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FISH COMMUNITY RESPONSES TO MANIPULATION OF YELLOW PERCH AND WALLEYE ABUNDANCE[1]

by

Timothy J. Goeman
Fisheries Biologist

Dennis W. Anderson
Regional Fisheries Manager

and

Dennis H. Schupp
Senior Fisheries Biologist

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Abstract

Stocking of yellow perch and walleye failed to alter the community structure in two pairs of small centrarchid lakes with high density, slow-growing fish populations. Two reference lakes received no stocking and provided a basis for documenting community responses caused by these attempted manipulations. Catch, growth at length, growth by growth year, age-frequency, correlation matrices, and proportional stock densities (PSD) calculations indicated that percid stocking at rates applied in this study was not a successful method of manipulating fish community structure. Significant changes in growth and catches occurred in all study lakes for all species, but these changes could not be attributed to attempted community manipulations. Natural variations in year-class strength accounted for most of the changes noted. PSD calculations indicated bluegill size structure decreased in 5 of 6 lakes during the study period. The northern pike-yellow perch predator-prey relationship may be a major and controlling aspect of community structure, maintaining the existing domain of stability. Stocking of yellow perch to restructure fish communities is not a viable management option in small centrarchid lakes with high density, slow-growing northern pike populations. Fish community manipulations should instead focus on removal or other manipulation of top predators to alter size/species composition and variations in biomass.

Introduction

Abundant yellow perch *Perca flavescens* and walleye *Stizostedion vitreum* are often associated with favorable fish community size structure. Many smaller fish lakes in Minnesota, however, are characterized by dense populations of stunted bluegill *Lepomis macrochirus* and northern pike *Esox lucius*. These fish communities cause a difficult problem for fisheries managers and constitute a fishery that is generally unsatisfactory to anglers. Yellow perch are usually rare in these fish lakes and walleye management is typically unsuccessful. Natural walleye lakes or lakes with successful walleye management programs tend to have less abundant, faster growing bluegills that are more acceptable to anglers. Lakes containing walleye and acceptable bluegill populations also contain abundant perch of all sizes. Partial or total chemical treatments have proven effective for improving overabundant, stunted bluegill populations, although associated costs and the availability of antimycin may limit use of this tool (Davis 1979).

Fish community density/size relationships are poorly understood with only a few documented exceptions. Yellow perch and centrarchid populations became less abundant in Escanaba Lake, Wisconsin following the establishment of walleye (Kempinger et al. 1977). These species were gradually increasing to pre-walleye abundance when northern pike became established. Smallmouth bass *Micropterus dolomieui*, bluegill, rock bass *Ambloplites rupestris*, black crappie *Pomoxis nigromaculatus*, and perch all declined in abundance as pike became a major component of the fish community. Ultimately, pike growth rates declined but walleye growth rates did not.

Northern pike stocking was associated with an increase in bluegill abundance but a decrease in bluegill growth rates in Wisconsin and Minnesota lakes (Snow 1974, Anderson et al. 1986). Yellow perch growth increased and resulted in establishment of a walleye-perch fishery after walleye stocking in a small Michigan lake (Schneider 1979). Declines in walleye and perch abundance were associated with increased pike density following pike stocking in Horseshoe Lake, Minnesota (Anderson et al. 1986). Perch abundance increased and growth rates declined after walleye were stocked in Manistee Lake, Michigan, but no consistent changes could be detected among other species (Laarman 1980). Eurasian perch *Perca fluviatilis* abundance in Lake Windermere, England declined when a gill net fishery reduced the mean size of pike and increased predation on younger perch (Bagenal 1977). A decline of pike in Oneida Lake was accompanied by an increase in walleye and perch abundance (Forney 1974). Diana (1987) modeled pike growth and demonstrated that food limitations due to removal of large prey resulted in stunting. A shift of only 7% of the total prey items from large prey to average prey size was enough to reduce final body size 80%.

Effective methods for increasing average bluegill and northern pike size would be valuable fisheries management tools in lakes with dense, slow-growing centrarchid populations. If these methods also improved the potential for successful walleye management, their importance would be further magnified. This study evaluated fish community responses to manipulation of walleye and yellow perch abundance. Specific objectives of the study were to determine if fish communities can be restructured to increase bluegill growth and average size, and determine the effects of these manipulations on the growth and abundance of other species in the fish community.

