MESH MODIFICATIONS OF COMMERCIAL DROP NETS FOR YELLOW PERCH IN SOUTHERN GREEN BAY, LAKE MICHIGAN

by

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ABSTRACT

Commercial drop nets were modified in one of three ways to reduce catches of sublegal (<191 mm) yellow perch (Perca flavescens) in Green Bay, Lake Michigan. In drop net pots modified with windows of larger mesh (67 & 70-mm stretched mesh), the percent of legal-sized yellow perch and the mean length of perch increased significantly from values obtained from the control pots (46-mm stretched mesh, the size used by most commercial fishermen). But catch per unit of effort of legal-sized perch (CPUE) was the same in the control and modified pots. The increase in percent legal composition of the catch was not sufficient to warrant further investigation.

Drop nets modified with larger mesh throughout the pot (57, 60, & 64-mm stretched mesh), and larger mesh covering only the last 2 hoops (57, 58, 62, and 65-mm stretched mesh) resulted in significant increases in percent of legal-sized yellow perch and mean length of perch captured, whereas CPUE declined significantly. Drop nets with larger mesh throughout the pot allowed more sublegal perch to escape than nets with an equal size mesh covering the last 2 hoops, but CPUE's were the same. Selection curves indicated that legal-sized perch escaped from the experimental meshes.

Management options that would require 55-mm stretched mesh throughout the pot along with the current minimum size length of 191 mm, or require 57-mm stretched mesh throughout the pot and retention of all perch captured by commercial

fishermen would result in catches of 80 - 90% legal-sized perch, and would reduce handling mortality associated with the fishery, allowing more perch to reach harvestable size.

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Introduction

The objective of this study was to identify net modifications that would allow sublegal yellow perch (*Perca flavescens*) to escape from commercial drop nets fished in southern Green Bay, Lake Michigan, while retaining legal-sized yellow perch.

Southern Green Bay's yellow perch population supports a substantial sport and commercial fishery. The yellow perch population fluctuates widely, indicated by variation in the commercial harvest ranging from a high of 1.09 million kilograms in 1943 to a low of 73,500 kilograms in 1966 (Figure 1). Griffin (1979) stated that intensive fishing, alewife (*Alosa pseudoharengus*) interference, market values, and environmental variables including wind, and to a lesser extent, water temperature, are the main variables affecting perch production in Green Bay. Since the mid 1940's there has been a downward trend in yield, erratic harvest, increased growth rates, reduction of age of fish in the population, and reduced age of first spawning (Griffin 1979). These trends, according to Van Oosten (1949) and Spangler et al. (1977), who defined responses of percids to exploitation, indicate that the perch population of southern Green Bay is heavily exploited. Currently, the southern Green Bay fishery depends on sporadic, successful year classes of yellow perch (Belonger 1979).

Management regulations for the commercial fishery

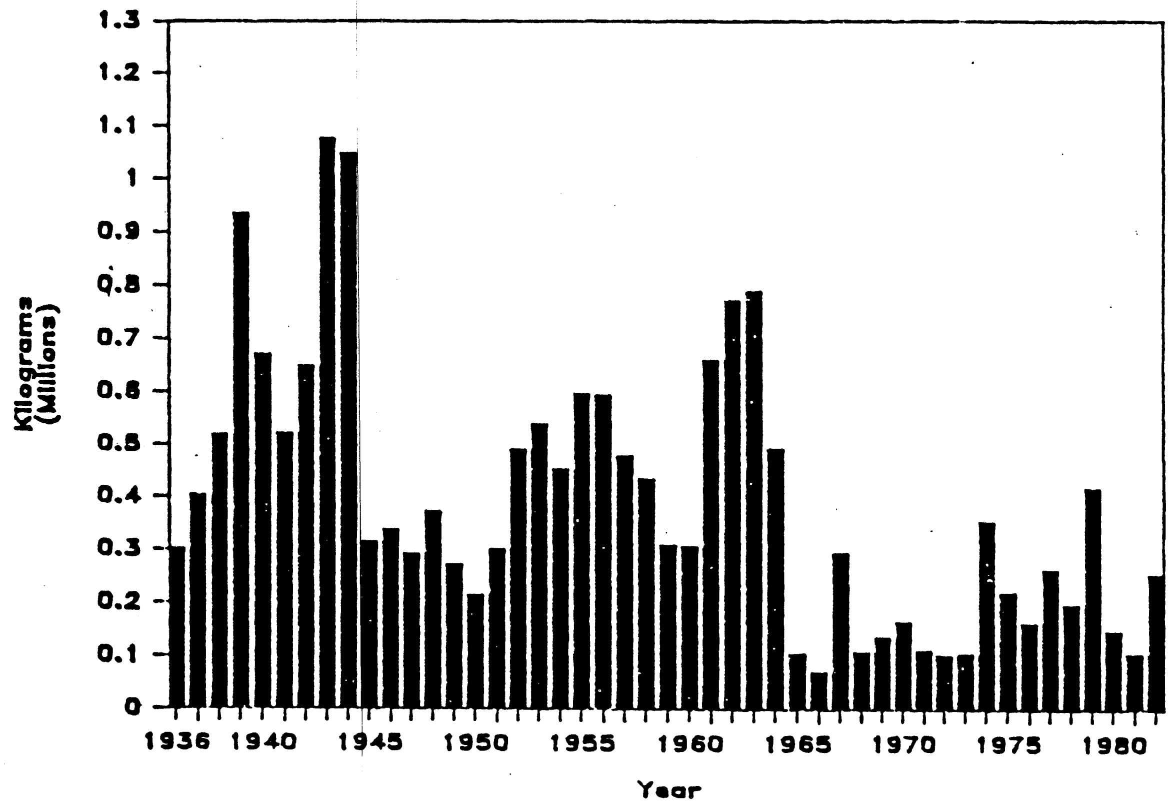


Figure 1.__Commercial harvest (in millions of kilograms) of yellow perch in southern Green Bay. (Wisconsin Department of Natural Resources, unpublished yellow perch data, Marinette, Wisconsin).

include a minimum mesh size of 60-mm stretched mesh for gillnets, closed seasons extending from April 9 to July 1 for dropnets and April 9 to May 20 for gillnets, restrictions on the number of dropnets used, various closed areas, and a minimum length limit of 191 mm since 1952 (Table 1). In 1983 a quota of 90,718 kg was set to limit the harvest of yellow perch from the Wisconsin waters of southern Green Bay. In 1984 the quota was raised to 158,757 kg (Wis. Adm. Code, chapter 25). Hartman (1978) estimated that yield per recruit would be greatest if the perch were not harvested until reaching age 4 or a length of 203 - 216 millimeters.

A problem in the fishery is nonharvest mortality of sublegal yellow perch (those fish < 190 millimeters long) captured in drop nets. Mesh sizes currently fished in commercial dropnets capture a large proportion of sublegal perch. In random samples of drop nets of the Wisconsin Department of Natural Resources, 66% of the fish sampled in 1979 and 59% of those sampled in 1980 were less than 190 millimeters long (Southern Green Bay Operations Staff 1980). These fish must be sorted and returned to the water. Coshun (M.S. Thesis in preparation, University of Wisconsin - Stevens Point) estimated that an average of 34% of the sublegal perch returned to the water would die from the handling within 24 hours. Other causes of mortality associated with capture of yellow perch are gull (*Larus* spp.) predation of perch that do not recover quickly when released, and periods of low dissolved oxygen that may kill fish

Table 1. Minimum commercial length limits (in millimeters and inches) for yellow perch in southern Green Bay (Griffin 1979).

Year	Minimum Length millimeters	inches
1907	none	none
1909	178	7.0
1917	203	8.0
1919	178	7.0
1939	203	8.0
1940	191	7.5
1943	203	8.0
1952 - 1984	191	7.5

trapped in a net.

This nonharvest mortality may be excessive. In 1979 the Southern Green Bay Operatons Staff of the Wisconsin Department of Natural Resources estimated that as much as 342 kilograms of yellow perch suffered nonharvest net mortality from one commercial fisherman's nets in one day's operation. Because a large portion of the sublegal perch captured in commercial drop nets are just below the 190-mm legal size (Table 2) and would spawn the following spring, reproduction could be increased if these fish were not captured.

Table 2. Number of yellow perch in various length groups measured from commercial drop nets in 1980 by the Southern Green Bay Operations Staff of the Wisconsin Department of Natural Resources.

Total length in mm	Number of perch	Percent distribution
100 - 109		
110 - 119	2	0.1
120 - 129	2	0.1
130 - 139	6	0.1
140 - 149	58	0.9
150 - 159	281	4.5
160 - 169	851	15.4
170 - 179	1462	34.2
180 - 189	1914	58.8
190 - 199	1582	79.2
200 - 209	830	89.9
210 - 219	403	95.0
220 - 229	193	97.5
230 - 239	97	98.8
240 - 249	47	99.4
250 - 259	17	99.6
260 - 269	7	99.7
270 - 279	5	99.8
280 - 289	5	99.8
290 - 299	7	99.9
> 300	7	100.0
Total	7776	
% < 190	58.8	
Mean length of perch captured	187 mm	

Methods

The seven drop nets used in this study, constructed of #18 nylon twine by commercial fishermen, had two pots separated by a lead (Figure 2). Four of the drop nets that I fished in the summers of 1982 and 1983 had leads 70 m long and 1.8 m deep. The leads were constructed of 57-mm stretched mesh. The hearts were 1.8 m high and 3.05 m wide. Two steel pipes attached to the bottom of the hearts kept them on the substrate while two wooden spreader poles provided floatation to keep the hearts open. The pots contained nine hoops, ranging from 1.07-m diameter proximal to the hearts to 0.91-m diameter in the hoop most distal to the hearts. There were 108 meshes (46-mm stretched mesh) tied around the hoops. Each pot had three funnels to prevent captured fish from escaping (Figure 2). The nets were treated with a preservative (Netcoat) before fishing.

