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Feasibility of Trap Nets for Harvesting and Observations on Distribution, Growth, and Survival of Yellow Perch in Southern Lake Michigan

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FEASIBILITY OF TRAP NETS FOR HARVESTING, AND OBSERVATIONS ON DISTRIBUTION, GROWTH, AND SURVIVAL OF YELLOW PERCH, IN SOUTHERN LAKE MICHIGAN, 1978-79[1]

Ronald W. Rybicki

[1]Contribution from Dingell-Johnson Project F-53-R, Michigan

Abstract

Experimental trap nets were tested in southern Lake Michigan at Saugatuck during May 22-September 20, 1978, and at Benton Harbor during May 1-September 26, 1979. Four pot sizes, ranging in volume from 3 to 31 m^3, were fished at depths of 5 to 27 m at 5-m intervals. Lifts were made at 1- to 9-day intervals. At the Benton Harbor site 1,725 yellow perch were tagged and released.

The small trap nets were held securely in place despite powerful wave action and high velocity currents. Although small by commercial fishing standards, the experimental yields of 5,500 kg in 1978 and 2,200 kg in 1979 were sufficiently large to indicate that small trap nets can effectively capture yellow perch. The seasonal average catch rate of yellow perch increased as the volume of the trap net increased from 61 fish per lift in the 3 m^3 net to 159 per lift in the 31 m^3 trap. The largest catches per unit effort occurred at 5- to 7-day lift intervals for most nets.

The temperature and depth distribution of yellow perch varied according to sex and month. During June and July males were mostly in deeper (18-27 m) and colder (6-10 C) water than females (5-14 m and 16-24 C). They had similar distributions during May, August, and September.

Annual survival estimates were 28 and 33% for males and 56 and 60% for females at Benton Harbor and Saugatuck, respectively.

Differences in length-weight and age-length curves of yellow perch between the two study areas suggested discrete stocks. The Saugatuck population tended to be heavier at a given length and larger at a given age.

Of the 1,725 yellow perch tagged, only 49 (3%) were reported captured during 1979-81. Most (86%) were caught within a radius of 14 miles of the release site. Nearly equal numbers were recaptured north and south of the release point in 1979, indicating no favored migratory direction.

Introduction

A study evaluating trap nets as a device to harvest commercially under-utilized species was conducted in southern Lake Michigan, from May through September in 1978 and 1979 (Rybicki 1980). Although the study focused principally on suckers (Catastomus spp.), yellow perch (Perca flavescens) were taken in substantial quantities and valuable biological data for perch were obtained. This paper presents observations on yellow perch survival, growth, and temperature-depth distributions, and on the feasibility of harvesting them with small trap nets.

Methods

Fourteen experimental trap nets were constructed for this project. Dimensions were varied so that the pots enclosed volumes of about 3, 9, 11, and 31 m^3 (Table 1). All pots were constructed from 50 mm (2-in) stretched mesh webbing; single hearts were made of 76 mm (3-in) mesh. Leads were built from 101 mm (4-in) mesh webbing and were 77 m (330 ft) long.

The trap-netter S/V JUDY was refurbished and used as the service vessel, and was crewed by a skipper and two seasonal employees. A 10-days-on and 4-days-off work schedule was chosen over the standard 40-hour work week to reduce travel time and increase sampling opportunity.

1978 Study

Saugatuck was selected as the study area in 1978 because excellent facilities were made available to us by the U. S. Fish and Wildlife Service, and because at the time the perch population at the Saugatuck site was believed to be representative of southern Lake Michigan.

The 3 m^3 nets were designated as the controls. Because not enough 9-, 11-, and 31-m^3 nets were available to fish all depths simultaneously, a 20-day rotation schedule was devised so that each net size was fished at all selected depths.

Six 3-m^3 nets were set in line at 5-m (15-ft) contour intervals, beginning at the 5-m contour and extending to the 27-m (90-ft) contour. A second string of the larger net sizes was set approximately 1.5 km (1 mile) distant on the same contours, to provide paired sets with the 3-m^3 nets. The three shallower sets and the three deeper sets were lifted on alternate days except on personnel pass days and when bad weather or mechanical failures forced delays.

The project at Saugatuck began on May 22, 1978 and terminated on September 20, 1978.

1979 Study

Benton Harbor was selected as the study site for 1979. The major reason for the site change was because examination of the 1978 results suggested that the fish populations in the Saugatuck area were not as representative as thought earlier.

Only the 3-m^3 nets were used because it was not necessary to repeat the net-size phase of the project. Six nets were again set in line at 5-m intervals, beginning on the 5-m (15-ft) contour and ending at the 27-m (90-ft) contour. These nets were set about 22 km (14 miles) south of the Benton Harbor piers, and were about 85 km (53 miles) south of the Saugatuck study location. To provide information on the direction in which tagged perch and suckers moved, we also set interceptor nets (4) on the 14-m (45-ft) contour at 3.2 km (2 miles) and 6.4 km (4 miles) north and south of the primary string.

The primary string and lateral interceptor nets were lifted on alternate days because only six nets could be lifted and their catch processed in 1 day. A 10-day work schedule was used again in 1979.

A total of 1,725 yellow perch were tagged during June 16-July 18 with Floy anchor tags. Tag shank was 16 mm (5/8 inch) long, and the tube was 29 mm (1 1/8 in) long. The tag was inserted just below the center of the dorsal fin. Only yellow perch caught in the 5- to 14-m depth range were tagged because those taken from deeper water bloated and could not sound.

The project began on May 1, 1979 and ended on September 26, 1979.