Description of Study Lakes

Six study lakes were selected in Crow Wing County, Minnesota. These lakes were comparable in size and each had large relative littoral areas (Table 1). Each study lake was considered a closed system for purposes of this study since fish could not readily move through lake inlets or outlets. Water chemistry data indicated these lakes were generally of low to moderate fertility.

All study lakes provided generally good centrarchid spawning habitat. Centrarchids and small northern pike were major components of the fish communities. These lakes have a history of fish stocking starting as early as 1909. Stocked species included various sizes and densities of northern pike, bass, sunfish, crappies, walleye, and trout. No stocking occurred in any of the study lakes in the years immediately preceding this project.

These six lakes had similar fish community structure. Bluegill populations were dense and consisted primarily of small individuals. Northern pike populations were also composed of high densities of small individuals. Largemouth bass provided the most desirable sport fisheries with a size structure that was generally acceptable to anglers. Densities of yellow perch were low to moderate with small, young fish dominating these populations.

Table 1. Six study lakes located in Crow Wing County, Minnesota, including water chemistry data collected in June 1987.

Lake	DOW no.	ha (A)	Littoral %	Tot. alk.	TP	TDS
Goodrich	18-226	144 (357)	65	73	0.011	85
Gilbert	18-320	149 (369)	61	94	0.029	116
O'Brien	18-227	76 (188)	55	75	0.011	87
Partridge	18-48	74 (184)	63	21	0.017	26
Lougee	18-342	75 (186)	89	74	0.029	97
Rogers	18-184	89 (219)	38	30	0.011	39

Methods

Field Methods

Yellow perch and walleye abundance was manipulated in two pairs of study lakes. O'Brien and Partridge lakes were stocked with adult perch in 1982 and 1983 (Table 2). Walleye and perch were stocked in Rogers and Lougee lakes in 1982 and 1983, with walleye stocking continuing in 1984 and 1985 (Table 2). Goodrich and Gilbert lakes received no stocking during the study period, serving as reference lakes.

Fish sampling to determine community responses to manipulation of percid abundance was conducted using a 2.54 cm (1 in) mesh 61 m (200 ft) long by 4.3 m (14 ft) deep seine containing a 0.64 cm (0.25 in) mesh bag. The study lakes were sampled in a random order during the period of June through September from 1982 through 1986. The seine was set out over a depth of approximately 4 to 5 m of water or out 60 m lakeward if water depth did not exceed 5 m. The net was laid out generally parallel to shore and then pulled directly to shore, seining approximately 0.4 ha (0.92 A).

Three seining stations were established on each of the lakes. The same

Table 2. Fish stocked for experimental manipulation of fish communities, 1982-1986.

Lake	Date	Species	Size	No.	Density[a]
O'Brien	121782	Yellow perch	adult	750	2.7
	121782	Yellow perch	adult	480	1.3
	120683	Yellow perch	adult	634	1.6
	121583	Yellow perch	adult	1,484	7.0
Partridge	120382	Yellow perch	adult	525	1.7
	123082	Yellow perch	adult	2,236	5.4
	010483	Yellow perch	adult	875	1.7
	122083	Yellow perch	adult	2,116	9.0
Lougee	122982	Yellow perch	adult	1,480	2.7
	010583	Yellow perch	adult	3,300	4.8
	050683	Walleye	fry	180,000	---
	101183	Walleye	fgl	1,660	0.6
	121683	Yellow perch	adult	1,426	4.5
	122383	Yellow perch	adult	2,750	4.0
	122383	Yellow perch	adult	2,982	1.5
	053184	Walleye	fry	200,000	---
	093084	Walleye	fgl	6,225	1.1
	053185	Walleye	fry	186,000	---
	093085	Walleye	fgl	525	0.5
Rogers	112482	Yellow perch	adult	705	3.2
	122082	Yellow perch	adult	1,624	5.5
	050683	Walleye	fry	200,000	---
	101183	Walleye	fgl	860	0.6
	121383	Yellow perch	adult	1,472	8.7
	053184	Walleye	fry	200,000	---
	093084	Walleye	fgl	3,290	2.6
	053185	Walleye	fry	219,000	---
	093085	Walleye	fgl	210	0.6

[a]kg/littoral ha.

stations were used during all years of the study. Attempts were made to seine each station at least three times during each year.