I measured the meshes of the pots to the nearest millimeter with a wedge-shaped gauge (Appendix A) inserted through a mesh with a 5-kilogram force (NAFO 1982). I measured a minimum of 20 meshes in each pot after the nets had been in the water for at least nine days.

The pot at one end of the nets was the control and consisted of 46-mm stretched mesh, the size normally used in the fishery. The pot at the other end was modified in one of two ways. In 1982, two windows of a larger sized mesh were placed in each modified pot, one behind the second tunnel and one behind the third tunnel on one side of the net. Each

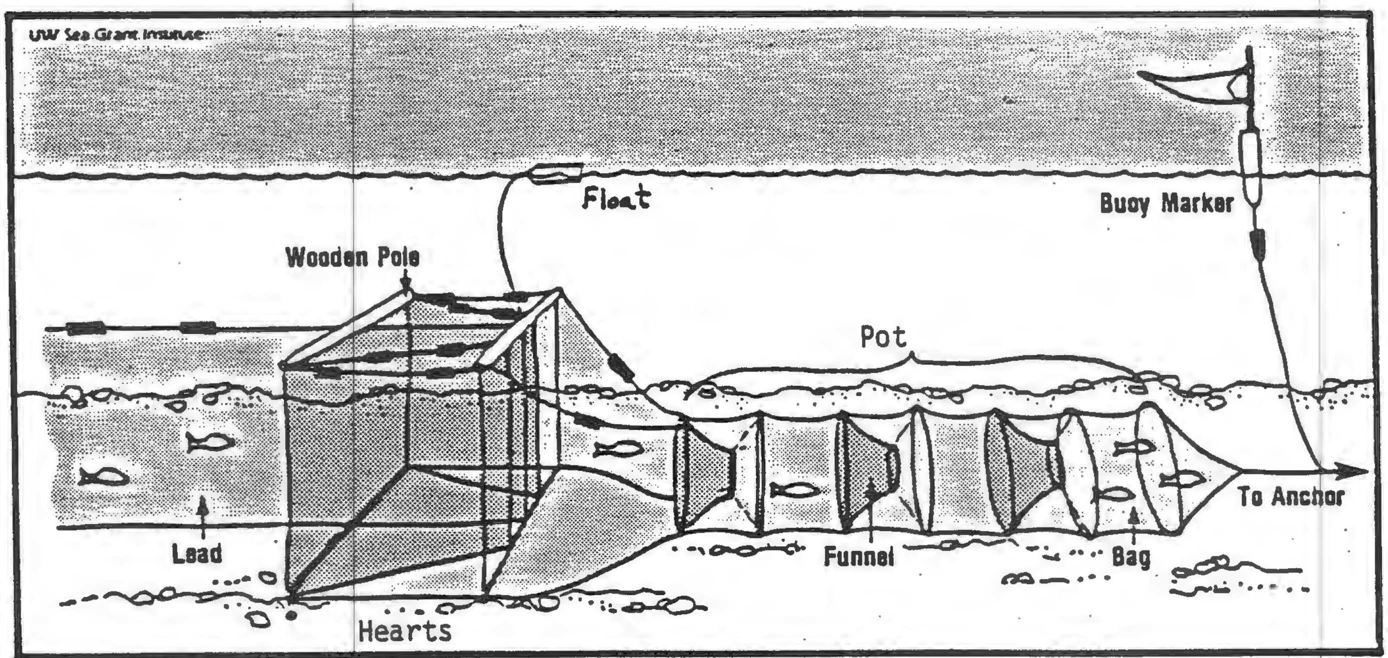


Figure 2.___ One end of a commercial drop net. The pot at the opposite end of the lead is identicle to this one.

window was approximately 305-mm square; constructed of #15 nylon twine, dyed green. Two pots contained windows of 67-mm stretched mesh and two pots had windows of 70-mm stretched mesh. In 1983 the windows were removed and the mesh covering the last 2 hoops was replaced with 57, 58, 62, or 65-mm mesh. The number of meshes placed around the hoops was adjusted to compensate for the increased mesh size (Table 3).

Three additional drop nets used in 1983 provided a third modification. They were similar to the original nets, but had larger mesh in both pots. One net had 57, one had 60, and one had 64-mm stretched mesh (Table 3). The leads on these nets were 73 m long and 2 m deep. Mesh size in the leads was 66-mm stretched mesh.

The nets were fished perpendicular to shore and lifted one pot at a time. I imitated commercial fishing practices as closely as possible. At each location the shoreward ends of the nets were fished at the same depth; the outside pots were often in deeper water although the depths did not differ by more than 1.2 meters. Two control pots were fished on the shoreward end and two on the outside ends of the nets. Wisconsin commercial fishing regulations require each pot to be lifted once every three days, but due to rough weather and unforseen problems such as mechanical failures, commercial fishermen cannot always adhere to this regulation. My sets lasted from one to seven days.

In 1982 I moved the nets from time to time when catches of yellow perch declined (Figure 3). In 1983 all nets were

Table 3. Description of drop nets and dates fished. Locations are shown in Figure 3.

Mesh Size (mm)	Modification	Number of Pots	Number of Meshes around 0.91m hoop	Dates Fished	Number of Pot-lifts
46	Entire Pot	4	108	11 June 82 - 30 Aug 82	74
				1 June 82 - 23 Aug 83	64
67	Window	2	108	11 June 82 - 30 Aug 82	46
70	Window	2	108	11 June 82 - 30 Aug 82	43
57	Entire Pot	2	102	1 June 83 - 22 Aug 83	46
60	Entire Pot	2	96	1 June 83 - 12 Aug 83	40
64	Entire Pot	2	90	4 June 83 - 9 Aug 83	35
57	Last 2 Hoops	1	108	15 July 83 - 5 Aug 83	7
58	Last 2 Hoops	1	96	15 July 83 - 15 Aug 83	10
62	Last 2 Hoops	1	102	15 July 83 - 23 Aug 83	11
65	Last 2 Hoops	1	90	15 July 83 - 22 Aug 83	10

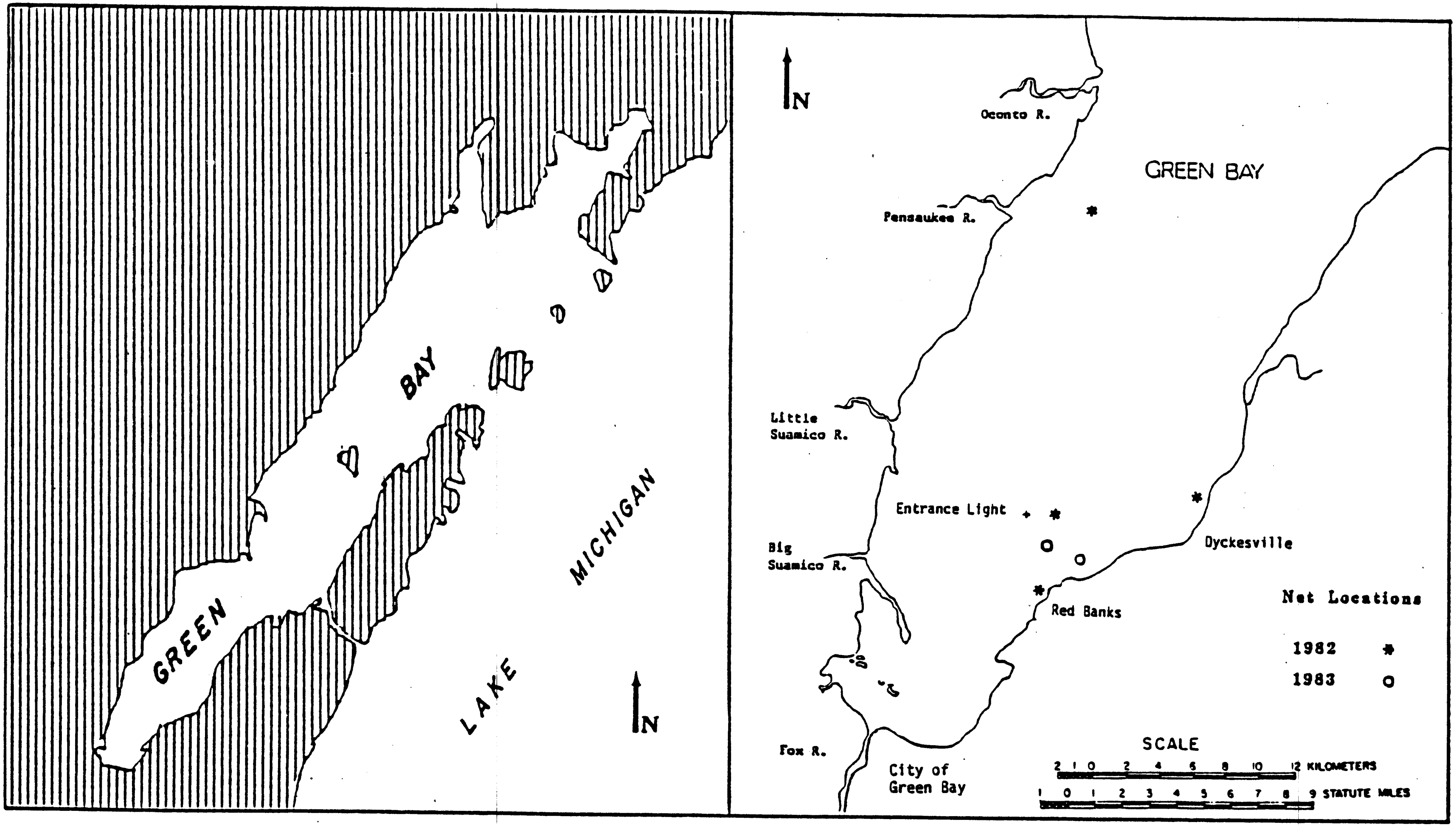


Figure 3. Study area and location of drop nets in 1982 and 1983.

fished in the same area for the entire season except during the last two weeks when one net was moved to deeper water in an attempt to capture more perch.