Results and Discussion

Gear evaluation

For many years trap nets have been used for commercial harvest of yellow perch in Lake Erie and in Saginaw Bay, Lake Huron. Traditionally, yellow perch in southern Lake Michigan were harvested with small-mesh gill nets. Commercial fishing for yellow perch was banned in 1970 in all Michigan waters of Lake Michigan, and it is unlikely that commercial harvest of yellow perch will be reinstated outside of the Indian treaty area (Grand Haven-Escanaba). Nevertheless, the gear evaluation results are presented to show the feasibility of using small trap nets for harvesting perch in southern Lake Michigan.

The study showed small trap nets can be fished successfully in southern Lake Michigan. The trap nets, regardless of size, remained securely in place at all depths fished (5-27 m) despite being subjected to gale force winds of up to 80 kph (50 mph), which caused powerful wave action and high velocity currents. Yields of yellow perch totaled 5,501 kg (12,201 lbs) at Saugatuck in 1978 and 2,161 kg (4,754 lbs) at Benton Harbor in 1979. Although these yields scarcely approached commercial proportions, they were sufficiently large to indicate small trap nets will capture yellow perch effectively.

The mean number of yellow perch caught per lift (CPE) increased as the volume of the net increased. The average catch was 61, 122, 120, and 159 perch per lift for the 3-, 9-, 11-, and 31-m^3 trap nets, respectively (Table 2). A two-way analysis of variance (net volume x net days) indicated this was a statistically significant difference ($P \leq 0.05$). The catch, however, was not directly proportional to the volume of the net: the 31-m^3 net was 10 times larger than the 3-m^3 net, but the average CPE in the larger net was only 2.6 times greater than that in the smaller net. The two trap nets of similar dimensions, 9 and 11 m^3, produced similar CPE's of 122 and 120.

Yellow perch CPE was also influenced ($P \leq 0.05$) by net days (Table 2). However, CPE was not linearly correlated to net days ($R^2 = 0.033$; $N = 338$). It appears CPE was maximized when lifts were made at 5- to 7-day intervals.

Statistically significant ($P \leq 0.05$) interaction effects in the analysis of variance indicated that some combination(s) of net size and net days produced different CPE's than others. Although not supported statistically, it appeared that the most successful combination was the 31-m^3 trap net lifted at 5- to 7-day intervals.

Why the largest trap net outfished the smallest is not obvious. Perhaps the higher profile increased the probability of capture and the greater volume reduced the probability of escape. The 3- to 31-m^3 nets retained yellow perch of similar size (Fig. 1). Apparently the greater efficiency of the larger trap net was not the result of size selectivity. It may be undesirable to use 5- to 7-day lift intervals, even though this maximized catches. Gilling in the heart of the trap was a persistent problem and would result in significant spoilage if nets were not lifted more frequently. Commercial-grade trap nets should be constructed of a mesh size that allows undersized fish to escape because perch brought up from deeper than 14 m (45 ft) could not sound and became easy prey for gulls.

Perch distribution

Distribution patterns were clearly evident when CPE's of yellow perch were grouped by month, sex, water temperature, and fishing depth. During May the sexes were broadly distributed over the 6- to 14-C range (Fig. 2), with the modal catch occurring at 10 C for both sexes. In June and July, most male yellow perch were in 6- to 14-C waters and most females, in sharp contrast, were in the 16- to 24-C range (Figs. 2 and 3). During August and September their distribution patterns were similar again because a large proportion of the males had shifted to warmer waters of 14-22 C. The distribution of yellow perch during September was similar to that reported by Brandt et al. (1980) for adult perch in the Grand Haven area of Lake Michigan in September 1977. He noted that adult yellow perch were caught primarily in the 15- to 18-C range, as compared to 14-16 C in this study.

Because depth and bottom water temperatures were correlated inversely ($P \leq 0.05$) during most 10-day sampling periods, the distribution patterns shown in Figures 2 and 3 also reflect the effects of depth. The sexes were similarly distributed during May, August, and September (Figs. 4 and 5). However, in June and July, the larger proportion of males was in the 18- to 20-m (60- to 90-ft) range, while most females were much shallower in the 5- to 14-m (15- to 45-ft) depth strata.

Environmental parameters not measured in this study may also have influenced the distribution of perch. Lechel (1974) used multiple regression analysis to examine the relationship between the yield of yellow perch and barometric pressure, wind direction and velocity, air and water temperature, light penetration, and turbidity in the Ludington area of Lake Michigan. He showed that the independent variables explained 77-79% of the variation in yield of male perch, and 45-95% of the variation in the yield of females. Lechel also noted that depth, although not analyzed as an independent variable, was important.

Sex composition

Sex composition of the total perch catch was 34% females in the Saugatuck area and 13% females at the Benton Harbor station. The low representation of female yellow perch at both sampling sites could not be explained from the data or from the literature. Liston and Tack (1975) reported male perch made up 66-73% of the experimental catches in the Ludington area of Lake Michigan during 1972-74. McComish (1981) noted that female perch generally were more abundant than males at a depth of 5 m in Indiana waters of Lake Michigan, although the overall sex ratio was approximately 1:1 during each year 1977-79. Wells and Jorgenson (1983) reported a 1:1 ratio during July-August 1979 in the Benton Harbor area, whereas, a 2.7-males:1-female ratio, for approximately the same time and depth, was found in this study.

Wells (1968) reported that yellow perch of undetermined sex followed the warm, upper water column farther into Lake Michigan than might be expected judging from their range on the bottom of the lake. If female perch seek a warmer, upper stratum of water, then they would have been less vulnerable to the trap nets in this study, set on the bottom in deeper and cooler water, and catches would have favored males, as observed.