Scale samples and catch data provided the basis for documenting fish community responses. Subsampling of seine haul catches was used to collect 10 scale samples per cm length group for northern pike, pumpkinseed *Lepomis gibbosus*, bluegill, largemouth bass, black crappie, and yellow perch during each year of sampling. Back-calculations for all species were computed for each year of study. Catch data included sampling effort, length, and weight data.

Standard lake survey sampling using gill nets and trap nets was conducted in 1987. These data were collected to compare standard sampling methods with seining as valid techniques for documenting community responses to manipulation of yellow perch and walleye abundance.

Analytical Methods

Catch data for each year of sampling (1982-1986) was expressed as CPUE for all species from each lake. Changes in CPUE during the five years of study were tested for significant between-year differences using one-way ANOVA.

Individual back-calculated lengths and corresponding growth increments for all species were sorted into data subsets of growth potentially affected by stocking percids and growth not subjected to the influence of stocking. These data subsets were used to evaluate changes in growth in each lake. Data from the reference lakes were sorted and analyzed as if community manipulation had been attempted for purposes of comparison with the stocked lakes.

Growth at length analyses were performed for six species from each lake. Growth increments from the two data subsets defined above were plotted against initial length for each species (Gutreuter 1987). Regression equations were developed describing growth that may have been influenced by percid stocking and growth not influenced by percid stocking. In some cases, polynomial equations were used to better describe growth at length characteristics. Multiple regression and ANOVA were used to compare growth before and after percid stocking and to determine significant changes in growth at length for each species. Growth year analyses for all species were performed on the same data subsets. The two sample t-test was used to determine significant changes in growth increments and total length.

Age and length data were used to project age frequency distributions for all species in each lake. An age-length key was used to determine changes in population structures during the study period.

Correlation matrices provided a means of evaluating all possible correlations between growth year and CPUE for all species.

Results

Significant between-year differences ($P < 0.05$) in CPUE occurred in each lake, but no consistent changes in CPUE were apparent (Tables 3 and 4). Significant changes occurred most frequently in Goodrich, Gilbert, and Partridge lakes. Pumpkinseed and yellow perch catches changed significantly in five of the six study lakes, however, no significant change in CPUE for either of these species was evident in O'Brien Lake (Table 4). Northern pike CPUE changed only in Partridge Lake.

Differences in growth at length were observed in each lake, but no relationships to community manipulation were perceptible (Table 5). Black crappie often showed variable growth at length while yellow perch, largemouth bass, and northern pike showed little variability. Increases and decreases in mean growth by growth year were evident in all study lakes irrespective of attempts at community manipulation (Table 6). No consistent species-specific growth responses to manipulation by stocking were evident in pairs of study lakes. Black crappie showed more changes in growth by growth year than other species regardless of treatment. All other species showed similar growth responses regardless of treatment.

Table 3. CPUE of the major taxa[a] and age groups for Lougee, Partridge, Rogers, O'Brien, Goodrich and Gilbert lakes[b], 1982-1986.