Yellow perch captured in each lift of a drop net were measured to the nearest millimeter. Usually, dead perch were not measured, but were estimated to be either legal-sized or sublegal, and were included in the total catch. Other data recorded for each lift were mesh size, number of legal and sublegal yellow perch, number of yellow perch gilled in the pot, surface and bottom water temperatures, dissolved oxygen concentration, and length of time in days since the pot had been lifted. Effort here is defined as one pot fished for 24 hours and is termed one pot-day. The mean length of yellow perch captured, the percent of legal-sized yellow perch captured, and the catch per unit of effort of legal-sized yellow perch per day (CPUE) were calculated from these data.

Some lifts in 1982 contained too many perch to measure and were subsampled. The perch in the pot were emptied onto the bottom of the boat and a portion of the catch was placed in a livewell to be measured. This portion was obtained by taking what I thought was a representative sample of the lift with an aluminum shovel. The perch that were not measured were counted and released. The CPUE of legal-sized perch per pot-day was determined for these lifts by multiplying the total catch for that pot by the percent of legal-sized perch in the sample. Catches were not subsampled in 1983.

I measured water temperature and dissolved oxygen concentration one-half meter above the substrate with a dissolved oxygen meter (Yellow Springs Instrument Co.; Model 54) and a Hach Kit (Hach Chemical Company, Ames, Iowa) when the meter failed.

The catches of perch in the control pots is assumed to be representative of the size structure of the population available to the modified pots. Therefore, catches of perch in the modified pots were compared to catches of perch in the control, or standard pots that were fished at the same time. One-way analysis of variance (ANOVA) was used to test the hypothesis of equality between pots. Variables tested were the percent of legal-sized perch in the pots, mean lengths of perch captured, and CPUE, the number of legal-sized perch per pot-day. If the null hypothesis was rejected, I used a multiple comparison test, Scheffe procedure, described by Zar (1974), to determine where the differences existed. Lifts with less than 2 perch were eliminated from all analyses.

Mean length of yellow perch captured, percent legal-sized fish in a pot, and CPUE of legal-sized yellow perch per day were regressed against mesh size. Since sample size in this study was large, 95% of the prediction errors are within $\pm$1.96 times the standard deviation of the observed Y values about the predicted Y values (Kachigan 1982). I also set hypothetical length limits of 203, 216, and 229 mm and calculated what the percent of legal-sized perch captured in each mesh size would have been at these minimum size lengths. I then regressed the percent legal perch at the hypothetical length limits against mesh size to obtain equations that would allow me to predict what percent of the catch in nets of various mesh sizes would be legal-sized at the hypothetical length limits.

The relationship between the probability of retaining a fish once it enters a net and the length of the fish, when presented graphically, is termed the length selection curve (Pope et al. 1975). Selection curves for perch captured were obtained by summing the catches at 10-mm length intervals and plotting the percent retention of each length group. Total effort for each modification and the control pots was adjusted so the efforts would be equal. The percent retention was determined by dividing the number of perch of a certain length that were captured in each modified pot by the number of perch of the same length that were captured in the control pots, multiplied by 100. This percentage represents the proportion of perch that were retained by the larger meshes. Pope et al. (1975) stated, "The simplest methods of fitting the selection curve, by eye, or by taking a straight mean, are usually in themselves quite adequate to do justice even to reasonably good selectivity data".

Selection curves for drop nets with larger mesh throughout the pot were determined by the function:

$$\text{If } X < Y, \text{ Then } S = 50 \times e^{B \times (X-Y)} \quad \text{or,}$$

$$\text{If } X > Y, \text{ Then } S = 100 - 50 \times e^{B \times (Y-X)}$$

where X = the length of perch (mm),

S = the percent retention at length (X),

Y = an estimate of the 50% retention length,

and $0 < B < 1$

I iterated values of B and Y and plotted curves to attain the best fit to the points as determined by inspection.

Curves for drop nets with larger mesh covering the last 2 hoops were fit by eye.

Results and Discussion

1982 Window Modification

Commercial drop nets with windows of larger-sized mesh in the pots allowed sublegal perch to escape (Table 4). The percent of legal-sized perch in the pots and the mean length of perch captured were directly related to mesh size in the windows, indicating that small perch were escaping. Values for both were significantly greater (Scheffe procedure; 2, 160 df, $P<0.05$) in drop nets with 70-mm mesh windows than in the control pots. Although CPUE of legal-sized perch per pot-day appeared to be inversely related to mesh size in the windows, the differences were not significant (Scheffe procedure; 2, 160 df, $P>0.05$, Table 4).

Drop nets with windows of larger mesh have been used previously in an attempt to reduce the numbers of sublegal perch captured. Belonger (1982) found that drop nets with 57-mm mesh windows of #15 nylon twine dyed black averaged 52.4% legal-sized perch in the pots whereas his control pots averaged 34.5%. His sample sizes were smaller than mine, 582 perch in the control pots and 550 perch in the modified pots, which may account for the different results. Other possible reasons for the difference in results include color of the twine in the windows, the hang of the window in the pot, and the size structure of the perch population available to the nets. Belonger's black windows were placed so that the meshes hung in a diamond shape; my green windows were hung so

Table 4. Drop net catches of yellow perch from 11 June 1982 - 30 August 1982.

Modification[a]	Total number of perch captured	Mean percent legal	Mean length (mm)	Mean CPUE (legals/ pot-day)
Control (46-mm mesh)	7673	27	181	8.0
Range		4.0-100	170-201	0.7-55.0
67-mm windows	2891	34	183	5.7
Range		4.7-100	173-207	0.5-34.6
70-mm windows	1786	39[b]	186[b]	5.6
Range		2.5-100	175-210	0.5-52.7

[a] See Table 3 for dates fished and the number of lifts.

[b] Significantly different from the control pots (Scheffe procedure; 2, 160 df, $P<0.05$).

that the meshes were square. Belonger fished his nets on the west shore of Green Bay from 5 October 1981 until 4 November 1981 in an area that was closed to commercial fishing. I fished my nets from 11 June 1982 - 30 August 1982 in areas open to commercial fishing.

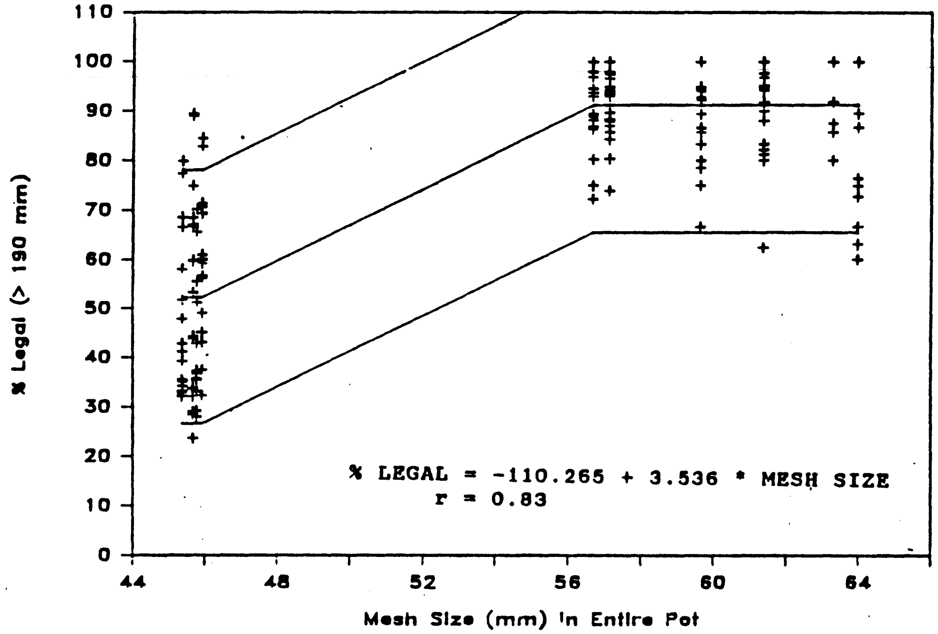
The relation between CPUE of legal-sized perch and mesh size in the windows also differed between Belonger's results and mine. The CPUE of legal-sized perch in Belonger's nets increased from 6.7 per pot-day in the control pots to 9.6 per pot-day in the modified pots. CPUE of legal-sized perch in my nets decreased, though the decrease was not significant (Scheffe procedure; 2, 160 df, $P>0.05$). The difference in results may be due to sampling variability; Belonger made 18 lifts; I made 163.

I would not recommend using windows to reduce catches of sublegal yellow perch. Although nets with windows allowed sublegal perch to escape, the largest window mesh fished, 70-mm, retained mostly sublegal perch, and the mean length of the catch was less than the minimum legal length (Table 4). Smolowitz (1983) recommended that no more than 20% of the catch should be sublegal in nets where a minimum size length of fish taken commercially is enforced. An area of larger mesh that is greater than the area of the windows would seem to be more efficient.

1983 Modifications

Drop nets with larger mesh in the entire pot or larger mesh on the last 2 hoops of the pot allowed sublegal perch to escape. In both experimental designs, the percent of legal-sized perch and the mean length of the perch captured were directly related to mesh size (Figures 4, 5), and CPUE of legal-sized perch was inversely related to mesh size (Figure 6).