Survival rates

Catch curve analysis (after Robson and Chapman 1961) indicated a differential survival rate between male and female yellow perch in the Benton Harbor area. The annual survival rate was 28% for males age V-IX, and 56% for females age IV-X (Table 3). The difference may have been the result of a lower natural mortality rate for females or it may have been due to a lower exploitation rate, if the females were in fact distributed farther offshore and thereby less vulnerable to the inshore sport fishery. Overall survival was computed from a unified catch curve and also as the geometric mean of the survival rate for each sex. The results were not appreciably different. The unified catch curve method produced an overall survival rate of 36% annually and, the geometric mean method produced an overall rate of 40%. The 40% survival rate is considered to be the better of the two estimates.

The survival rate for male yellow perch in the Saugatuck area was estimated to have been 33% (Table 3). The survival rate for females in this locality could not be computed by catch curve analysis because of the convex configuration of the descending leg of the curve. Consequently, the 60% annual survival given in Table 3 for females was calculated by the weighted mean survival technique (Ricker 1958). The geometric mean survival for both sexes was 44%.

The survival of females at Saugatuck was also estimated by solving these two equations:

$$Z = (Z_m + Z_f)/2$$

and $s_f = e\text{-}Z_f$

where: Z was the instantaneous total mortality (0.761, corresponding to s = 0.467) determined from a catch curve that used the summed male and female age frequencies given in Appendix A;

Z_m was the instantaneous male mortality (1.10, corresponding to s = 0.333); and

Z_f was the unknown instantaneous female mortality.

The resulting estimate was 65%, which was not greatly different from the 60% calculated by the weighted mean method.

The survival rates of female yellow perch at Benton Harbor and Saugatuck were about twice the survival of their male counterparts. The difference in overall survival rates of yellow perch between the two study areas was minor (Saugatuck, 44%; Benton Harbor, 40%). If natural mortality of the exploited stock (age III and older are taken in the sport fishery according to personal communication with D. Johnson) is comparable to the average of 22% assumed by Hartman et al. (1980) for Lake Erie perch, then the annual exploitation rate (u) for southern Lake Michigan stocks in 1978-79 was on the order of 40-44%.

Growth

Length-weight and age-length curves suggest that Benton Harbor and Saugatuck may have discrete yellow perch stocks. Male perch in the Saugatuck area were heavier at lengths greater than 230 mm than were males of comparable length at Benton Harbor, and significantly so ($P < 0.05$) at lengths greater than 240 mm (Table 4). The Saugatuck female perch were heavier at all lengths than the Benton Harbor females, with the differences being significant ($P < 0.05$) up to 310 mm. Length-weight regression coefficients are presented in Table 5 by sex and sampling station.

Saugatuck males were significantly longer ($P < 0.05$) than Benton Harbor males at ages III, IV, and V (Table 6). Also, the age-length curves (Fig. 6) were of different configurations. The curve for the Benton Harbor males was of the exponential type, while that for the Saugatuck males was asymptotic. Benton Harbor females were consistently faster growing than Saugatuck females (Table 6). However, the differences were not statistically significant ($P > 0.05$) because of the relatively large variance about regression for the Benton Harbor stock. Length-age regression coefficients for yellow perch by sex and study site are given in Table 7, and empirical mean length and weight by sex, age, and station are presented in Appendix B.

Within each station, analysis of covariance showed that both slope and intercept in the length-weight regressions differed significantly ($P \leq 0.05$) between the sexes, with the females being the larger (Table 4).

Movements of tagged perch

The number of tagged perch recaptured was disappointingly small. Of the 1,725 perch tagged and released at Benton Harbor during June 16-July 18, 1979, only 40 were reported caught in 1979, 4 in 1980, and 5 in 1981, for a total of 49 (3%).

Most (47%, N = 23) of the recaptures were made in the experimental trap nets. There was a 43% (N = 21) return from anglers, an 8% return (N = 4) from Indiana and Wisconsin commercial fishermen, and a 2% (N = 1) return from experimental fishing gear set in the area by researchers from The University of Michigan.

Because nearly 50% of the fish were recaptured within 3 weeks and the number of returns was so small, few conclusions on migratory tendencies can be drawn. A total of 42 (86%) tags were recovered within a radius of 14 miles of the release site (Table 8). One tagged perch was recaptured 9 miles away the second day following release and another was recaptured 38 miles distant 39 days after tagging. Three perch were recaptured by Indiana commercial fishermen in the vicinity of Michigan City and Gary in June and August 1981, 25-30 miles away. Another tagged perch was caught by a commercial fisherman near Racine, Wisconsin, in September 1981; this was a straight line distance of about 90 miles or a shoreline distance of roughly 130 miles from the release site. There was no apparent tendency to migrate in any one direction. In 1979 about as many (16) tagged perch were caught north of the release location as south of it (15).

The small number of returns is very puzzling because large numbers of perch were tagged, quite intensive fisheries existed for many miles to either side of the release site, and a large amount of research gear was deployed. Possible explanations include mortality due to tagging, tag loss, lack of reporting by the sport and commercial fisheries (despite extensive publicity given the tagging project), and low vulnerability to recapture because the perch became pelagic. In any case, our return of 2.8% was nearly the same as the 2.6% return reported by Mraz (1951) for yellow perch in Green Bay.

Acknowledgments

I wish to acknowledge cooperation of D. C. Johnson, District 12 Fisheries Biologist for his help in this study of the harvest of yellow perch; also I would like to thank J. C. Schneider and W. C. Latta for their editing efforts.

