1	0
Northern Pike	0	0	1	0	0

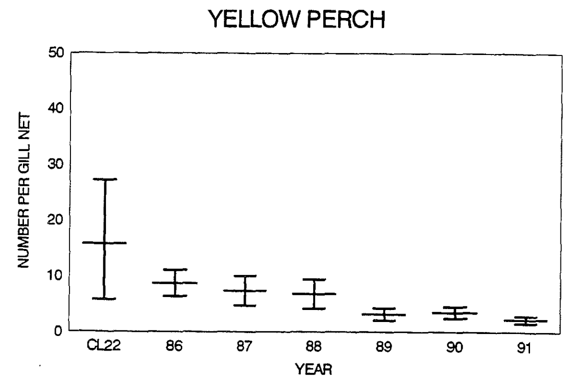
Lake Miltona

	1987	1988	1989	1990	1991
Examined	36	40	38	43	27
With Food	14	12	15	19	8
Fish	14	12	15	19	8
Unknown	3	3	1	4	3
Adult Perch	9	5	11	12	3
Age 0 Perch	0	1	1	1	0
Darter[1]	0	2	0	1	0
Cyprinids[2]	0	0	0	0	1
Centrarchids[3]	2	0	2	1	0

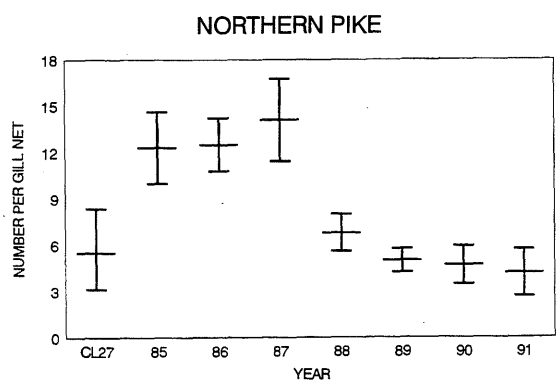
[1]*Etheostoma* spp.
[2]Family Cyprinidal
[3]*Lepomis* spp.
[4]*Coregonus* artedi

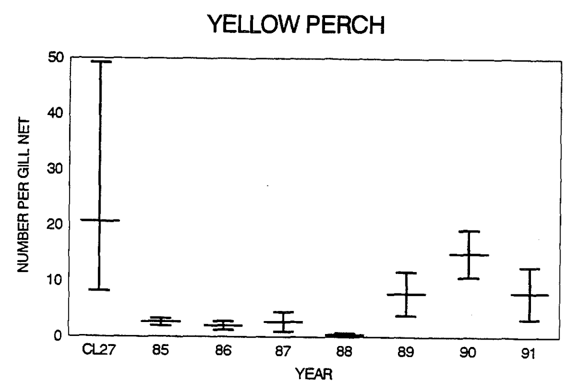
LAKE IDA



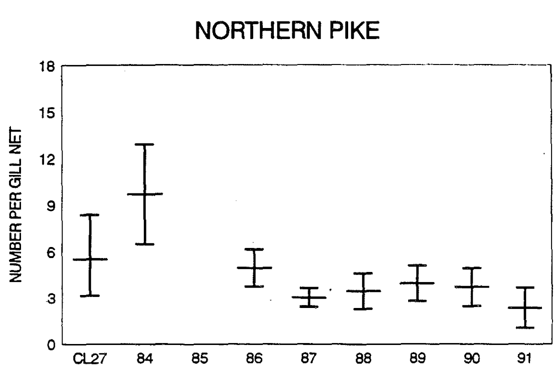


LAKE MARY





LAKE MILTONA



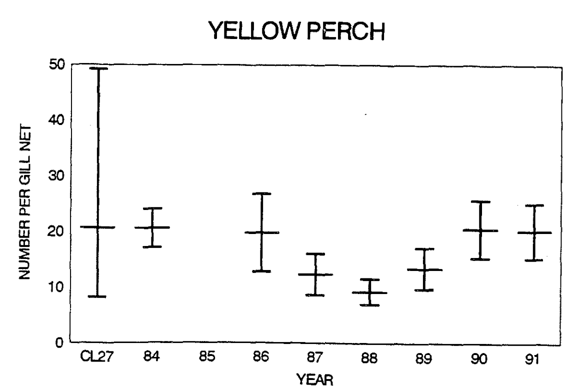


Figure 9. Gill net CPUE median with 80% confidence interval of northern pike and yellow perch from lakes Mary, Ida, and Miltona. Lake class median, and first and third quartiles are shown on the left side of each graph.

Table 11. Age distribution and mean length (mm) by age at capture for gill netted northern pike from lakes Mary, Ida, and Miltona, 1986-1991.

Lake Mary

Age	1986 No.	1986 mm	1987 No.	1987 mm	1988 No.	1988 mm	1989 No.	1989 mm	1990 No.	1990 mm	1991 No.	1991 mm
1	24	373	18	370	5	375	6	379	16	403	0	-
2	50	450	78	454	30	421	12	437	15	494	20	463
3	35	510	22	514	24	481	18	481	8	541	14	494
4	9	547	7	568	6	606	5	532	4	542	4	524
5	5	555	7	579	2	618	4	588	0	-	4	580
6	2	637	1	692	0	-	0	-	1	891	0	-
7	0	-	1	816	0	-	0	-	1	907	0	-
8	0	-	1	870	0	-	0	-	0	-	0	-

Lake Ida

Age	1986 No.	1986 mm	1987 No.	1987 mm	1988 No.	1988 mm	1989 No.	1989 mm	1990 No.	1990 mm	1991 No.	1991 mm
1	1	432	15	426	11	406	1	374	17	396	2	443
2	33	475	49	485	37	484	23	475	23	471	74	482
3	30	538	53	536	35	522	24	541	42	517	39	520
4	7	636	12	644	16	577	11	585	9	561	9	625
5	1	585	3	594	3	555	11	642	5	615	5	710
6	0	-	1	589	1	695	7	687	2	714	1	744
7	2	790	1	772	1	882	3	789	0	-	0	-
10	0	-	0	-	0	-	1	950	1	905	1	771