		CPUE																
Year	Hauls	LMB	LMB YOY	NOP	NOP YOY	BLC	BLC YOY	BLG	BLG YRL	BLG YOY	PMK	YEP	YEP YRL	YEP YOY	OTM	DAR	HSF	BLH
									Goodrich Lake									
82	10	6.0	12.0	9.4	3.1	99.7	111.7	345.2	97.8	8.9	6.9	46.7	10.8	576.3	21.3	0.3	14.2	2.6
83	15	2.4	14.0	5.5	0.0	15.4	37.1	225.5	60.0	316.3	2.4	5.1	15.6	170.2	5.9	1.5	10.2	1.4
84	10	7.0	22.9	5.5	0.1	19.1	148.6	147.4	68.4	6.0	8.7	74.4	120.6	385.7	194.2	5.1	3.2	2.2
85	9	9.0	23.9	4.9	0.1	35.4	177.7	304.6	193.7	10.1	10.9	34.7	12.6	425.1	257.3	3.1	3.6	0.9
86	9	4.9	36.8	5.9	0.8	44.9	362.3	234.4	17.1	50.3	15.0	49.3	79.0	398.8	617.9	1.8	2.0	0.3
									Gilbert Lake									
82	12	5.3	8.7	2.9	0.0	61.9	5.5	313.1	13.2	2.3	2.7	7.6	1.6	35.7	18.9	0.0	2.9	0.1
83	15	4.2	9.1	1.9	0.0	90.3	1.9	167.6	9.0	5.7	2.3	1.7	15.5	4.8	10.7	0.1	4.0	0.0
84	10	10.4	5.5	3.7	0.0	125.1	1.6	277.9	67.3	0.7	10.0	54.0	24.8	3.1	6.9	0.0	0.0	0.4
85	10	3.2	3.2	0.7	0.0	95.3	1.2	146.8	6.7	5.2	6.4	2.3	0.9	1.9	13.4	0.0	5.1	0.1
86	9	4.7	19.4	1.8	0.0	39.6	177.1	209.1	9.3	7.1	5.0	4.7	5.7	23.2	6.4	0.0	3.1	0.0
									Partridge Lake									
82	12	7.3	33.3	8.7	0.3	11.3	0.8	514.7	11.7	20.7	10.4	16.7	17.1	58.1	76.5	0.6	9.7	0.0
83	18	5.3	44.1	8.6	1.1	11.9	0.1	351.9	34.7	205.8	3.7	27.2	9.5	54.1	445.3	0.0	19.3	0.2
84	9	4.3	43.3	7.9	3.4	0.3	2.1	499.7	168.4	7.2	31.3	69.2	71.3	127.4	180.9	0.0	24.8	0.1
85	9	5.9	5.9	1.9	0.2	4.2	1.8	286.4	52.8	1.3	14.1	40.9	55.8	595.6	77.3	0.2	11.7	0.0
86	9	2.1	15.8	2.7	0.3	13.7	17.2	186.2	41.8	36.4	14.7	4.0	31.8	1805.9	71.9	2.4	12.8	0.2
									O'Brien Lake									
82	12	7.6	19.0	2.4	0.7	6.2	0.6	276.5	79.0	1.3	4.3	16.2	0.6	38.0	18.0	0.0	2.2	0.6
83	15	10.0	17.0	2.3	0.0	15.1	0.3	246.7	30.9	73.4	1.7	3.7	9.8	3.7	9.8	0.0	3.3	3.3
84	11	7.6	18.3	1.7	0.5	21.5	4.4	227.2	191.8	0.8	5.0	10.0	2.3	23.4	4.4	0.1	5.9	2.2
85	9	5.3	5.2	2.1	0.3	5.9	2.2	271.6	90.4	14.2	4.8	13.3	2.9	7.6	2.6	0.3	0.1	2.0
86	9	4.9	27.9	2.0	0.3	27.9	1.7	271.7	34.8	8.2	6.6	5.1	4.3	30.2	6.9	0.0	1.7	0.0

Table 3 continued. CPUE of the major taxa[a] and age groups for Lougee, Partridge, Rogers, O'Brien, Goodrich and Gilbert lakes[b], 1982-1986.