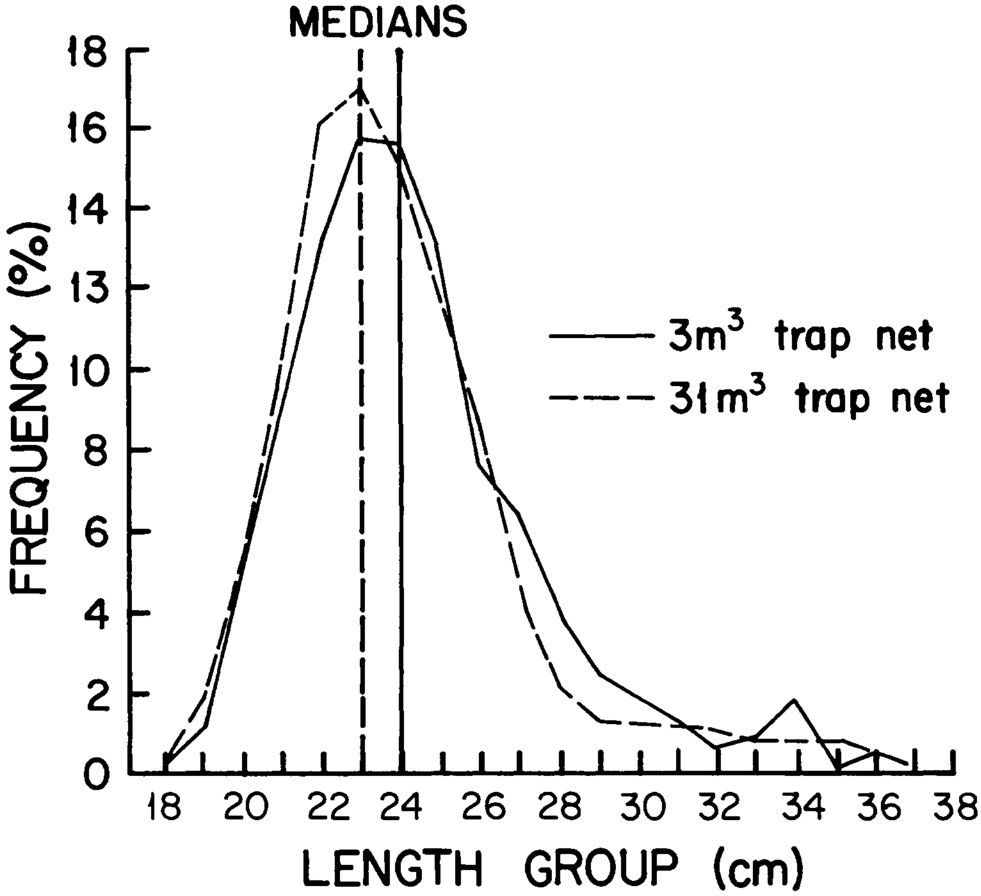

Figure 1. Length distribution of yellow perch caught in 3-m^3 and 31-m^3 trap nets in southern Lake Michigan off Saugatuck, May 23-September, 10, 1978.

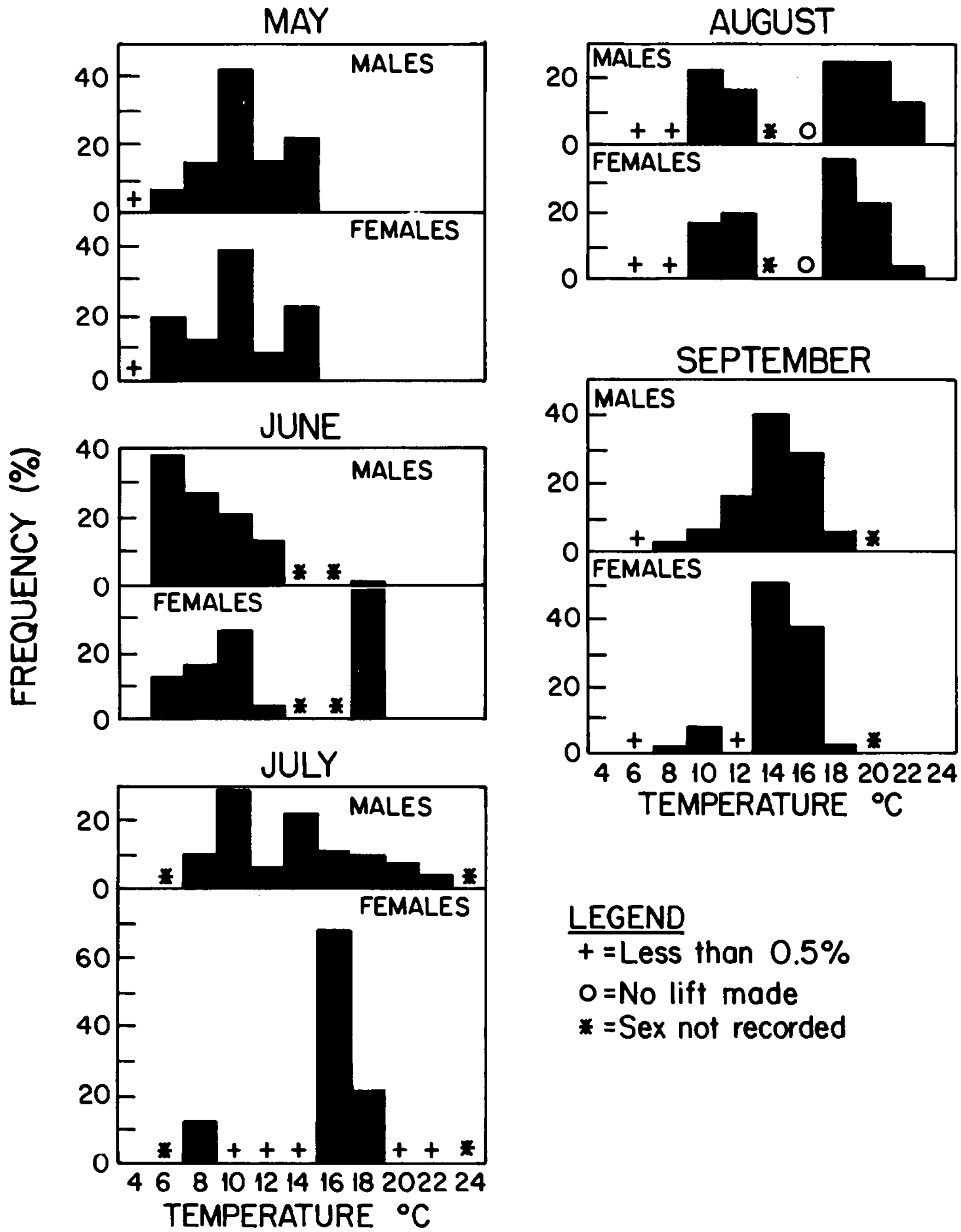

Figure 2. Frequency distributions (as percent of monthly CPE) of yellow perch in relation to temperature, month, and sex for the Benton Harbor station in 1979.