Lake Miltona

Age	1986 No.	1986 mm	1987 No.	1987 mm	1988 No.	1988 mm	1989 No.	1989 mm	1990 No.	1990 mm	1991 No.	1991 mm
1	3	457	11	398	7	396	2	412	5	410	1	401
2	23	504	8	500	23	516	15	516	16	513	12	499
3	26	596	12	596	6	557	12	582	19	588	7	553
4	5	625	3	607	4	670	2	661	3	707	6	601
5	3	623	1	522	0	-	4	715	1	824	0	-
6	0	-	0	-	0	-	2	710	0	-	0	-
7	0	-	1	717	0	-	1	780	0	-	0	-

onset of a drought period. The low lake level restricted access of pike to a large spawning area. The age structure of the gill net catch showed poor northern pike year classes beginning in 1987 (Table 11).

Yellow perch gill net CPUEs also changed at Lake Mary. CPUE was very low from 1985 through 1988, then approached or exceeded the Lake Class 27 first quartile of 8.2 beginning in 1989 (Figure 9). Length-frequencies from gill nets showed the 1986 and 1987 yellow perch year classes to be much stronger than the 1983-1985 or 1988 year classes (Figure 10).

Walleye stocking may have affected the yellow perch population in Lake Ida. Yellow perch gill net CPUE declined throughout the study and was below the Lake Class 22 first quartile of 5.8 by 1989 (Figure 9). The gill net length frequencies showed a substantial decline of yellow perch < 170 mm since 1988 (Figure 11). This suggests that the 1985-1988 yellow perch year classes in Lake Ida were low in abundance by the time they recruited to the gill nets. These year classes were all well represented as young-of-the-year (YOY) in shoreline seining samples (Table 12). Yellow perch were the dominant item in the stomachs of gill netted walleye (Table 9). Most of this sample consisted of the large 1986 walleye year class established by fingerling stocking. An abundant northern pike population also preyed mainly on yellow perch (Table 10). Northern pike gill net CPUE on Lake Ida was consistently above the

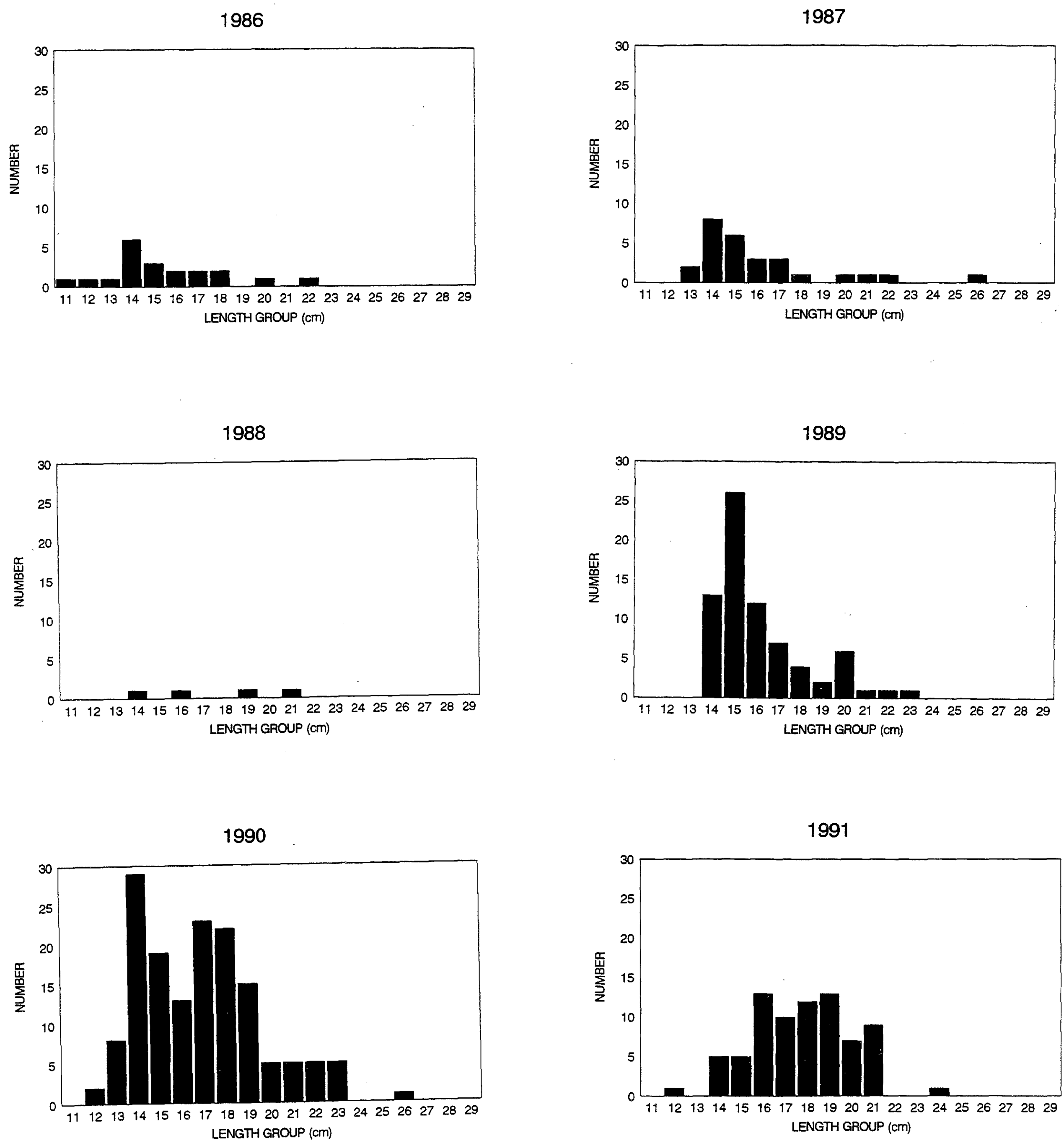


Figure 10. Length frequency of gill netted yellow perch from Lake Mary.