		CPUE																
Year	Hauls	LMB	LMB YOY	NOP	NOP YOY	BLC	BLC YOY	BLG	BLG YRL	BLG YOY	PMK	YEP	YEP YRL	YEP YOY	OTM	DAR	HSF	BLH
									Lougee Lake									
82	12	5.6	15.8	1.2	0.1	4.0	4.7	170.3	45.4	8.9	8.4	4.9	23.9	541.8	97.0	1.1	12.8	0.0
83	16	3.3	31.9	1.0	0.0	98.3	1.3	240.7	39.3	39.3	3.4	2.9	6.9	15.5	38.4	5.6	22.6	0.3
84	10	4.2	31.5	1.5	0.0	70.4	5.3	265.4	159.1	0.0	16.5	19.1	0.5	145.3	60.5	1.5	29.4	0.0
85	9	6.9	9.8	0.6	0.0	178.3	0.0	368.0	25.6	0.0	22.6	9.4	4.6	0.7	5.7	3.0	9.4	0.3
86	9	2.9	30.4	1.0	0.0	82.3	4.9	353.3	8.6	19.4	31.3	25.0	2.3	221.0	21.3	2.9	13.3	0.1
									Rogers Lake									
82	12	5.8	15.3	11.9	0.5	57.7	17.3	443.0	292.0	22.2	5.2	11.3	1.4	19.3	319.2	1.6	10.3	2.2
83	16	3.8	25.6	10.1	2.5	14.6	25.8	328.8	448.3	566.9	4.4	8.8	12.4	32.6	194.7	2.0	54.3	4.3
84	10	6.2	29.1	8.7	0.3	8.3	2.9	346.0	607.7	6.8	15.8	43.2	22.7	67.6	94.1	1.0	9.8	9.3
85	8	5.0	20.0	10.8	0.3	4.9	42.5	168.8	411.8	74.4	10.5	23.0	80.9	132.6	260.5	0.8	5.3	4.0
86	9	5.9	12.1	14.1	0.3	2.6	9.2	367.3	268.4	15.3	17.8	15.1	11.9	16.7	63.3	0.8	11.7	3.9

[a] Taxa abbreviations are as follows: northern pike--NOP, minnows--OTM, bullhead--BLH, hybrid sunfish--HSF, pumpkinseed--PMK, bluegill--BLG, largemouth bass--LMB, black crappie--BLC, yellow perch--YEP, darter--DAR.
[b] Lake treatments were as follows: controls--Goodrich and Gilbert; perch stocked--Partridge and O'Brien; perch and walleye stocked--Lougee and Rogers.

This sheet replaces page 9 in Minnesota DNR Investigational Report No. 404 where poor printing left some values illegible.

Table 4. Significant between-year differences in CPUE as determined by one-way ANOVA for selected taxa from six study lakes, 1982-1986 ($P<0.05$).

Lake	Species								
	LMB	LMBYOY	NOP	BLC	BLG	PMK	YEP	YEPY	OTM
Goodrich	.05	.05	NS	.05	NS	.05	.05	NS	.05
Gilbert	.05	.05	NS	.05	.05	.05	.05	NS	NS
Partridge	.05	NS	.05	NS	.05	.05	.05	.05	NS
O'Brien	NS	NS	NS	.05	NS	NS	NS	NS	NS
Lougee	NS	NS	NS	NS	NS	.05	.05	NS	NS
Rogers	NS	NS	NS	NS	NS	.05	.05	.05	NS

Table 5. Changes in growth at length for six species from six study lakes near Brainerd, Minnesota, 1982-1986.

Lake	Species							
	NOP	PMK	BLG	BLC	LMB	YEP	Lake totals	Pair totals
Goodrich	NS[a]	-	NS	+	+	NS	2+ 1-	
Gilbert	NS	+	-	-	NS	NS	1+ 2-	3+ 3-
O'Brien	NS	+	+	+	NS	NS	3+ 0-	
Partridge	NS	-	+	+	NS	NS	2+ 1-	5+ 1-
Lougee	+	NS	-	-	+	NS	2+ 2-	
Rogers	NS	NS	+	+	NS	+	3+ 0-	5+ 2-
Species Total	1+ 0-	2+ 2-	3+ 2-	4+ 2-	2+ 0-	1+ 0-		13+ 6-

[a] NS indicates growth at length did not significantly change, based on comparisons of regression lines. A "+" denotes growth improved following percid stocking and a "-" represents decreased growth at length following stocking.

Table 6. Significance of changes ($P<0.05$) in mean growth by growth year (GY) for six species from data collected during 1982-1986. Changes are specified as either positive or negative with responses (Resp.) for each lake summarized as a percentage.