The relationships above should remain the same with differences in gear design, but different values may be obtained. One pot that I fished had fewer meshes tied around the hoops than the other pots with nearly the same mesh size, yet it allowed more perch to escape. The pot with 58-mm mesh covering the last 2 hoops had 96 meshes tied around the hoops (Table 3). Mean length and the percent of legal-sized perch captured in this pot were significantly greater (Scheffe procedure; 4, 89 df, $P<0.05$) than mean length and percent of legal-sized perch captured in pots with 57 and 62-mm mesh covering the last 2 hoops (Table 5) with 108 and 102 meshes around the last 2 hoops. The CPUE in this pot was not significantly different from that in the pots with 57 and 62-mm mesh covering the last 2 hoops (Scheffe procedure; 4, 97 df, $P>0.05$). The other pots that I fished had decreasing numbers of meshes tied around the hoops as mesh size increased, a common practice of the commercial fisherman who constructed three of my nets (R. Champion, personal



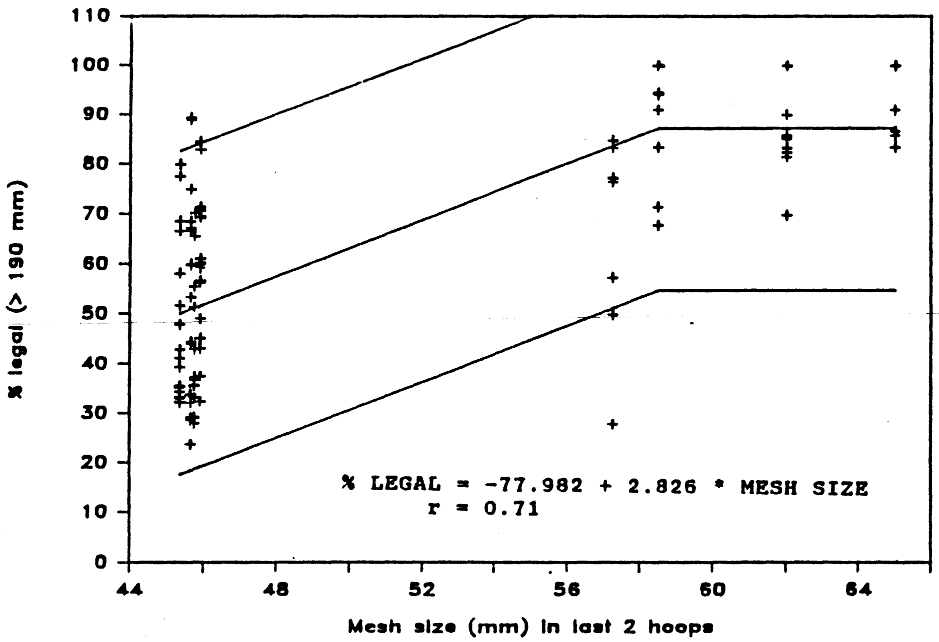
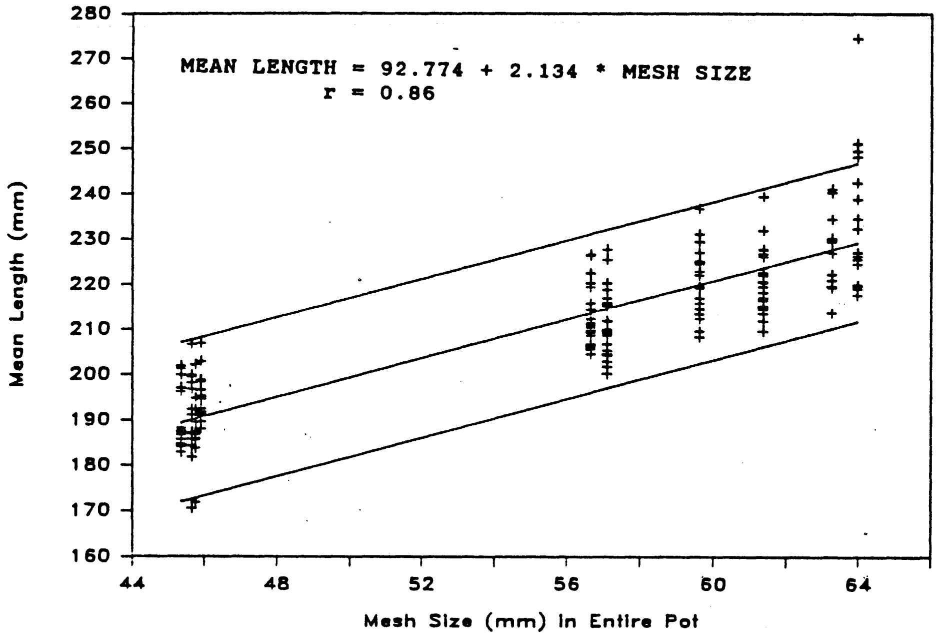


Figure 4.__ Percent legal-sized yellow perch versus mesh size for drop nets with various mesh modifications. Each point represents one lift of a drop net pot. The center line represents the regression equation for the data; upper and lower lines indicate the 95% predictive limits.



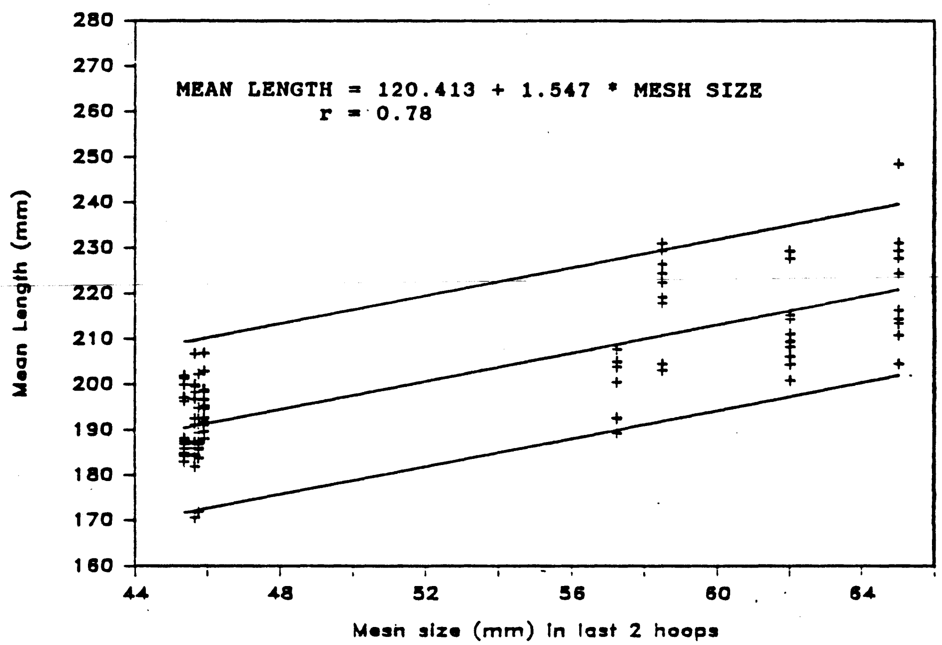


Figure 5.__ Mean length of yellow perch captured in commercial drop nets versus mesh size. Each point represents one lift of a pot. The center line represents the regression equation for the data; upper and lower lines indicate the 95% predictive limits.

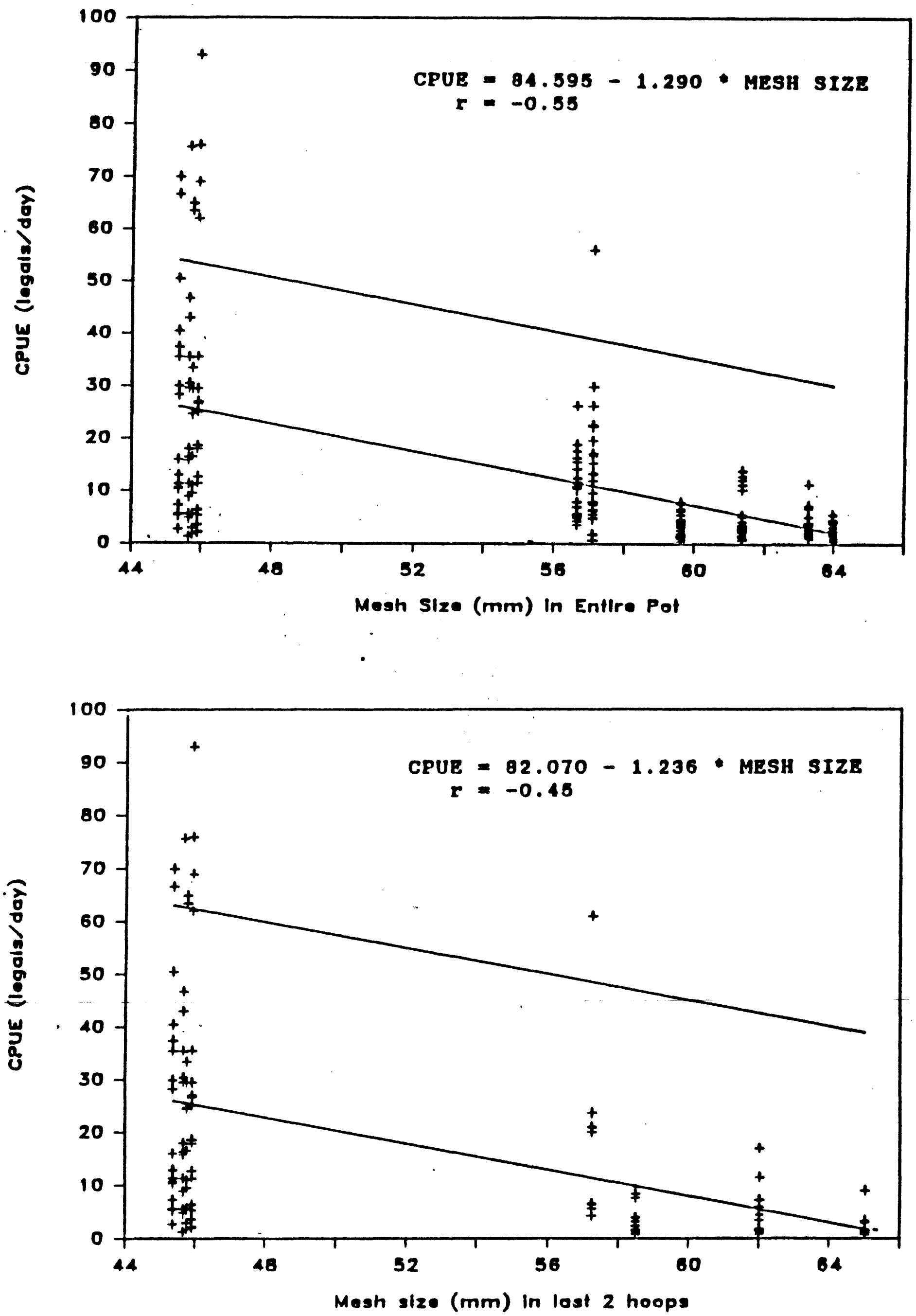


Figure 6.__ CPUE of legal-sized yellow perch captured in commercial drop nets versus mesh size. Each point represents one lift of a drop net pot. The lower line represents the regression equation for the data. The upper line indicates the upper range of the 95% predictive limit. The two regression lines in this figure are not significantly different (Analysis of Covariance). A single equation describing the relationship is Y = 81.708 - 1.231 * X; where Y = CPUE (legals/pot-day) and X = mesh size (mm); r = -0.57.