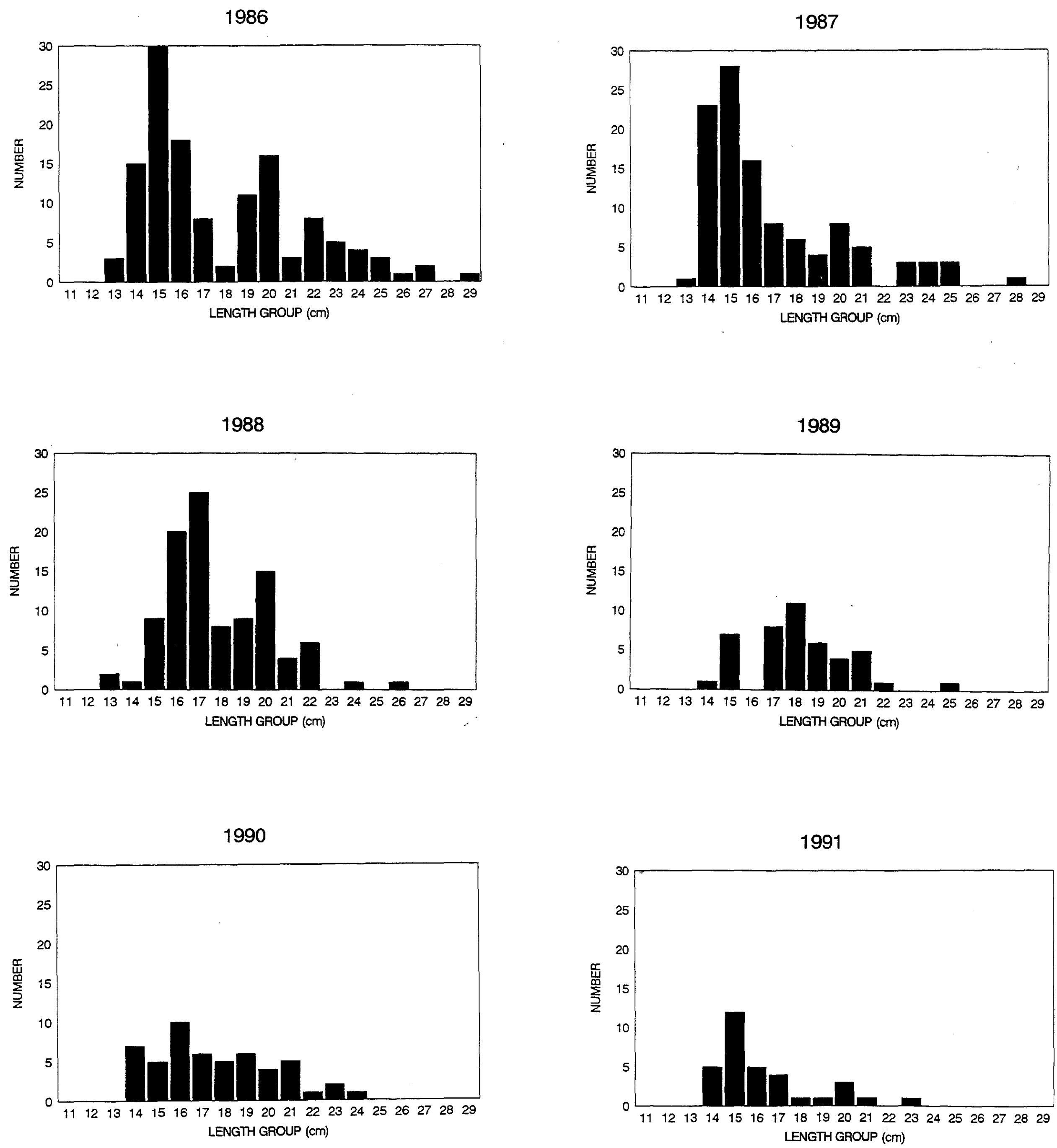


Figure 11. Length frequency of gill netted yellow perch from Lake Ida.

Table 12. Total catch and mean length (mm) (standard error) of age 0 yellow perch from nine shoreline seine hauls at lakes Mary, Ida, and Miltona, late August, 1986-1991.

	Lake Mary		Lake Ida		Lake Miltona	
	No.	mm	No.	mm	No.	mm
1986	225	53(0.31)	343	49(0.33)	351	49(0.33)
1987	983	61(0.17)	221	55(0.39)	198	50(0.43)
1988	344	60(0.19)	143	58(0.38)	187	52(0.40)
1989	324	58(0.18)	276	51(0.33)	1464	44(0.23)
1990	42	52(0.51)	648	45(0.22)	333	48(0.43)
1991	122	51(0.41)	3	52(1.20)	27	51(1.34)

Lake Class 22 median and exceeded the third quartile in 1987 and 1991 (Figure 9).

Predation by young walleye may have reduced yellow perch recruitment in Lake Miltona. Gill net CPUE of yellow perch (Figure 9) was inversely correlated with CPUE of walleye at Miltona Lake (r = -0.923, P = 0.003). Poor yellow perch year classes from 1985 and 1986 were evident from the gill net length frequencies (Figure 12). Natural reproduction of walleye occurred in 1985 and was substantial in 1986. Stomach contents of gill netted walleye were dominated by YOY yellow perch (Table 9). Although northern pike stomachs usually contained adult yellow perch (Table 10), the low population of pike in Lake Miltona probably limited their influence on yellow perch numbers. Northern pike abundance in Lake Miltona was lowest among the study lakes, falling below the first quartile for Lake Class 27 lakes in 1991 (Figure 9).

Gill net CPUE of white sucker at Miltona Lake was inversely related to walleye abundance (r= -0.768, P = 0.049). No white sucker were aged and no white sucker were seen in walleye stomachs.

Walleye Angling

High density fingerling stocking did not improve walleye angling on Lake Mary. Walleye harvest rates and yields were lower 3 to 5 years after high density stocking than they were earlier (Table 13). Harvest rates and yields during 1990 and 1991 were less than one-half the average of the previous four years (Figure 13).