Lake	GY	Species NOP Inc	NOP TL	PMK Inc	PMK TL	BLG Inc	BLG TL	BLC Inc	BLC TL	LMB Inc	LMB TL	YEP Inc	YEP TL	% Resp.
	1	-	-	NS	NS	NS	NS	-	-	NS	NS	-	-	
	2	NS	-	NS	NS	NS	NS	+	NS	+	+	NS	NS	+= 9%
GDR	3	NS	-	NS	NS	NS	NS	+	NS	NS	+	NS	NS	-=14%
	4	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	
	5	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS			
	1	NS	NS	+	+	NS	NS	-	-	-	-	NS	NS	
	2	NS	-	NS	NS	NS	NS	+	NS	NS	NS	NS	-	+=16%
GIL	3	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	-=12%
	4	NS		+	+	+		+	NS	NS				
	5			NS	NS	+	NS	NS						
	1	-	-	NS	NS	+	+	NS	NS	NS	NS	-	-	
	2	+	-	NS	NS	+	+	+	+	NS	NS	NS	-	+=23%
OBR	3	NS	NS	NS	NS	+	NS	+	NS	NS	+	NS	NS	-=11%
	4	NS	NS	NS	NS	+	NS	NS	NS	NS	+	NS		
	5	NS		NS	NS	NS	NS	NS	+	NS	NS			
	1	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	-	-	
	2	NS	+	NS	NS	+	NS	+	+	NS	NS	NS	-	+=16%
PRT	3	NS	+	NS	NS	+	NS	+	+	NS	NS	NS	NS	-= 5%
	4	NS	NS	NS	NS	NS	NS	NS	+	NS	NS	NS		
	5		NS	NS	NS	NS	NS	NS	NS	NS				
	1	-	-	+	+	NS	NS	NS	NS	+	+	-	-	
	2	NS	NS	NS	NS	NS	NS	+	NS	NS	+	+	NS	+=20%
RGR	3	NS	NS	NS	-	NS	NS	+	+	NS	NS	NS	NS	-=13%
	4	NS	NS	NS	-	NS	NS	+	+	NS	NS	NS		
	5	NS	NS	NS	-	NS	NS	NS			NS			
	1	NS	NS	+	+	+	+	-	-	NS	NS	NS	NS	
	2	+	NS	NS	NS	-	NS	NS	-	NS	+	NS	NS	+=24%
LOG	3	NS	NS	NS	NS	NS	-	-	NS	NS	+	NS	NS	-+11%
	4	NS	NS	+	NS	NS	NS	NS	+	NS	+	NS		
	5			NS	NS	NS	NS	+	+	NS	+			
Total Responses		14		12		14		29		14		12		

Table symbols: GDR--Goodrich, GIL--Gilbert, OBR--O'Brien, PRT--Partridge, RGR--Rogers, LOG--Lougee, NS--not significant, NOP--northern pike, PMK--pumpkinseed, BLG--bluegill, BLC--black crappie, LMB--largemouth bass, YEP--yellow perch, Inc--growth increment, TL--total length.

No changes were observed in the age structure of species evaluated. Age frequency distributions in all study lakes displayed minor changes which could be attributed to natural variations in year-class strength. Yellow perch age frequencies were not altered by stocking. Ages determined for this species were most frequently 3 or less, rarely reaching 4. Similarly, northern pike age frequencies were not altered. Black crappie year-class strength was the most variable in all study lakes.

No significant correlations ($P<0.05$) between growth year and CPUE, or among growth years could be attributed to percid stocking. No consistent trends regarding species or pairs of study lakes were evident.

Standard lake survey netting conducted both before and after this study provided an index of changes in fish population size structure that occurred over the study period. Bluegill PSD (proportional stock density) calculations changed significantly in all study lakes except Rogers (Table 7). Significant changes in bluegill PSD were consistently negative. Northern pike PSD changes were significant in four of the six study lakes, but there were no trends related to percid stocking (Table 7).

Walleye survival in Rogers and Lougee lakes was poor. Fingerlings survived the first several years following stocking, but were not found during intensive sampling at the end of the study (1986) and the year following the study (1987).