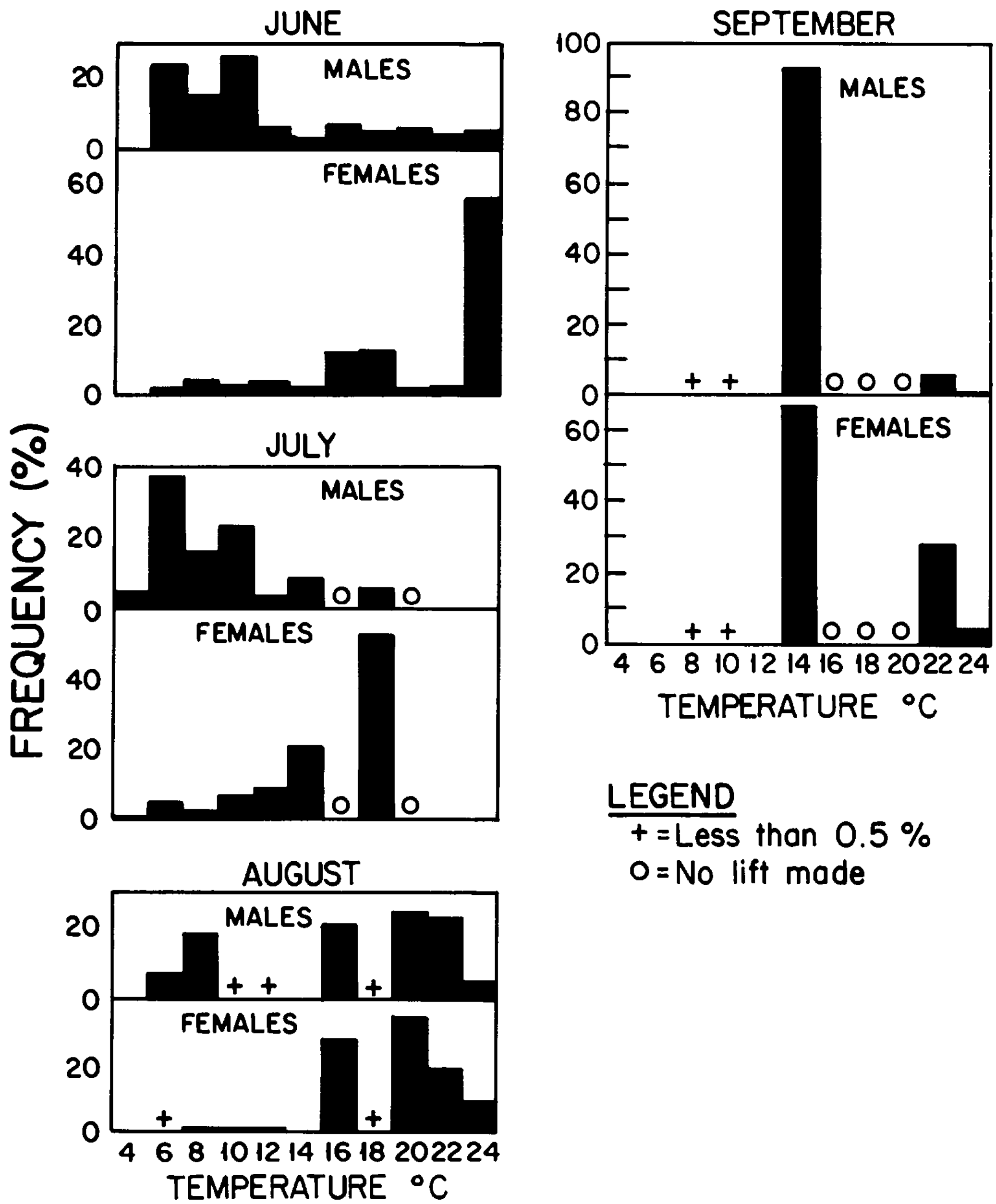

Figure 3. Frequency distribution (as percent of monthly CPE) of yellow perch in relation to temperature, month, and sex for the Saugatuck station in 1978.