The poorer walleye angling at Lake Mary was not consistent with the high gill net catches of walleye. Furthermore, the abundance of the 1986, 1988, and 1989 year classes, which should have supported the fishery, was above average (Figure 5). Harvest rates by anglers seeking walleye were significantly correlated with the previous year's electrofishing CPUE of age 2-4 walleye (r = 0.875, P = 0.023). Spring harvest rates from Lake Mary were similar throughout the study, but lower harvest rates during the summer and fall accounted for the decline in 1990 and 1991 (Table 13, Figure 13). High prey abundance has been associated with lower fishing success for walleye (Forney 1967; Serns and Kempinger 1981). The increased abundance of yellow perch from 1989 through 1991 may have made walleye more difficult to catch.

A strong 1986 year class established by fingerling stocking influenced walleye angling at Lake Ida. Harvest rates during 1989 were more than twice the average of 1986-1988, remained high during 1990, and returned to earlier levels in 1991 (Table 13). The 1989 yield of walleye was 48% higher and the 1990 yield 35% higher than the 1986-88 average (Figure 13). Walleye harvest rates were not correlated with CPUE from any population assessment method.

The 1986 year class at Lake Miltona also improved walleye angling success. Harvest rates during 1988 were more than twice and during 1989 and 3.4 times those of 1986-1987 (Figure 13). Harvest rates returned to 1986-1987 levels during 1991. Walleye yields from 1988 through 1990 were the highest recorded during the study. A creel survey at Lake Miltona during 1983, when the large 1981 year class was recruiting, recorded harvest rates by walleye anglers of 0.16/hr in May-June, 0.14/hr in July-August, and 0.38/hr in September-October, and averaged

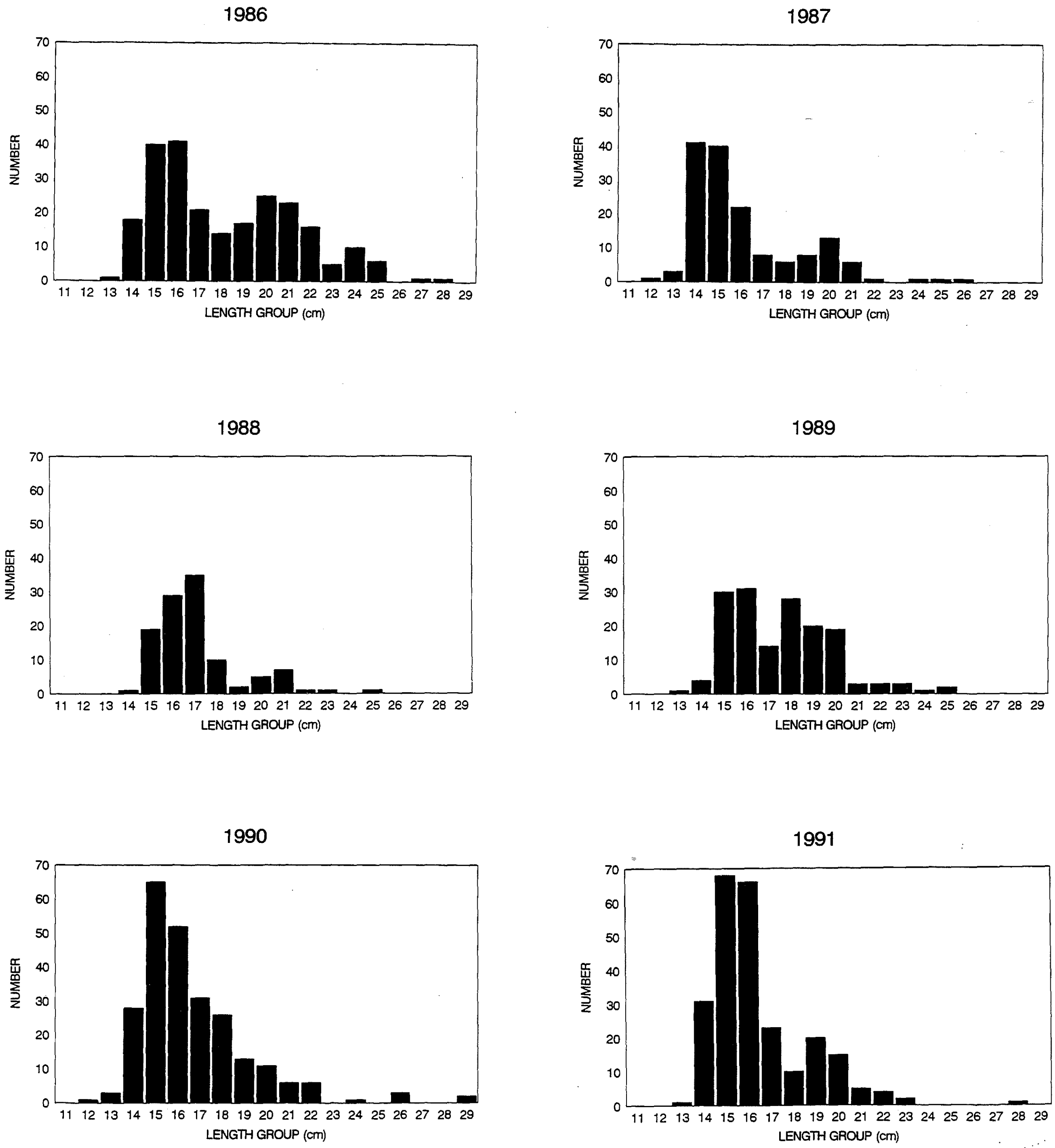


Figure 12. Length frequency of gill netted yellow perch from Lake Miltona.

Table 13. Estimated walleye harvest rates (standard error) by season, lakes Mary, Ida, and Miltona during the open-water seasons, 1986-1991.