Discussion

The stocking of yellow perch or perch and walleye combined had no apparent effect on community structure or fish population size structure and growth. Significant between-year differences in CPUE were attributed to natural variations in year-class strength. The influence of year-class strength was demonstrated by yellow

Table 7. PSD values for bluegill and northern pike for six study lakes from data collected before and after study 125.

	Bluegill					
	PSD	n	Year	PSD	n	Year
Gilbert[a]	37.1	132	1982	13.7	146	1987
Goodrich[a]	61.3	326	1982	31.0	197	1987
O'Brien[a]	87.4	508	1980	65.4	246	1987
Partridge[a]	25.6	117	1973	9.4	212	1987
Lougee[a]	63.3	352	1979	15.1	238	1987
Rogers	65.0	40	1980	72.2	291	1987

PSD=number>15cm/number>7cm x 100

	Northern Pike					
	PSD	n	Year	PSD	n	Year
Gilbert	18.3	71	1982	24.5	49	1987
Goodrich[a]	23.3	90	1982	8.2	49	1987
O'Brien[a]	19.2	26	1980	36.0	50	1987
Partridge[a]	61.9	21	1973	26.1	138	1987
Lougee[a]	48.3	29	1979	67.7	62	1987
Rogers	12.9	31	1980	23.1	39	1987

PSD=number>53cm/number>36cm x 100

[a] Significant changes in PSD ($P<0.05$).

perch CPUE. Perch CPUE changed significantly in three of the four lakes stocked. The two reference lakes (Goodrich and Gilbert), however, also showed significant changes in perch CPUE. The lowest catch of adult perch occurred in 5 of the 6 study lakes in 1983, even though substantial stocking of this species took place the previous year. Bluegill and pumpkinseed CPUE showed no parallel interspecific trends in any of the study lakes, substantiating the observation of distinct diet and habitat separation for these two species (Mittelbach 1984). Black crappie CPUE fluctuated widely in all study lakes probably reflecting highly variable year-class strength.

Growth at length analyses should provide a more sensitive measure of growth changes than more traditional growth at age summaries when dealing with high density, slow-growing populations. Significant changes in growth at length occurred in all lakes but there were no consistent patterns related to percid stocking. Variable changes in growth even within pairs of study lakes suggests that changes in growth at length could not be attributed to percid stocking.

Mean growth (increment and total length) by growth year showed significant increases and decreases in all lakes with no discernible relationship to attempted community manipulation. Significant variations in mean growth by growth year were attributed to biotic and abiotic factors other than percid stocking.

Sporadic changes in population age structures occurred during the five years of study, but these changes were within ranges considered normal. Stocking did not alter the age distribution of yellow perch. Predation by northern pike likely prevented most perch from surviving beyond age 3.

PSD values for bluegill decreased significantly in all lakes except Rogers for several possible reasons. Selective angling for larger bluegills may have contributed to the decline in size quality of this species as documented by Coble (1988). We noted that of the six study lakes, only Rogers Lake has a remote, primitive access which may limit angling pressure on this lake. Additionally, Rogers is the least developed of the study lakes, and as a result, may have maintained a better bluegill size structure.

Yellow perch and northern pike data collected during the study suggest close predator-prey interactions between these two species as has been reported by other investigators (LeCren 1987, Anderson et al. 1986, Maloney et al. 1977). Lougee and O'Brien lakes had the highest and second highest catches of yellow perch in 1987 survey netting. These were the same lakes showing significant increases in PSD for northern pike during the study period. Lougee Lake also recorded the lowest and least variable CPUE for northern pike during the 5 years of study. Prey selectivity and preference may be implied by these relationships (Wahl et al. 1988).

There was no evidence of walleye survival beyond age 2 in any of the study lakes. Causes of this apparent poor survival are speculative, but may include competition or predation within the community.