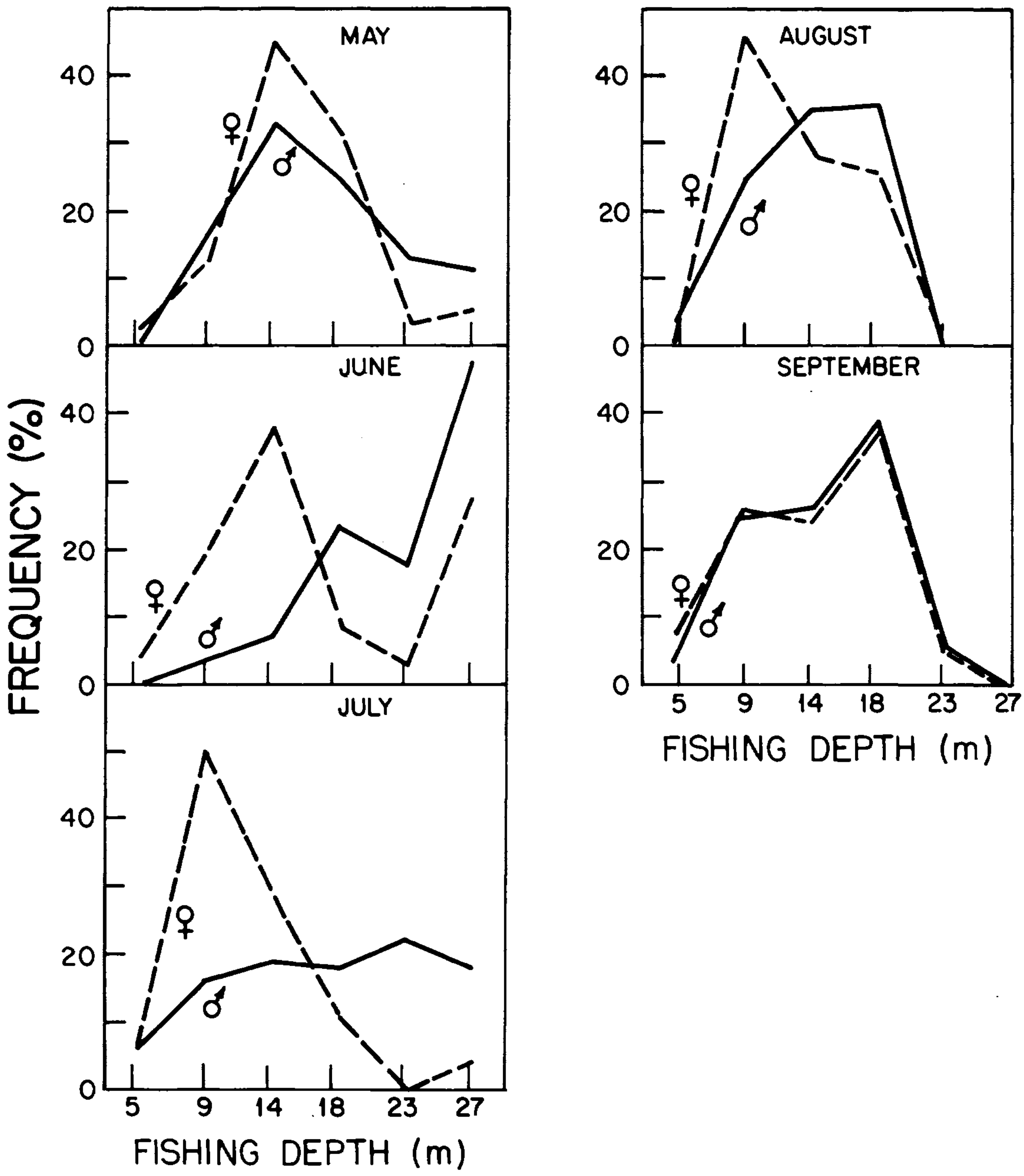

Figure 4. Frequency distributions (as percent of monthly CPE) of yellow perch in relation to fishing depth, month, and sex based on catches in 3-m³ trap nets lifted at 1- to 3-day intervals at the Benton Harbor station in 1979.