Year	Spring	Summer	Fall	All Seasons
Lake Mary				
1986	0.10(0.02)	0.13(0.03)	0.05(0.06)	0.11(0.02)
1987	0.07(0.01)	0.07(0.03)	0.08(0.07)	0.07(0.01)
1988	0.11(0.05)	0.10(0.05)	0.41(0.09)	0.13(0.04)
1989	0.11(0.04)	0.22(0.08)	0.26(0.08)	0.15(0.04)
1990	0.06(0.04)	0.05(0.02)	0.00(0.00)	0.06(0.02)
1991	0.08(0.01)	0.00(0.00)	0.02(0.02)	0.06(0.02)
Mean	0.09	0.09	0.14	0.10
Lake Ida				
1986	0.12(0.07)	0.16(0.07)	0.30(0.04)	0.19(0.05)
1987	0.09(0.04)	0.16(0.05)	0.22(0.06)	0.14(0.03)
1988	0.10(0.06)	0.14(0.02)	0.51(0.15)	0.18(0.05)
1989	0.39(0.09)	0.32(0.06)	0.63(0.16)	0.41(0.06)
1990	0.30(0.08)	0.26(0.05)	0.33(0.11)	0.29(0.04)
1991	0.13(0.05)	0.27(0.05)	0.36(0.09)	0.21(0.04)
Mean	0.19	0.22	0.38	0.24
Lake Miltona				
1986	0.07(0.06)	0.11(0.04)	0.05(0.03)	0.09(0.04)
1987	0.08(0.05)	0.17(0.08)	0.01(0.01)	0.10(0.04)
1988	0.11(0.02)	0.23(0.06)	0.41(0.11)	0.19(0.04)
1989	0.23(0.07)	0.26(0.06)	0.70(0.15)	0.33(0.05)
1990	0.09(0.02)	0.23(0.05)	0.28(0.07)	0.18(0.03)
1991	0.04(0.01)	0.10(0.03)	0.12(0.06)	0.08(0.02)
Mean	0.10	0.18	0.26	0.16

Table 14. Estimated open-water walleye harvest by cohort from Lake Mary. Values estimated by the linear year class model are in parenthesis. Apportionment of natural and stocked fish was determined by tag returns for the 1986-1988 cohorts. Cost per fish is based on $0.30/fingerling stocked.[1]

	Cohort								
Age	1981	1982	1983	1984	1985	1986	1987	1988	1986-88
2	(446)	(432)	(380)	1,620	215	943	301	243	
3	(1,115)	(1,080)	442	2,664	2,702	1,429	400	810	
4	(620)	957	274	1,886	636	375	389	(906)	
5	368	167	535	424	57	261	(271)	(399)	
6	119	267	127	12	143	(237)	(139)	(204)	
7	141	34	12	26	(51)	(88)	(51)	(75)	
8	51	6	3	(33)		(20)	(35)	(20)	(30)
Total	2,859	2,943	1,773	6,665	3,823	3,368	1,571	2,666	7,605
Natural						1,751	943	1,520	4,214 (55%)
Stocked						1,617	628	1,146	3,391 (45%)
Number Stocked						132,648	38,498	50,682	221,828
%Return						1.2	1.6	2.3	1.5
Cost						$24.61	$18.39	$13.27	$19.63

[1] KMPG Peat Marwick 1990.

Table 16. Estimated open-water walleye harvest by cohort from Lake Miltona. Values estimated by the linear year class model are in parenthesis. Apportionment of natural and stocked fish was determined by tag returns for the 1986-1988 cohorts. Cost per fish is based on $0.30/fingerling stocked.[1]

	Cohort								
Age	1981	1982	1983	1984	1985	1986	1987	1988	1986-88
2	(3,242)	(1,171)	(1,325)	0	2,565	7,284	2,426	1,509	
3	(6,389)	(2,308)	1,817	2,101	5,552	11,436	3,830	2,278	
4	(3,130)	202	1,459	993	2,900	7,308	1,137	(1,933)	
5	1,615	730	802	445	1,075	2,389	(890)	(1,054)	
6	2,278	255	242	172	302	(1,493)	(480)	(568)	
7	1,210	135	63	93	(276)	(810)	(259)	(308)	
8	561	72	9	(95)		(144)	(424)	(136)	(161)
Total	18,424	4,873	5,717	3,899	12,814	31,143	9,158	7,810	48,111
Natural						24,914	6,685	4,530	36,129 (75%)
Stocked						6,229	2,473	3,280	11,982 (25%)
Number Stocked						135,383	39,745	25,788	200,916
%Return						4.6	6.2	12.7	6.0%
Cost						$6.52	$4.82	$2.36	$5.03

[1] KMPG Peat Marwick

0.20/hr for the season (Schalekamp and Nelson 1986). These results were similar to those observed in 1988 (Table 13).

Low angling success and the abundance of naturally reproduced walleye in Lake Mary caused a very low return to the angler of stocked fingerlings. Stocked walleye provided 45% of the harvest from the 1986-1988 cohorts, but this was fewer than 3,400 fish (Table 14). Returns to the open-water creel from the three tagged cohorts averaged 1.5%, and ranged from 1.2% to 2.3% of fingerlings stocked. Winter angling pressure was approximately 20% of open-water pressure during the winter of 1990-1991, and walleye harvest rates were similar to the open-water seasons (Parsons and Pereira, in prep.). Total returns of the three tagged cohorts to the creel, including winter harvest, was estimated at 1.8% giving a cost of $16.35 per stocked walleye returned to the angler.

The return of stocked fingerlings to the creel was highest at Lake Ida. Fingerling stocking contributed an estimated 37,000 walleye to the creel (Table 15). The return was relatively consistent for the tagged 1986-1988 year classes and averaged 7.0% (Table 15). Cost per fish for the three tagged cohorts returning to the creel ranged from $3.62 to $4.66 and averaged $4.27. The winter walleye harvest was negligible compared to the open-water harvest (Parsons and Pereira, in prep.), and did not lower the cost per walleye returned to the creel.