Major changes in fish community structure did not occur during the 5-year study even where yellow perch and walleye were heavily stocked. The complexity of species relationships in these small centrarchid lakes seems controlled primarily by northern pike as the top predator (Pimm et al. 1987, McQueen et al. 1986). Pike not only show a preference for perch as prey (Anderson et al. 1986, LeCren 1987, Maloney et al. 1977), but are also selective for prey items of optimum size (Domaneskii 1962, LeCren 1987, Christie et al. 1987, Wahl et al. 1988). The result of this size selective predation can be the elimination of the optimum size prey potentially leading to a dense, slow-growing population of predators (LeCren 1987, Pimm et al. 1987). This scenario accurately depicts the pike-perch relationship in the lakes examined during this study. High density, slow-growing pike populations existed in these lakes before the study began. A cause for this population size structure is speculative, but it is likely related to long-term angling pressure and subsequent removal of the largest pike. As the population responded to angling pressure with increased recruitment, more small, young pike preyed more heavily upon perch altering the size structure of this species, too. The stocking of perch in 1982 and 1983 for this study represented a temporary increase of optimum-size prey items that were immediately selected for by the abundant predator (northern pike). Our analyses show that this influx of desirable-sized prey items was not sufficient to influence growth of pike, and was short-lived at best. Pimm et al. (1987) point out that predators are capable of severely reducing prey numbers, especially when selection (for size in this case) is involved.

Holling (1973) describes an area of community stability as a domain. Domains consist of distinct size/density assemblages of particular species, rather than an infinite continuum of size/density possibilities. Major community alterations are necessary to shift from one domain to another. In this study the domain of stability was partially composed of high density, slow-growing northern pike populations, and moderately dense yellow perch populations dominated by small individuals. A former domain was possibly composed of fewer, faster growing pike with medium to large-sized perch in moderate densities, but fishing caused the establishment of the latter domain of attraction. The influx of stocked adult perch was not effective as a method of community alteration to restore the former and more desirable domain.

Although community manipulation by stocking of percids was not successful, community manipulation to improve the quality of Minnesota fish lakes may be successful by employing a different approach. McQueen et al. (1986) contend that biomass at each trophic level can be controlled from above by predators. Changes in species composition and variations in biomass would be included in this type of predator manipulation. Other investigators (Colby et al. 1987, Pimm et al. 1987) have concluded that introductions or removal of top predators would be the most effective means of manipulating community structure. Introductions, such as the stocking of perch and walleye in this study, are likely to fail when applied alone because no gap exists for new species or sizes of species at the current stability level.

Management Implications

Northern pike stocking to supplement existing populations or create new fisheries should be approached cautiously by fisheries managers. Prey species should be monitored regularly to prevent predator densities from overwhelming the existing prey base resulting in high density, slow-growing predator populations. Yellow perch size structure and abundance should be of particular concern to managers. Generally, substantial numbers of larger perch are more desirable than a population dominated by smaller individuals.

Black crappie exhibited variable year-class strength more frequently than any other species evaluated in the study. CPUE, growth at length, growth by growth year, and changes in mean growth increments and total length, all indicated black crappie year-class variability was common in all study lakes.

Walleye stocking in small centrarchid lakes is likely to fail due, at least in part, to competition and predation within the community. This conclusion will particularly apply when the pike population and other community components are characterized by high densities and slow growth.

Stocking of yellow perch or perch and walleye combined are not effective methods of restructuring fish communities in small centrarchid lakes at the levels applied in this study. Mean annual perch stocking rates of 8.2 kg/littoral ha (7.3 pounds/littoral A) for two consecutive years was not adequate to restructure the fish community. More intensive stocking for a longer duration may have some value, but would be experimental at the present time. Attempts at community manipulation should focus on removal, harvest or other manipulation of top predators in the fish community. This "top down" approach has the best potential for effective manipulation of community structure by controlling species composition and variations in biomass. Manipulation of prey species may have some merit when applied in conjunction with this type of predator manipulation, but manipulations of percid abundance alone is not recommended.

PSD values from several sample periods spread over 5 to 20 years may provide fisheries managers with an index for monitoring changes in size quality of various species available to anglers. This index may assist managers in detecting changes in size quality only if accurate historical data is correctly interpreted. Standard lake survey netting provides an adequate tool for fisheries managers to detect changes in fish communities if these surveys are thorough. Adequate sample sizes coupled with detailed age and growth analyses are essential components of a useful lake survey. Data analyses could include PSD calculations, age-frequency distributions, and historical catch comparisons, as well as more routine summaries. A consistent four to five year survey schedule is of paramount importance.

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