Table 5. Drop net catches of yellow perch from 1 June 1983 - 23 August 1983. Standard deviations are in parenthesis.

Modification[a]	Number of perch captured	Mean percent legal	Mean length (mm)	Mean CPUE (legals/ pot-day)
Control	10799	51[b,c,d,e,f,g]	191[b,c]	25.6[b,c,d,e]
(46-mm mesh)		(18)	(7.55)	(22.52)
Range		24-89	171-207	1.2-93.0
57-mm mesh	2182	92[b]	212[b]	12.7[b]
throughout pot		(8)	(7.32)	(9.50)
Range		75-100	195-228	0.8-56.0
60-mm mesh	720	91[c]	221[b]	4.6[c]
throughout pot		(10)	(7.46)	(3.45)
Range		63-100	208-240	0.6-14.0
64-mm mesh	422	91[d]	232[b]	3.1[b]
throughout pot		(13)	(13.0)	(2.20)
Range		60-100	214-275	0.6-11.3
57-mm mesh	757	65[h,i]	199[d]	20.3
in last 2 hoops		(21)	(7.28)	(19.72)
Range		47-100	207-241	4.3-61.0
58-mm mesh	115	90[e,h]	221[c,d]	3.3[d]
in last 2 hoops		(12)	(10.0)	(2.75)
Range		71-100	203-231	0.8-8.5
62-mm mesh	206	86[f]	213[c,d]	5.2[e]
in last 2 hoops		(8)	(9.01)	(5.09)
Range		70-100	201-130	0.9-17.0
65-mm mesh	87	93[g]	222[c,d]	2.5[f]
in last 2 hoops		(7)	(12.8)	(2.48)
Range		83-100	205-249	0.8-9.0

[a] See Table 3 for dates fished and the number of lifts and Appendix B for the length frequencies of the perch captured and the total effort for each pot.

[b,c,d,e,f,g,h,i] Values marked with a superscript are significantly different (Scheffe procedure, P 0.05) from any other value in the same column having the same superscript.

communication). If the fishery is to be controlled closely by mesh size regulation of drop nets, it would be necessary also to regulate the number of meshes to be placed around hoops of stated diameters.

Percent legal:

An increase in the percent of legal-sized fish in catches would result in fewer discards. The mean percent of the catch of perch that was legal-sized increased from 51 in the control pots to 91 - 92 in pots with 57-mm or larger mesh in the entire pot and to 86 - 93 in drop net pots with 58-mm or larger mesh covering the last 2 hoops (Table 5, Figure 4). These significant increases from the control value (Table 5) indicate that sublegal perch were escaping from the pots with larger mesh.

There seemed to be a limit to the highest percent legal that can be achieved. The mean percent legal did not increase in pots with meshes larger than 57-mm. There was no significant difference (Scheffe procedure; 3, 181 df, P>0.05) in the mean percent of the catch that was legal-sized in the pots with 57, 60, and 64-mm mesh throughout the pot and in pots with 58, 62, and 65-mm mesh covering the last 2 hoops (Scheffe procedure; 4, 97 df, P>0.05).

The relationship between the percent of legal-sized perch captured and mesh size can be expressed with the functions:

$$Y = -110.265 + 3.536\,(X) \qquad (1)$$

where Y = Percent legal

X = Mesh size (mm) in the entire pot and

$$Y = -77.982 + 2.826\,(X) \qquad (2)$$

where Y = Percent legal

X = Mesh size (mm) covering last 2 hoops

The equations may be used to estimate the percent legal that would be captured in pots with 46 - 57-mm mesh throughout the pot and 46 - 58-mm mesh covering the last 2 hoops, respectively. However, predictive limits (95%) for these equations are large, ± 25.7 for equation (1), and ± 32.5 for equation (2). These wide ranges are due to the variation in the percent of legal-sized perch captured in the control pots. The percent legal in these pots ranged from 24 to 89% (Figure 4, Table 5); ranges were smaller in all other pots fished.

A change in the size structure of the perch population that was available to the control pots may account for the difference in the percent of legal-sized perch captured in the control pots in 1982 (27) and 1983 (51). The same nets were fished in both years. I obtained relative abundance data for yellow perch of ages 0^+ - V^+ for the years 1978 - 1983 from fall trawling data collected by the Wisconsin Department of Natural Resources (unpublished yellow perch data, Marinette, Wisconsin). A relatively strong year class of perch occured in 1980, which during the summer of 1982 may have been largely smaller than 190 mm, and larger than 190 mm in the summer of 1983 (Table 6). Also, during 1982 the nets were fished in an area that was intensively fished by commercial fishermen, who may have reduced the abundance of legal-sized perch. In 1983 the nets were fished in an area closed to commercial fishing. I believe that ranges of a magnitude of 27 - 51% legal would not occur from year to year in larger mesh nets because the small perch retained by the control pots are not retained by the larger mesh nets (Appendix B).

Mesh sizes and percent legal in relation to increasing the minimum size length:

If regulations were changed to increase the minimum legal length of yellow perch, they should also be changed to increase the minimum legal mesh size of drop nets. If not, that is if the minimum legal length were increased, but the same standard mesh size (46 mm) were used, most of the fish caught would be sublegal size (Table 7) and would have to be sorted and discarded. For example, if the minimum legal length were increased from 191 to 216 mm, only 7% of the yellow perch captured would be of legal size, based on my catches in 1983. Coshun (M.S. Thesis in preparation, University of Wisconsin - Stevens Point) estimated that 34%

Table 6. Relative abundance of yellow perch by age from fall index station trawling in southern Green Bay, 1978 - 1983 (Wisconsin Department of Natural Resources, unpublished perch data, Marinette, Wisconsin).

	Catch per trawl-hour at age 0+ through V+					
Year	0+	I+	II+	III+	IV+	V+
1978	639	1512	21	1		
1979	862	168	512	3		
1980	1112	677	95	58		
1981	197	493	115	9	0.4	1
1982	5737	231	238	39	0.7	
1983	196	2117	205	44	6	2

Table 7. Hypothetical minimum length limits and the estimated mean percent of legal-sized perch in drop nets with various mesh sizes throughout the pot. Mean percent legal for each mesh size was calculated by regressing the percent legal at each minimum length limit against mesh size in the drop nets that I fished.

Mesh size (mm)	Minimum length limit (mm) 190	203	216	229
46	52	25	7	<1
48	60	34	14	4
51	70	47	24	10
54	81	61	34	15
57	91	74	43	21
60	91	88	53	27
Predictive limits (95%)	±26	±34	±36	±32

of sublegal perch die from the handling associated with sorting in the drop net fishery.

Mean length of perch captured:

Mean length of captured yellow perch increased as mesh size increased (Table 5, Figure 5), because fewer small perch were captured (Appendix B). The relation between mean length of perch captured and mesh size can be described by the functions:

$$Y = 92.774 + 2.134\ (X) \qquad (3)$$

where Y = mean length of perch captured (mm), and

X = mesh size (mm) throughout the pot, and

$$Y = 120.413 + 1.547\ (X) \qquad (4)$$

where Y = mean length of perch captured (mm), and

X = mesh size (mm) covering last 2 hoops

Predictive limits (95%) for these equations are: $\pm$17.5 mm for equation (3) and $\pm$18.7 mm for equation (4). Equation (3) has a significantly greater slope (Analysis of Covariance; F-test; 1, 305 df, $P<0.05$) than equation (4), indicating that pots with larger mesh throughout the pot allowed more perch to escape than pots with larger mesh covering the last 2 hoops.

The mean length (191 mm) of perch captured in the control pots during 1983 differed significantly (F-test; 1, 136 df, P<0.05) from the mean length of perch captured in the same pots fished in 1982 (181 mm). I attribute this difference to a change in size structure of perch available to the nets, as discussed on page 25. An increase in abundance of small perch, or a decrease in abundance of large perch, would reduce the mean length of perch captured.

CPUE (number of legal sized yellow perch per pot-day):

Catches of yellow perch in the control pots fluctuated widely (Figure 7). Short-term fluctuations in catches may be caused by migration of perch in the sampling area. The area that I fished was closed to commercial fishing all year, whereas commercial fishing began on 1 July 1983 in other areas of the bay. Catches of legal-sized perch in June and July were significantly greater (Scheffe procedure; 2, 61 df, P<0.05) than in August, 1983. The decline in CPUE in my nets after July may have been a result of the commercial fishery reducing the population of legal-sized perch.

