

THE SMALLMOUTH BASS POPULATION AND FISHERY
IN A NORTHERN WISCONSIN LAKE,
CLEAR LAKE, ONEIDA COUNTY

by

Patricia Marinac

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ABSTRACT

Smallmouth bass (Micropterus dolomieu) were captured in fyke nets and tagged in Clear Lake, Oneida County, Wisconsin. A creel survey was conducted to obtain information pertaining to the fishery. Fyke net samples for 1974 and 1975 consisted of 98 and 96 percent of fish in age classes I through IV. Total lengths at annuli I through XI were 92, 142, 185, 240, 297, 354, 394, 427, 453, 473, and 487 mm. Smallmouth bass spawned in late June, when the water temperature approached 19°C. Crayfish was the most important food item and comprised 74 percent by number and 65 percent by volume of the contents of stomachs containing food. Total annual mortality rates, calculated using catch curves, were 78 percent in 1974 and 77 percent in 1975. The exploitation rate, which was corrected for tag loss, was 42 percent for bass over 225 mm long, for 1974 and 1975 combined. Exploitation rates for length groups were: 37 percent (225 - 305 mm), 85 percent (306 - 357 mm), and 43 percent (358 mm and above). Estimates of total fishing pressure were 49 and 36 hours per hectare in 1974 and 1975. Catch rates were 5 and 7 smallmouth bass for 100 hours of effort. Mean length of creeled smallmouth bass was 200 mm in both years. The harvest, estimated in two ways in the two years, ranged from 729 (2.1 bass/ha) to 1307 smallmouth bass (3.8 bass/ha). Smallmouth bass less than 300 mm long (age classes I through IV) made up 98 percent of the anglers' harvest in 1974 and 97 percent in 1975.

Population estimates, calculated from creel survey data, were 3237 (9.5/ha) and 2723 (8.0/ha) smallmouth bass over 225 mm long in 1974 and 1975. Production per unit recruitment was estimated to be 1265 grams per 1000 grams. Length limits of 240, 297, 322, and 354 mm would increase the weight harvested by 2, 13.5, 13.8, and 14.4 percent over the present no limit regulation, based on calculations of equilibrium yield per unit recruitment.

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TABLE OF CONTENTS

	Page
INTRODUCTION	1
MATERIALS AND METHODS	3
RESULTS AND DISCUSSION	7
Age and Lengths of Smallmouth Bass	7
Growth	7
Spawning	14
Food Habits	14
Mortality Rates	15
Fishing Pressure, Catch Rate, Harvest of Smallmouth Bass and Other Species	22
Population Estimate and Estimated Total Harvest	30
Production and Equilibrium Yield per Unit Recruitment	32
LITERATURE CITED	35
APPENDICES	38

LIST OF TABLES

	Page
Table 1. Number of smallmouth bass tagged in Clear Lake with Swedish smolt attachment and various fishing lines in 1974 and 1975, and the number of tags returned by anglers.....	4
Table 2. Mean total length (mm) at each annulus for smallmouth bass from Clear Lake, Wisconsin and 21 other populations.....	11
Table 3. Back calculated mean weights at annulus formation for a sample of 355 Clear Lake smallmouth bass captured in 1974 and 1975.....	10
Table 4. Food items from 59 Clear Lake smallmouth bass, 147 through 350 mm long, captured by anglers, August, 1974, through August, 1975.....	15
Table 5. Total annual mortality rates in this study and for 9 smallmouth bass populations reported by Coble 1975.....	17
Table 6. Number of smallmouth bass tagged in Clear Lake, estimated number captured by anglers, and estimated exploitation rates, 1974 and 1975.....	19
Table 7. Number of smallmouth bass tagged in Clear Lake, estimated number captured by anglers, and estimated exploitation rates for three length and age groups, 1974 and 1975 combined.....	20
Table 8. Instantaneous mortality rates (Z, M, and F) and conditional mortality rates (A, m, and n) for smallmouth bass in Clear Lake, 1974 and 1975.....	20
Table 9. Annual fishing and natural mortality rates (percent) of smallmouth bass in seven northern populations. Data for populations other than Clear Lake from Coble 1975.....	21
Table 10. Number creelred, estimated harvest, and observed catch rate of smallmouth bass in Clear Lake by month, 1974 and 1975.....	24

Table 11. Harvest, mean length of harvested smallmouth bass, number harvested per unit effort, and angling pressure for 11 smallmouth bass populations.....	25
Table 12. Number of various species observed in the creel, estimated number harvested, and number harvested per 100 hours of effort in Clear Lake, 1974 and 1975.....	29
Table 13. Petersen population estimates (N) of smallmouth bass 225 mm and longer, statistics used in their calculation for Clear Lake, 1974 and 1975.....	30
Table 14. Estimated total harvest of smallmouth bass in Clear Lake, 1974 and 1975, by two methods of data analysis.....	32

LIST OF FIGURES

	Page
Figure 1. Length and ages of smallmouth bass captured in fyke nets in Clear Lake, 1974 and 1975.....	8
Figure 2. Relationship between total length (mm) and anterior scale radius for smallmouth bass from Clear Lake, Wisconsin.....	9
Figure 3. Catch curves from creel survey data for smallmouth bass in Clear Lake, Wisconsin, 1974 and 1975. A is total annual mortality rate. Lines placed by the method of least squares.....	16

INTRODUCTION

The smallmouth bass (Micropterus dolomieu) is a popular and common sport fish inhabiting many of the lakes of northern Wisconsin. Objectives of this study were to describe the characteristics of the smallmouth bass population and fishery in Clear Lake, Oneida County, Wisconsin, and to obtain information that might be useful for management of the species.