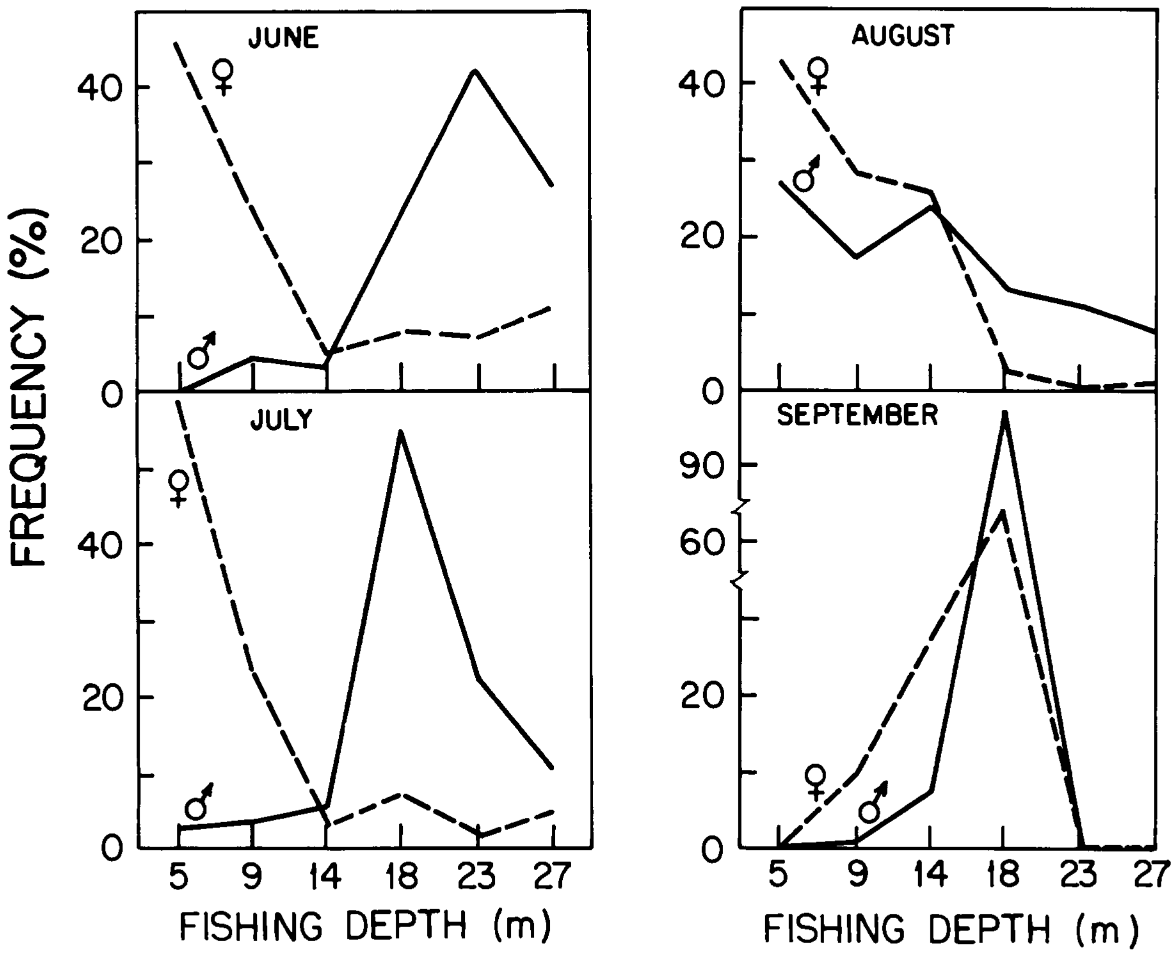

Figure 5. Frequency distributions (as percent of monthly CPE) of yellow perch in relation to fishing depth, month, and sex based on catches in 3-m^3 trap nets lifted at 1- to 3-day intervals at the Saugatuck station in 1979.

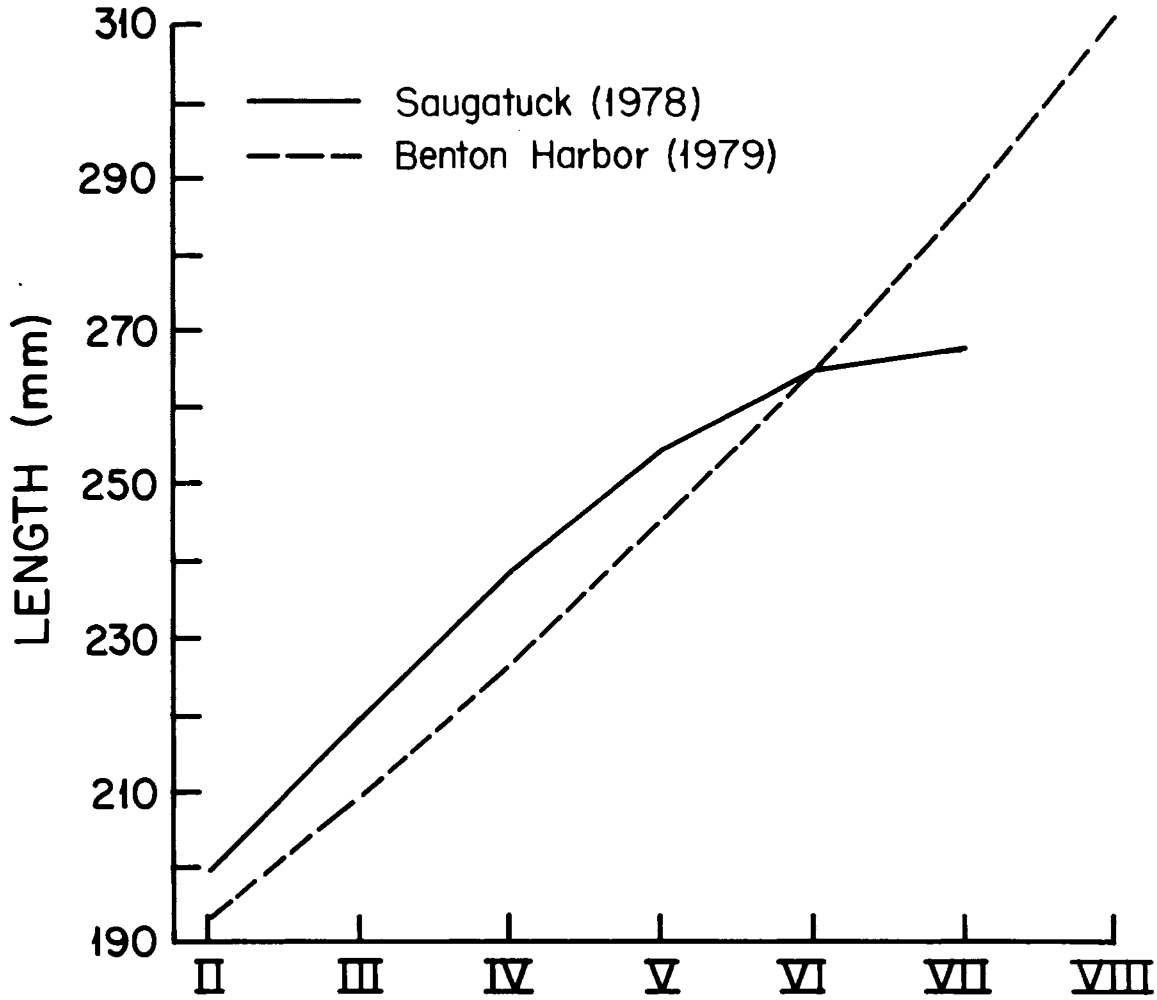

Figure 6. Growth of male yellow perch at Saugatuck and Benton Harbor, based on regressions in Table 8.

Table 1. Dimensions of pots in experimental trap nets.

Number of nets	Height m (ft)	Width m (ft)	Length m (ft)	Volume m^3 (ft^3)
6	0.9(3)	1.5(5)	2.4(8)	3.4(120)
2	1.8(6)	1.8(6)	2.7(9)	9.2(324)
4	1.8(6)	2.4(8)	2.4(8)	10.9(384)
2	3.0(10)	3.0(10)	(3.4(11)	31.1(1,100)

Table 2. Mean number of yellow perch caught per trap-net lift off Saugatuck in 1978, by net size and net days.