The reduction in CPUE with increases in mesh size (Figure 6) can hardly be appealing to a commercial fisherman. For example, the CPUE in the drop net pots with 57-mm mesh throughout the pot was 12.7, or 50% less than the CPUE in the standard pots. However, the reduction in CPUE would be compensated to some extent by the decrease in time required

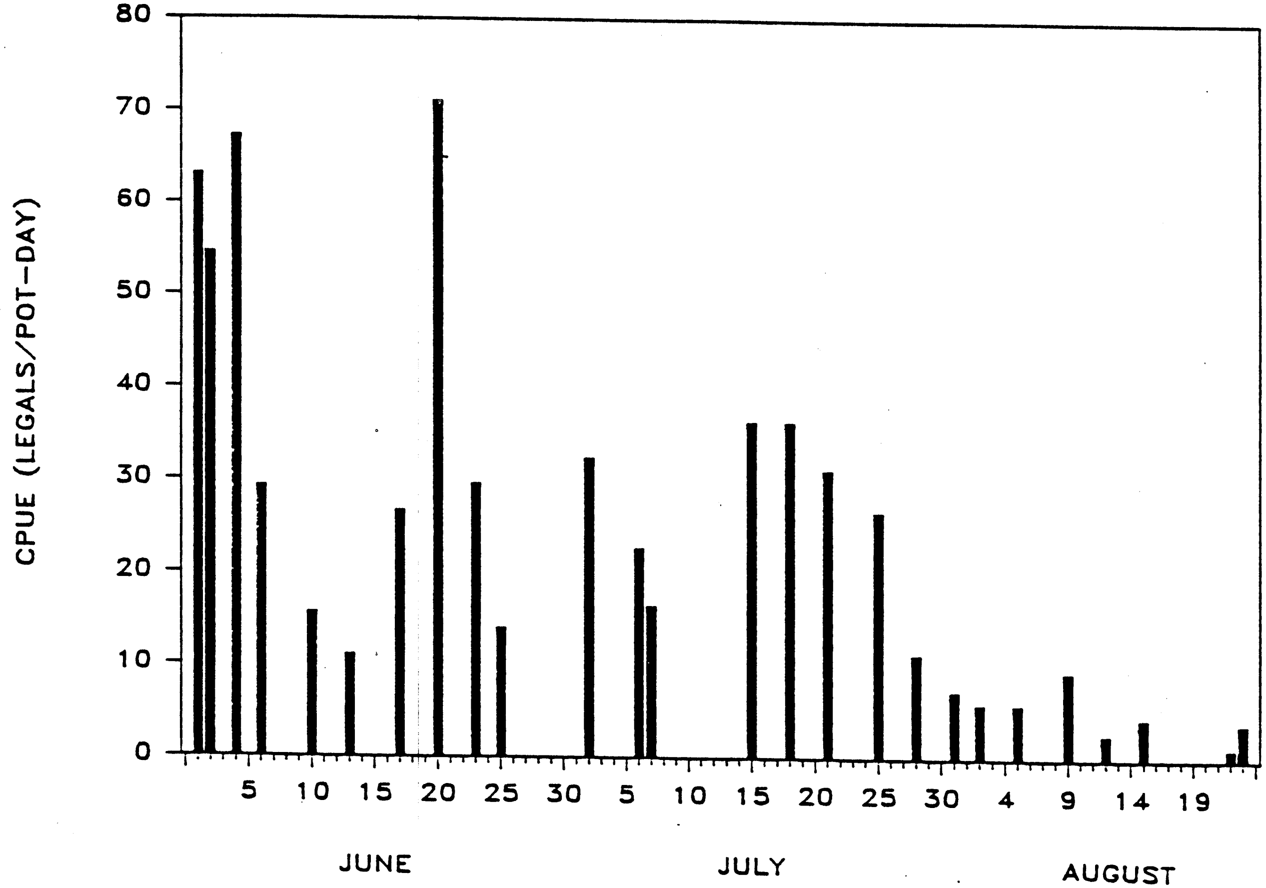


Figure 7.__ CPUE of legal-sized yellow perch captured in standard commercial drop nets (46-mm stretched mesh) from 1 June 1983 - 23 August 1983. When more than one pot was lifted on a given day the CPUE's were averaged for that day.

to sort the sublegal perch from the catch. Moreover, the reduction may not be as great as my data indicate. In the present fishery substantial mortality, e.g. an estimated 34%, of sublegal perch, occurs as a result of drop net associated handling (Coshun, M.S. Thesis in preparation, University of Wisconsin - Stevens Point). If that source of mortality were eliminated by use of larger mesh nets, many of those perch should survive to enter the fishery as legal fish. Such an increase in fish of legal size would also increase the number of spawners, which should tend to increase further the exploitable stock.

I do not know if my CPUE's were similar to those of commercial fishermen. On one hand, they may have been lower because I fished my nets in one area throughout the summer and did not move them, except one, as commercial fishermen would have when catches of perch declined. On the other hand, they may have been higher because I was the only one fishing the study area in 1983.

Gilling:

Most lifts of drop net pots yielded some gilled perch. The gilled perch require time and effort to remove, and a gilled perch returned to the water will likely die due to handling and the loss of the mucous layer. Many of the commercial fishermen that I dealt with were concerned about the larger meshes gilling more perch. I found that the mean number of perch gilled per lift increased and then decreased as mesh size increased (Figure 8). The increase in the mean number of perch gilled in the 57-mm stretched mesh was significant (Scheffe procedure; 3, 155 df, $P<0.05$). Because fewer perch were captured in the larger meshes (Table 5, Appendix B) the percent of the total catch that was gilled increased as mesh size increased.

The majority of the perch gilled in the control pots were sublegal (personal observation) whereas the mean lengths of perch gilled in the 57, 60, and 64-mm stretched mesh pots were 203, 218, and 221 mm, respectively. The effort expended to remove the gilled perch may be overlooked by commercial fishermen if the effort results in perch that may be kept rather than discarded.

Selection curves:

The experimental mesh sizes used in this study would be inefficient for a yellow perch fishery with a minimum length limit of 191 mm because they all allowed 50% or more of the perch 190 - 200 mm long to escape (Figures 9, 10, Appendix C). Drop net pots with 57, 60, and 64-mm stretched mesh throughout the pot had 50% retention lengths of 199, 216, and 218 mm. Pots with 58, 62, and 65-mm stretched mesh covering the last 2 hoops had 50% retention lengths of 216, 213, and 218 mm respectively. Data for the pot with 57-mm mesh

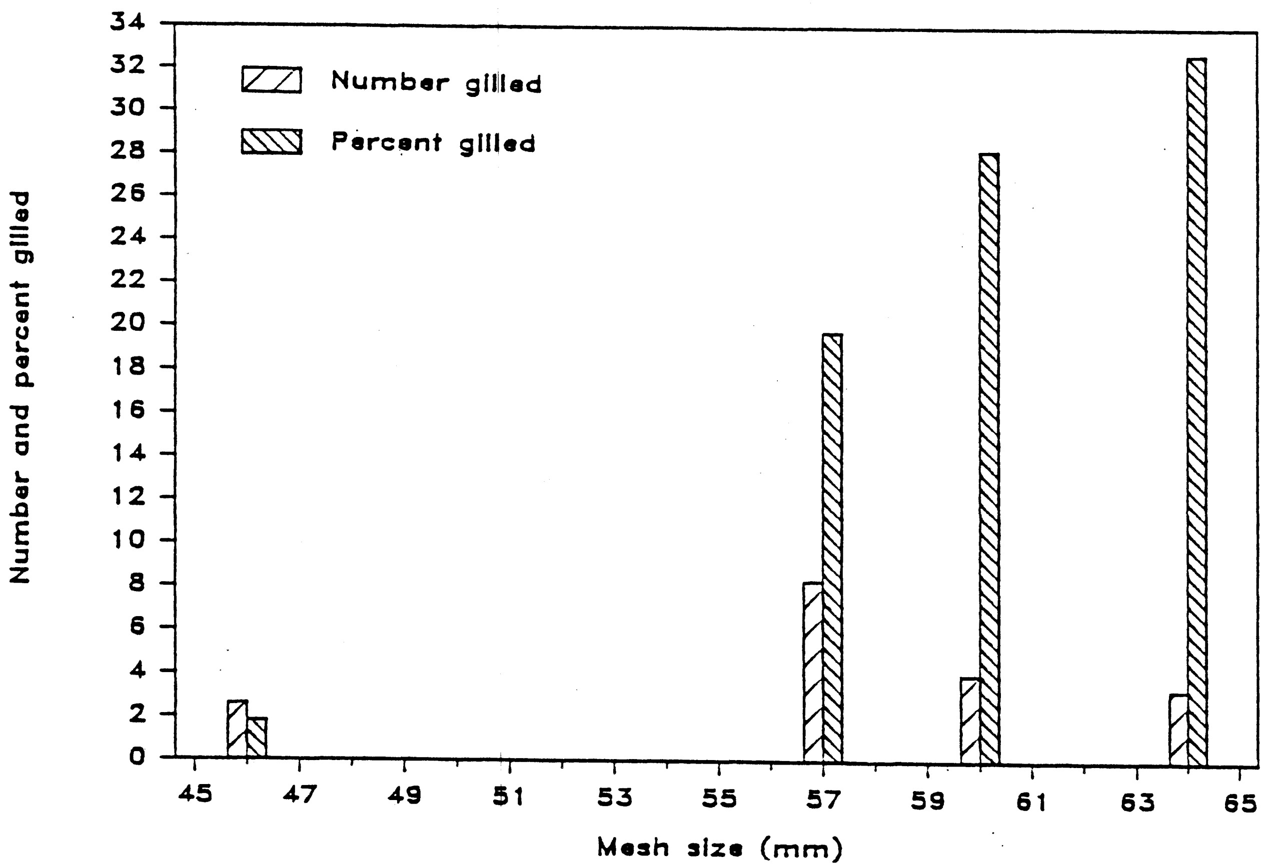


Figure 8.__ Number of perch and the percent of the total catch that was gilled per lift in drop net pots with various mesh sizes throughout the pot. The number of perch gilled in the 57-mm stretched mesh pots was significantly greater (Scheffe procedure; 3, 155 df, $P<0.05$) than the number gilled in the other pots.