Returns of walleye stocked during 1986-1988 at Lake Miltona and returned to the open-water creel ranged from 4.6% to 12.7% of stocked walleye and averaged 6.0% (Table 16). Fingerling stocking provided an estimated 12,000 fish to the creel. Winter angling pressure was 40,700 hrs in 1990-1991, approximately 30% of open-water estimates (Parsons and Pereira, in prep.). Harvest rates by walleye anglers were 0.10/hr, which meant that the winter walleye harvest contributed an estimated 25% of the total harvest. Total returns to the creel, including winter harvest, was estimated at 7.5% giving a cost of $4.02 per stocked walleye returned to the angler. Only 25% of the total catch, however, from the three year classes that included tagged fingerlings, could be attributed to fingerling stocking.

ERRATA

Minnesota Department of Natural Resources
Investigational Report 435, 1994

EVALUATION OF WALLEYE FINGERLING STOCKING
IN THREE WEST-CENTRAL MINNESOTA LAKES

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Table Errata

Page 26 Correction - Add Table 15

Table 15. Estimated open-water walleye harvest by cohort from Lake Ida. Values estimated by the linear year class model are in parenthesis. Apportionment of natural and stocked fish was determined by tag returns for the 1986-1988 cohorts. Cost per fish is based on $0.30/fingerling stocked.[1]

Age	1981	1982	1983	1984	Cohort 1985	1986	1987	1988	1986-88
2	(1,425)	(4,082)	(984)	3,528	1,088	2,142	3,183	1,013	
3	(2,973)	(8,518)	1,129	5,691	3,199	7,485	5,632	4,629	
4	(2,828)	8,186	855	4,907	3,429	8,990	4,118	5,421)	
5	847	4,506	488	1,557	1,390	3,719	(1,524)	2,181)	
6	466	2,006	109	434	287	(1,047)	(506)	(724)	
7	190	1,284	116	415	(298)	(758)	(367)	(525)	
8	82	333	32	(117)		(89)	(226)	(109)	(156)
Total	8,811	28,914	3,713	16,649	9,780	24,367	15,439	14,648	54,454
Natural						3,411	8,955	5,713	18,079 (33%)
Stocked						20,956	6,484	8,935	36,375 (67%)
Number Stocked						325,389	84,165	107,948	517,502
%Return						6.4	7.7	8.3	7.0
Cost						$4.66	$3.89	$3.62	$4.27

[1] KMPG Peat Marwick 1990.

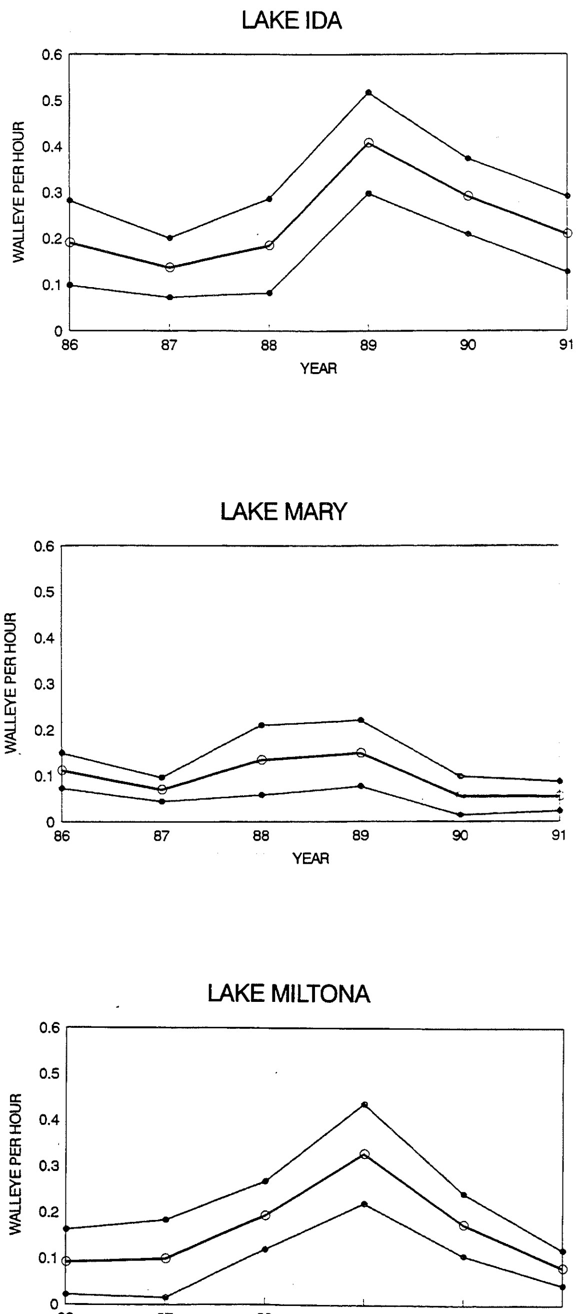

Figure 13. Harvest rate of walleye by anglers seeking walleye on lakes Mary, Ida, and Miltona Lakes. Outer lines indicate +/- two standard errors.

Discussion

The effects of high density walleye fingerling stocking on the walleye sport fisheries of two lakes were inconsistent. A strong year class was created by stocking in Lake Ida in 1986 and walleye angling improved for two years. Catch rates were higher 2 to 3 years after the 1986 stocking and yields were higher 3 to 4 years later. On the other hand, catch rates and yields from Lake Mary 3 to 5 years after stocking declined to low levels. Walleye angling success improved markedly at Lake Miltona, the reference lake, due to a strong natural 1986 year class. Subsequent fingerling stockings in 1987 and 1988 (high density in Lake Ida and normal density in Lake Miltona) did not prevent harvest rates and yields from declining. Bandow et al. (1993) found similar results from lakes Madison and Elysian in southern Minnesota. Both lakes had good walleye fisheries in 1988 and 1989 due to strong 1986 year classes. Harvest rates, however, fell over 60% in 1990 due to the failure to establish a strong 1988 year class with fingerling stockings.

Walleye from each of the stocked cohorts survived and were caught by anglers from the three study lakes. Naturally hatched walleye of the 1986-88 cohorts were also present and caught from each lake. The harvest of stocked fish exceeded that of naturally hatched fish from Lake Ida, but not from lakes Mary and Miltona. The positive results from Lake Ida were mainly due to the very successful 1986 stocking.