Net volume (m^3)	Net days							
	1	2	3	5	7	8	9	Mean
3	45	49	36	117	91	15	73	61
9	139	111	113	82	271	51	87	122
11	81	64	35	164	197	67	230	120
31	77	93	62	352	433	8	85	159
Mean	86	79	61	179	248	35	119	---

Table 3. Survival rates for yellow perch in the Saugatuck (1978) and Benton Harbor (1979) areas of Lake Michigan.

Area	Sex	Ages	Survival rate	95% confidence limits
Saugatuck	Male	V-VIII	0.333	±0.055
	Female	V-X	0.596	---
	Both	V-X	0.445	±0.028
Benton Harbor	Male	V-IX	0.283	±0.040
	Female	IV-X	0.556	±0.056
	Both	IV-X	0.397	---

Table 4. Predicted yellow perch round weight and 95% confidence limits by sex, total length, and station, based on length-weight regression equations in Table 5.

		Saugatuck			Benton Harbor		
		Pre- dicted weight	95% confidence limits		Pre- dicted weight	95% confidence limits	
Sex	Length group (mm)	(g)	Lower	Upper	(g)	Lower	Upper
Males	190	61	58	64	64	63	65
	200	73	70	76	76	75	77
	210	87	84	90	88	87	89
	220	102	99	105	102	101	103
	230	119	117	121	117	116	118
	240	138	135	141	134	132	136
	250	159	156	162	152	150	154
	260	182	177	187	172	169	175
	270	207	200	214	193	189	197
	280	235	226	244	217	212	222
	290	265	253	277	242	235	249
	300	298	283	313	269	261	277
Females	200	90	83	97	77	72	82
	210	105	98	112	90	85	95
	220	121	114	128	106	101	111
	230	139	132	146	122	117	127
	240	158	151	165	141	136	146
	250	179	172	186	162	156	168
	260	203	196	210	184	178	190
	270	228	221	235	209	203	215
	280	255	248	262	236	229	243
	290	284	278	290	265	257	273
	300	315	309	321	297	288	306
	310	349	343	355	331	320	342
	320	385	378	392	368	355	381
	330	424	416	432	408	392	424
	340	465	455	475	451	432	470
	350	508	495	521	496	473	519
	360	554	539	569	545	518	572
	370	603	584	622	597	565	629

Table 5. Regressions of total length (L in mm) on round weight (in gm) for southern Lake Michigan perch, by station and sex.

Area and date	Sex	N	Length range (mm)	Regression
Saugatuck				
7/10-8/2/78	Males	96	189-302	$8.2325\ (10^{-7})L^{3.4549}$
	Females	53	216-370	$6.8655\ (10^{-6})L^{3.0932}$
	All	.149	189-370	$7.1929\ (10^{-7})L^{3.4816}$
Benton Harbor				
7/9-8/1/79	Males	341	185-342	$4.7186\ (10^{-6})L^{3.1309}$
	Females	48	195-371	$1.6479\ (10^{-6})L^{3.3328}$
	All	389	185-371	$2.0269\ (10^{-6})L^{3.2869}$

Table 6. Predicted yellow perch total length and 95% confidence limits, by sex, age, and station, based on age-length regression equations in Table 7.

		Saugatuck[1]			Benton Harbor[2]		
		Predicted length (mm)	95% confidence limits		Predicted length (mm)	95% confidence limits	
Sex	Age group		Lower	Upper		Lower	Upper
Males	II	199	194	204	193	189	197
	III	219	214	224	209	207	211
	IV	238	235	241	226	224	228
	V	254	251	257	245	242	248
	VI	265	259	272	265	260	270
	VII	268	256	280	287	279	295
	VIII	---	---	---	311	299	323
Females	III	213	203	223	215	205	225
	IV	256	247	265	267	259	275
	V	292	285	299	302	296	308
	VI	319	314	324	325	317	333
	VII	337	333	341	341	327	355
	VIII	345	337	353	356	331	381

[1]July 10 through August 2, 1978.

[2]July 9 through August 1, 1979.

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Approved by W. C. Latta

Typed by G. M. Zurek

APPENDIX

Appendix A. Age frequencies of yellow perch in experimental trap-net catches in southern Lake Michigan, Saugatuck (May-September 1978) and Benton Harbor (May-September 1979).

Age group	Saugatuck			Benton Harbor		
	Males	Females	Total	Males	Females	Total
II	13	0	13	45	1	46
III	193	31	224	428	78	506
IV	359	131	490	426	60	486
V	176	157	333	249	31	280
VI	50	91	141	71	18	89
VII	27	76	103	16	13	29
VIII	4	43	47	7	12	19
IX	0	12	12	3	2	5
X	1	4	5	0	1	1

Appendix B. Mean total length (mm) and round weight (gm) of yellow perch in southern Lake Michigan by station, sex, and age group.

Station and date	Sex		Age group II	III	IV	V	VI	VII	VIII	IX
Saugatuck	Male	Length	201	218	240	254	265	268	264	---
7/10-8/2/78		Weight	75	98	140	171	196	220	200	---
		Number	4	23	32	22	10	4	1	0
	Female	Length	---	216	256	290	322	339	342	343
		Weight	---	110	206	286	381	460	479	490
		Number	0	1	5	11	8	14	10	4
	Both	Length	201	218	242	266	290	323	335	361
		Weight	75	98	149	209	278	407	354	490
		Number	4	24	37	33	18	18	11	4
Benton Harbor	Male	Length	193	209	227	248	268	235	342	---
7/9-8/1/78		Weight	70	88	114	155	195	120	450	---
		Number	1	113	149	61	14	2	1	0
	Female	Length	---	215	265	303	318	344	355	---
		Weight	---	96	210	320	395	470	480	---
		Number	0	12	7	17	4	5	3	0
	Both	Length	193	209	229	260	279	314	352	---
		Weight	70	89	118	191	239	370	473	---
		Number	1	125	156	78	18	7	4	0