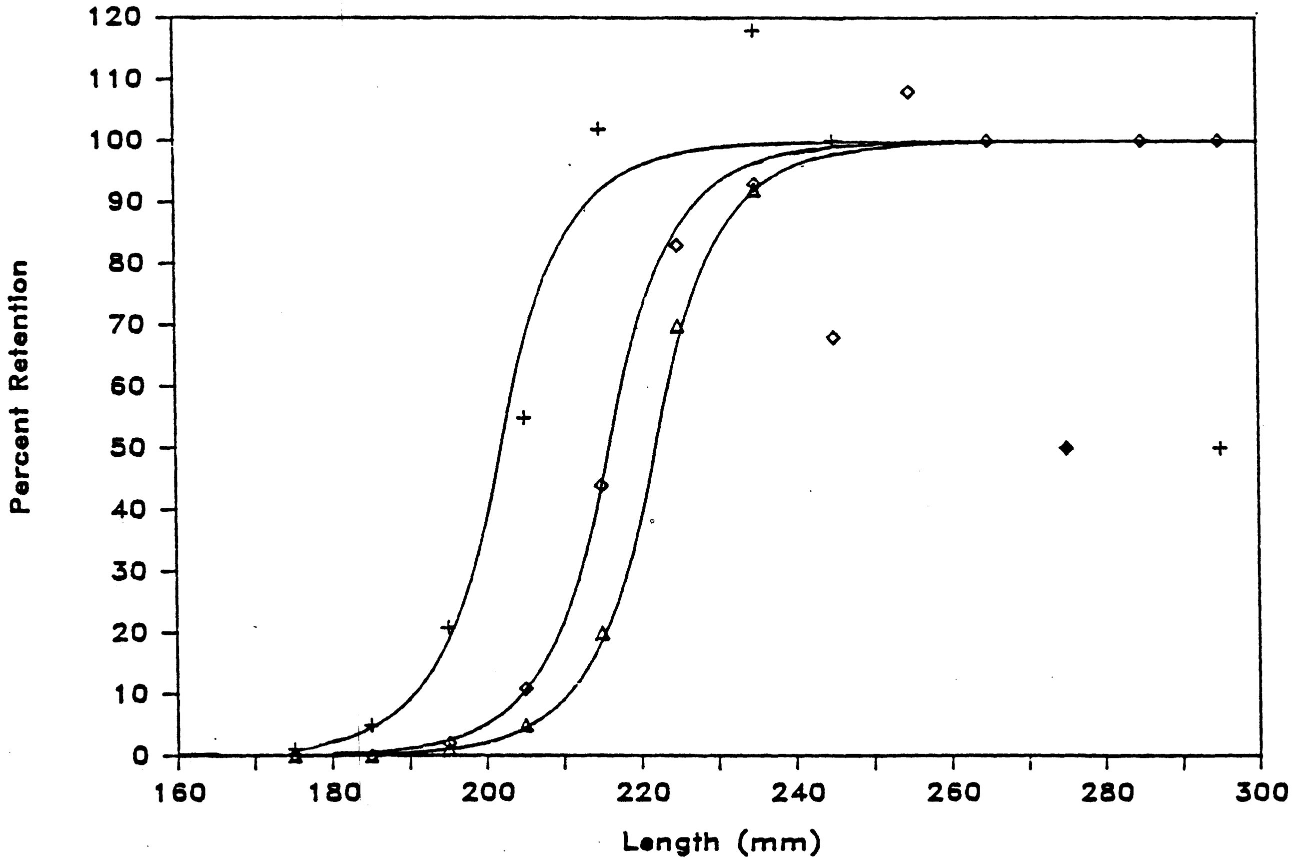


Figure 9.__ Selection curves for drop nets with, from left to right, 57, 60, and 64-mm stretched mesh throughout the pot. The curves were fit by eye.

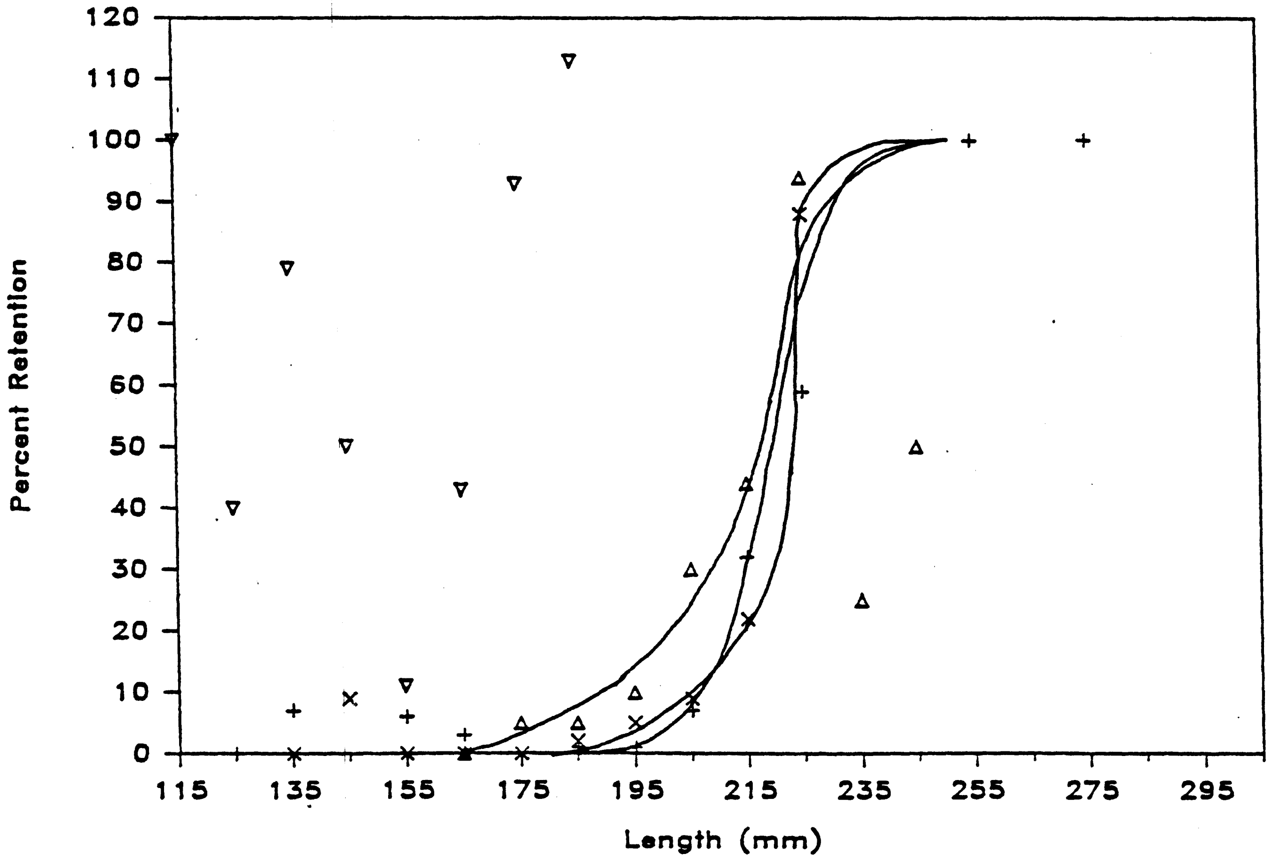


Figure 10.__ Selection curves for drop nets with, from left to right, 62, 58, and 65-mm stretched mesh covering the last 2 hoops. Data for the pot with 57-mm stretched mesh covering the last 2 hoops (▽) were too erratic to draw a curve through. The curves were fit by eye.

covering the last 2 hoops were so erratic that I could not determine a selection curve for it (Figure 9).

Management Options

There are many management options for the yellow perch drop net fishery in Green Bay. I will discuss two:

1. Maintain the current minimum size limit and add a minimum mesh size restriction that would be based on the percent legal composition of the catch.

2. Enforce a minimum mesh size restriction with no minimum size limit and allow the commercial fishermen to harvest all yellow perch captured in a drop net pot constructed of this mesh.

Option 1 would result in some handling mortality, but if the mesh size were one for which 80 or 90% of the catch was of legal size (Figure 4), this mortality would be much less than the mortality now occurring. Smolowitz (1983) recommended that where a minimum length of fish harvested is enforced, a mesh size should be chosen where a minimum of 80% of the catch would be legal-sized. A mesh of 54-mm stretched mesh should result in catches averaging 80% legal-sized yellow perch based on my catches in 1983 (Figure 4), and a mesh size of 57-mm stretched mesh or greater would result in

90% legal perch in the catches.

Option 2 would eliminate handling mortality, and would allow commercial fishermen to increase their effort, as no time would be spent sorting the yellow perch captured. A drop net with 57-mm stretched mesh (102 meshes tied around the 0.9 m hoops) did not retain perch smaller than 170 mm, and the perch smaller than 190 mm comprised less than 6% of the total catch for that net (Figure 10, Appendix B, C).

Both options would require monitoring the size of mesh in the nets fished, and option 1 would also require monitoring the sizes of the perch harvested. Without a minimum size limit, there would be an incentive for commercial fishermen to use a smaller mesh; therefore, a mesh regulation would have to be strictly enforced (Smolowitz 1983). Also, if option 2 were chosen, the management of the gill net fishery would need to be revised to allow for the harvest of all perch captured in gill nets.

To attain higher percentages of legal-sized yellow perch in a net, the mesh used must allow some harvestable perch to escape. The drop net that I fished with 57-mm stretched mesh throughout the pots had an average catch of 92% legal-sized perch, yet only 21% of the perch 190 - 199 mm TL that entered the net were retained by the mesh (Figure 9, Appendix C). Whether or not the initial losses to the drop net fishery would be recovered as a result of long term changes in the yellow perch population, provided a mesh regulation is enforced, is beyond the scope of this study. Ricker (1975) stated that the immediate effect of a change in fishing is often quite different from the long term effects. A new condition may be reached in which CPUE is greater than before the change. However, there is a tendency to look at short-term losses rather than long-term gains. It is easier to see harvestable fish escaping from nets than to see gradual long-term increases in catch.