The presence of fish from each stocking and of naturally hatched fish from each year of stocking in the anglers catch raises a question. Were the stocked fish an addition to the anglers catch or a substitution for natural fish that might otherwise have survived? There is no clear answer to the question. The 1986 year class established by stocking Lake Ida appears to be an addition. Harvest rates and yields increased substantially though gill net CPUE remained within historic ranges. On the other hand, fishing success and walleye yield declined at Lake Mary following high density stocking, and gill net CPUE remained within historic ranges. This suggests that stocking did not make a significant addition at Lake Mary. The higher harvest rates, yields, and gill net CPUE at Lake Miltona from 1988 through 1990 were mainly due to the strong, natural 1986 year class. Fishing at Lake Miltona would probably have been just as good without stocking which indicates a replacement of natural fish.

Natural reproduction was more variable in Lake Ida than in lakes Mary and Miltona. Since natural reproduction was less evident in Lake Ida, stocking could be considered maintenance stocking by Laarman's (1980) definition. Many authors have reported successful results from maintenance fingerling stocking. Summer fingerling stocking established a substantial walleye fishery in a 363 hectare southern Minnesota bass-panfish lake (Groebner 1960). In 341 hectare Seven Island Lake, Wisconsin, Hauber (1983) found a substantial contribution of stocked fish at age 1+ during a period of poor natural reproduction. In West Okoboji Lake, Iowa, stocked fall fingerlings contributed significantly to the YOY population, and the highest number of fall fingerlings stocked corresponded to the highest fall YOY population estimate (McWilliams and Larscheid 1992). Laarman (1980) found that stocked fall fingerlings accounted for 90% of the walleye population in 348 hectare Manistee Lake, Michigan, but only 3.5% of stocked fish were harvested by anglers. On the other hand, the high yields at Lake Ida were similar to those at Mille Lacs Lake, Minnesota which has highly variable recruitment and supports a good walleye fishery without stocking (MN DNR, unpublished data).

Natural reproduction contributed more at lakes Mary and Miltona, and fingerling stocking was less effective. This is consistent with Laarman's (1980) finding that supplemental stocking was usually not successful. Variation of year class strength was low at Lake Mary, suggesting relatively consistent recruitment. Lake Miltona was supported by strong natural year classes. These results are similar to those of other studies of supplemental fingerling stocking. In Escanaba Lake, Wisconsin, Kempinger and Churchill (1972) estimated that three of four summer fingerling stockings on top of an established, naturally reproducing population yielded only 1% of stocked fish to the creel. The other stocking yielded 13% to the creel. In Pike Lake (211 hectare) Wisconsin, Mraz (1968) found stockings of 4,000 to 5,000 fall fingerlings per year did not augment the population. Presence of natural walleye was 50 times greater than that of stocked fish in later years. Two years of summer fingerling stocking at rates of 143 and 168/hectare in 694 hectare Many Point Lake, Minnesota did not increase angling catch rates (Olson and Wesloh 1962).

The cost of stocked walleye returned to the creel depends on survival of stocked fish and successful harvest by anglers. The cost was very high at Lake Mary. Stocked fingerlings survived since they contributed 40-50% of the estimated harvest, but walleye angling success was low. Less than 2% of the stocked fingerlings were eventually caught. High density fingerling stocking did not produce a very strong year class during the study. Strong year classes are apparently necessary for walleye angling to improve, as was the case at lakes Ida and Miltona.

The costs of stocked walleye were lower at lakes Ida and Miltona because anglers harvested a higher percentage of the stocked fingerlings. This study, however, raised questions about whether fingerling stocking was the most efficient management for these lakes. The cost of the fingerling stocking that produced the strong 1986 year class on Lake Ida was over $70,000. An equally strong 1982 year class in Lake Ida was the result of either natural reproduction or fry stocking. The 4 million fry stocked in 1982 cost only $2,000 ($0.50/1000 fry, MNDNR file data).

The estimated cost per fingerling returned to the creel relied on the assumption that we could predict harvest of stocked walleye older than age 6 after 1991. No creel surveys of the study lakes were conducted after 1991. We were able to do this by using the YCSM and harvest estimates of older fish from 1986-91. Kempinger and Churchill (1972) found that only 12% of a walleye cohort's contribution to the fishery occurred at ages 6 or older at Escanaba Lake, Wisconsin. Forecasts of the harvest of the three tagged year classes at ages 6-8 were 11-13% for Lake Mary, 6-10% for Lake Ida, and 9-13% for Lake Miltona.

Strong year classes in Lake Ida (1982) and in Lake Miltona (1981) corresponded with fry stocking. Several studies have shown that walleye fry stocking produced better results than fingerling stocking in lakes where natural reproduction had become poor or variable. Schweigert et al. (1977) found fry stocking produced a very strong year class in a 160 hectare Manitoba lake, whereas fall fingerling stocking did not. Fry were more influential in establishing the most abundant year classes than fall fingerlings in Rathbun Lake, Iowa (Mitzner 1992). Mitzner (1992) also estimated the cost per live walleye the following spring at $0.22 for those stocked as fry and $1.08 to $1.50 for fall fingerlings due to differential overwinter survival. McWilliams and Larscheid (1992) attributed strong year classes in East Okoboji Lake, Iowa, to fry stocking rather than fall fingerling stocking.

Lower mortality may favor survival of fingerlings from natural reproduction or fry stocking. Stocked fingerlings may experience mortality rates of 10% to 20% due to harvest and transportation (Lound and Dobie 1958; Laarman 1980; Schreiner 1985). The mortality tests conducted during this study showed similar results. McWilliams and Larscheid (1992) reported that fingerlings stocked in the fall in Iowa lakes experienced overwinter mortality rates 2-16 times greater than fingerlings originating from natural reproduction or fry stockings. Mitzner (1992) reported mortalities of fall stocked fingerlings 1.2 to 11 times that of fingerlings originating from fry stocking at Rathbun Lake, Iowa. Mraz (1968) estimated that survival of native fingerlings was 50 times greater than that of stocked fish of the same age one year after stocking.