Switching to a larger mesh may not be economically feasible for some fishermen, and may cause them to withdraw from the fishery or switch to other gears, most notably gillnets. Such a change to gill nets may lead to gear conflict situations, not only among commercial fishermen, but also with sport fishermen as well.

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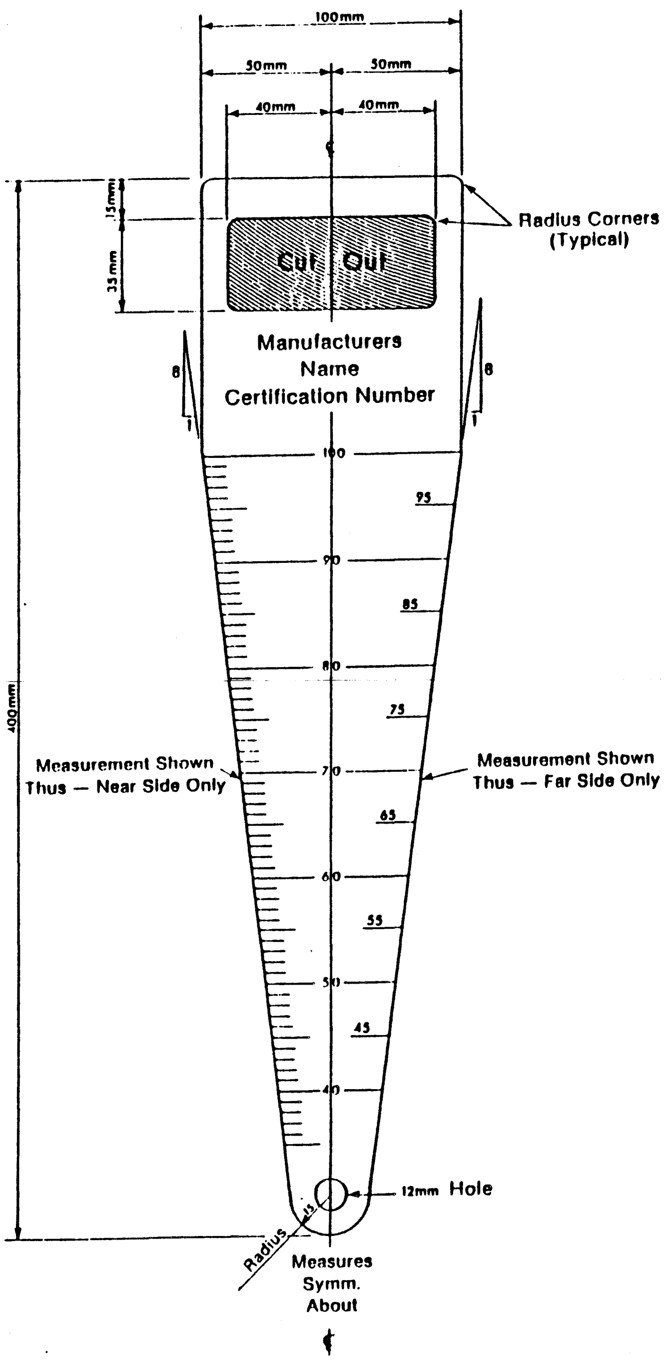
APPENDIX A

Gauge used to measure meshes in drop nets in this study. The gauge was inserted through a mesh with a pull of 5 kilograms. This gauge has been certified by the Northwest Atlantic Fisheries Organization, which recommends the gauge have a constant thickness of not less than 2 mm and not more than 2.4 mm, but the gauge used in this study was 1.5 mm thick (NAFO 1982).



APPENDIX B

Length frequencies of yellow perch captured during 1983 in drop nets with various modifications.

	NUMBER OF PERCH CAPTURED							
Total length in mm	46-mm (control)	57-mm (entire pot)	60-mm (entire pot)	64-mm (entire pot)	57-mm (last 2 hoops)	58-mm (last 2 hoops)	62-mm (last 2 hoops)	65-mm (last 2 hoops)
100 -109								
110 -119	3				1			
120 -129	10				1			
130 -139	28				5			1
140 -149	45				5	2		
150 -159	103				1			1
160 -169	557				8			1
170 -179	1360	15	3	2	53		5	
180 -189	1943	88	9	5	115	3	10	2
190 -199	1793	370	40	13	165	10	17	2
200 -209	977	525	108	36	98	11	36	9
210 -219	406	404	175	60	41	13	26	18
220 -229	164	232	133	86	20	23	25	15
230 -239	70	80	63	48	6	9	2	9
240 -249	33	32	22	30	2	9	1	9
250 -259	15	22	16	21	3	3	2	1
260 -269	3	10	3	15	1	1		
270 -279	2	1	1	9		4	2	1
280 -289	1	2	1	3				
290 -299	2	1	2		1			
> 300		4	2	2		1		
Effort (pot-days)	175	170	170	132	23	41	41	40

APPENDIX C

Data used to construct selection curves for perch. Catches adjusted to 150 days of effort.

Length (mm)	(A) Number of perch in 46-mm pot (control)	(B) Number of perch in 57-mm pot (entire)	B/A	B/A * 100 (percent retention)
115	3			
125	9			
135	24			
145	39			
155	88			
165	477			
175	1166	13	0.01	1
185	1665	78	0.05	5
195	1537	326	0.21	21
205	837	463	0.55	55
215	348	356	1.02	102
225	141	205	1.45	145
235	60	71	1.18	118
245	28	28	1.00	100
255	13	19	1.46	146
265	3	9	3.00	300
275	2	1	0.50	50
285	1	2	2.00	200
295	2	1	0.50	50
305		2		
315		1		
325				
335				
345		1		

APPENDIX C continued

Data used to construct selection curves for perch. Catches adjusted to 150 days of effort.

Length (mm)	(A) Number of perch in 46-mm pot (control)	(B) Number of perch in 60-mm pot (entire)	B/A	B/A * 100 (percent retention)
115	3			
125	9			
135	24			
145	39			
155	88			
165	477			
175	1166	3	0.00	0
185	1665	8	0.00	0
195	1537	35	0.02	2
205	837	95	0.11	11
215	348	154	0.44	44
225	141	117	0.83	83
235	60	56	0.93	93
245	28	19	0.68	68
255	13	14	1.08	108
265	3	3	1.00	100
275	2	1	0.50	50
285	1	1	1.00	100
295	2	2	1.00	100
305		1		
315				
325		1		
335				
345				

APPENDIX C continued

Data used to construct selection curves for perch. Catches adjusted to 150 days of effort.

Length (mm)	(A) Number of perch in 46-mm pot (control)	(B) Number of perch in 64-mm pot (entire)	B/A	B/A * 100 (percent retention)
115	3			
125	9			
135	24			
145	39			
155	88			
165	477			
175	1166	2	0.00	0
185	1665	6	0.00	0
195	1537	15	0.01	1
205	837	41	0.05	5
215	348	68	0.20	20
225	141	98	0.70	70
235	60	55	0.92	92
245	28	34	1.21	121
255	13	24	1.85	185
265	3	17	5.67	567
275	2	10	5.00	500
285	1	3	3.00	300
295	2			
305		1		
315				
325		1		
335				
345				

APPENDIX C continued

Data used to construct selection curves for perch. Catches adjusted to 50 days of effort.

Length (mm)	(A) Number of perch in 46-mm pot (control)	(B) Number of perch in 57-mm pot (last 2 hoops)	B/A	B/A * 100 (percent retention)
115	2	2	1.00	100
125	5	2	0.40	40
135	14	11	0.79	79
145	22	11	0.50	50
155	18	2	0.11	11
165	40	17	0.43	43
175	124	115	0.93	93
185	222	250	1.13	113
195	219	359	1.64	164
205	148	213	1.44	144
215	73	89	1.23	123
225	32	43	1.34	134
235	8	13	1.63	163
245	2	4	2.00	200
255	1	7	7.00	700
265		2		
275	1			
285				
295				
305				
315				
325				

APPENDIX C continued

Data used to construct selection curves for perch. Catches adjusted to 50 days of effort.

Length (mm)	(A) Number of perch in 46-mm pot (control)	(B) Number of perch in 58-mm pot (last 2 hoops)	B/A	B/A * 100 (percent retention)
115	2			
125	5			
135	14		0.00	0
145	22	2	0.09	9
155	18			0
165	40			0
175	124			0
185	222	4	0.02	2
195	219	12	0.05	5
205	148	13	0.09	9
215	73	16	0.22	22
225	32	28	0.88	88
235	8	11	1.38	138
245	2	11	5.50	550
255	1	4	4.00	400
265		1	5.50	550
275	1	5		
285				
295				
305				
315		1		

APPENDIX C continued

Data used to construct selection curves for perch. Catches adjusted to 50 days of effort.

Length (mm)	(A) Number of perch in 46-mm pot (control)	(B) Number of perch in 62-mm pot (last 2 hoops)	B/A	B/A * 100 (percent retention)
115	2			
125	5			
135	14			
145	22			
155	18			
165	40			0
175	124	6	0.05	5
185	222	12	0.05	5
195	219	21	0.10	10
205	148	44	0.30	30
215	73	32	0.44	44
225	32	30	0.94	94
235	8	2	0.25	25
245	2	1	0.50	50
255	1	2	2.00	200
265				
275	1	2	2.00	200
285				
295				
305				
315				

APPENDIX C continued

Data used to construct selection curves for perch. Catches adjusted to 50 days of effort.

Length (mm)	(A) Number of perch in 46-mm pot (control)	(B) Number of perch in 65-mm pot (last 2 hoops)	B/A	B/A * 100 (percent retention)
115	2			
125	5		0.00	0
135	14	1	0.07	7
145	22			
155	18	1	0.06	6
165	40	1	0.03	3
175	124			
185	222	3	0.01	1
195	219	3	0.01	1
205	148	11	0.07	7
215	73	23	0.32	32
225	32	19	0.59	59
235	8	11	1.38	138
245	2	11	5.50	550
255	1	1	1.00	100
265				
275	1	1	1.00	100
285				
295				
305				