Area management information strongly suggests natural reproduction or a combination of natural reproduction and fry stocking is quite successful in Lake Class 22 and 27 waters. Walleye harvest rates from creel surveys on five other Lake Class 27 waters, while this study was underway, were as good or better than those seen in the study waters. Lakes Minnewaska (0.22 walleye/hr, Kessler 1990), Osakis (0.17/hr, Kessler 1991), and Little Pine (0.24/hr, Kavanaugh 1991) were all managed with fry stocking. Fry stocking was stopped on Big Pine Lake (0.32/hr, Kavanaugh 1991) because it was determined that natural reproduction supported the walleye fishery. In Lake Reno (0.40/hr, Kessler 1990), good year classes have been produced with fry, fingerlings, or no stocking.

Few changes in the fish communities occurred in the three study lakes during the fingerling stocking evaluation. In Lake Mary, northern pike abundance decreased and yellow perch abundance increased, but this was probably unrelated to walleye stocking. Colby et al. (1987) discussed several studies where declines in northern pike abundance allowed yellow perch populations to expand. This was probably the case in Lake Mary as well. Yellow perch abundance declined throughout the study in Lake Ida. Predation by the consistently high walleye and northern pike populations probably exerted strong predatory pressures on the yellow perch. Walleye can severely deplete a year class of YOY yellow perch (Forney 1977), whereas predation by northern pike on yellow perch sizes critical to recruitment of spawners magnifies the effects on the yellow perch population (Anderson and Schupp 1986). Cannibalism by walleye becomes more intense when YOY yellow perch are not abundant enough to act as a buffer (Chevalier 1973; Forney 1974). Lake Ida was the only lake in this study where walleye cannibalism and predation by northern pike on walleye were observed. More benthic invertebrates were consumed by walleye in Lake Ida than in the other two lakes. Lake Ida was also the only lake where invertebrates were found in northern pike stomachs. The consumption of invertebrates and slower growth of walleye in Lake Ida suggests that trophic interactions and walleye stocking should be closely monitored.

The results of this study suggested suppression by a large walleye year class of a following year class. The 1986 year class was the strongest in each study lake, and 1987 was poor in each lake. The 1986 year class in Lake Miltona was extremely strong and may also have affected the 1988 stocking. Small fingerlings from 1987 stockings were underrepresented in the 3 lakes and from the 1988 stocking in Lake Miltona. Cannibalism by older walleye is most intense on the smaller individuals of following year classes (Chevalier 1973). Higher tagging mortality for small fingerlings could produce similar results, but small fingerlings from the 1988 year class were not underrepresented in lakes Mary or Ida. Thus predation or some other cause of natural mortality, such as competition for a common food resource, seems more likely. Increased foraging effort may have reduced growths rate of the 1987 year classes prolonging their vulnerability to larger predators.

The inverse correlation between gill net CPUE of walleye and yellow perch at Lake Miltona suggests that a high walleye population can depress the forage base. Also, growth of the 1986 and 1987 walleye year classes was slower than for other year classes. Therefore, we urge caution about attempting to keep the Lake Miltona walleye population consistently at the high levels of 1988-1990.

Total annual mortality rates of walleye in the three study lakes were generally lower than others reported in Minnesota (Strand 1980; Thorn 1984; Osborn and Schupp 1985). Mortality was lower in Lake Mary than in lakes Ida and Miltona. This was likely due to substantially lower exploitation rates in Lake Mary.

Coded wire tags proved to be a suitable method for marking walleye fingerlings. Tag retention was excellent, and handling mortality did not bias the results. The 10+-day mortality test on tagged fingerlings indicated lower survival. Heidinger and Cook (1988) also found higher mortality of tagged walleye fingerlings. Heidinger and Cook (1988), however, tagged very small fingerlings (51-75 mm), and conducted their experiment in the summer at water temperatures ≥ 20°C. Their results, therefore, are not directly applicable to this study because we tagged fingerlings ≥ 100 mm at temperatures ranging from 7 to 19°C. Larger sized walleye fingerlings and lower temperatures reduce handling/hauling mortality rates.

Field data provided good evidence that tagging mortality was not higher than mortality due to pond harvest and transportation. Of the fingerlings stocked in 1986 in Lakes Ida, 5% were tagged. Samples of the 1986 year class during 1987, 1988, and 1990 indicated that 4.8%-4.9% were tagged. Even if tagging mortality was somewhat higher than pond harvest and transport mortality, it was compensated for by the manner in which untagged fingerlings were stocked. Untagged fingerlings were stocked directly in the lake, and no allowance was made for weak fish that probably would have died if held overnight. Schreiner (1985) investigated standard Minnesota walleye fingerling harvest, handling, and hauling techniques. He found fingerlings held 48 hours in mesh cribs had a 10% mortality rate and an additional 10% were moribund. Similarly, Laarman (1980) estimated initial stocking mortality due to handling and transportation ranged from 2-16% with a mean of 10%.

No significant differences in mortality were found between seined and trap netted fingerlings. Confounding factors were seined fingerlings were 20 mm longer as compared to trap netted fingerlings, and trap netted fingerlings of equal length to seined fingerlings were transported a longer distance. This is similar to mortality rates for seined and trap netted walleye fingerlings found by Lound and Dobie (1958).

Management Recommendations

The results of this study and reviews of other lake and creel surveys indicate that fingerling stocking should only be considered for Lake Class 22 and 27 lakes when natural reproduction and fry stocking have been clearly shown to be unsuccessful. Improved walleye angling is dependent upon strong year classes. Natural reproduction can produce such year classes in these lake classes. When supplemental stocking is deemed necessary, fry stocking is more cost effective than fingerling stocking. Using an alternate or every third year fry stocking schedule would allow for good evaluation of natural reproduction as well as being cost effective in producing a strong year class.

Since natural reproduction was important, particularly in lakes Mary and Miltona, walleye spawning areas need to be identified. Protection of these areas, and enhancement if necessary, should be a priority.

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