In 1974 and 1975, smallmouth bass and other species were captured in fyke nets, weighed, total length measured and marked, scales were removed for age determination, and fish were released. Growth rate, food habits, population estimates, and mortality rates were determined. A creel survey was conducted to obtain information on effort, harvest, catch per unit effort, and exploitation rates. Equilibrium yield and production per unit recruitment were calculated under present conditions and under various simulated length regulations.

Clear Lake, located in north-central Oneida County, Wisconsin, is a 342 hectare (846 acre) soft-water, oligotrophic seepage lake, with no inlet or outlet. Total alkalinity is 10 parts per million and maximum depth is 29 meters. Littoral substrate consists of about 65 percent sand, 10 percent gravel, 15 percent rubble and some boulders and muck (Andrews and Threinen 1966). Aquatic vegetation is sparse. The 20 kilometer shoreline is almost entirely state-owned; the lake is located in the American Legion State Forest. A public campground and two boat landings provide access to the lake. The only other access

point is a girls' camp, located on the northeast shore (Appendix A). The islands, located in the southwest area of the lake, are privately owned and house residences that are in use for brief periods during summer.

Fish species present, in addition to smallmouth bass, include walleye (Stizostedion vitreum), largemouth bass (Micropterus salmoides), muskellunge (Esox masquinongy), yellow perch (Perca flavescens), bluegill (Lepomis macrochirus), rock bass (Ambloplites rupestris), black crappie (Pomoxis nigromaculatus), pumpkinseed (Lepomis gibbosus), white sucker (Catostomus commersoni), yellow bullhead (Ictalurus natalis), and various species of minnows including blacknose shiner (Notropis heterolepis), common shiner (Notropis cornutus), and blunt-nose minnow (Pimephales notatus).

MATERIALS AND METHODS

Four or five foot fyke nets, with leads of varying lengths, were used to capture fish. A maximum of ten nets was set at any one time for the periods May 28 through July 10, 1974, and May 27 through July 9, 1975. Net locations were moved regularly to try to insure a random catch (Appendix A).

Captured fish were anesthetized with MS-222 to facilitate handling. Smallmouth bass and largemouth bass were weighed, measured, and marked, and had scales removed for age determination. Fish under 225 mm long were given a fin clip and released. In 1974 a one-half right pelvic fin clip was applied and in 1975 a one-half upper caudal clip. Fish greater than 225 mm long were tagged and fin clipped; one half left pelvic fin in 1974 and one-half left pectoral in 1975. A plastic oval tag (15 X 5 X 0.75 mm) was attached just anterior to the spiny dorsal fin using surgical needles (Saunders 1968). Each tag was numbered and printed with a return address. In 1974, 102 tags were attached with 30-lb test monofilament fishing line and 130 tags with 12-lb test nylon multifilament line with the Swedish smolt attachment (Saunders 1968). In 1975, 12-lb test multifilament line (50 tags) and 20-lb test multifilament line (97 tags) were used for Swedish smolt attachment (Table 1).

A creel survey was conducted from May through October of both years. Sampling followed a plan presented by Best and Boles (1956) in which five days each week were sampled, including all weekend days and holidays and three randomly selected weekdays, with no day being

missed in two consecutive weeks. The fishing day was divided into two eight-hour periods: from 6 AM to 2 PM and 2 PM to 10 PM. Some anglers were observed fishing past 10 PM, but their efforts were directed at walleye. The 16-hour fishing day adequately covered the period in which smallmouth bass were caught. One 8-hour period was surveyed each of the five survey days. The period was assigned randomly, with an equal number of early and late days per month.

A winter creel survey was conducted from the time of ice cover until the close of the season. A resident of the area surveyed the lake on one randomly selected weekday and one weekend day. Throughout the winter of 1974, no anglers were observed and there was only minimal sign of ice-fishing activity. The winter fishery is directed at walleye, and it is assumed no smallmouth bass were creeled.

Table 1. Number of smallmouth bass tagged in Clear Lake with Swedish smolt attachment and various fishing lines in 1974 and 1975, and the number of tags returned by anglers.

	1974	1975	Total
30-lb test monofilament			
number tagged	102		102
number returned	27		27
percent	26		26
12-lb test multifilament			
number tagged	130	50	180
number returned	42	18	60
percent	32	36	33
20-lb test multifilament			
number tagged		97	97
number returned		42	42
percent		43	43

Anglers were interviewed at the boat landings at the completion of their fishing trips. Tags were recovered and information pertaining to the fishing trip obtained. Information collected included the

where N is the population estimate; M is the number marked; C is catch observed in the creel survey; and R is the number of recaptures seen in the creel survey.

The total annual mortality rate and the exploitation rates for each length group were used in formulae of Ricker (1975) to calculate instantaneous mortality rates and conditional fishing and natural mortality rates:

$$A = 1 - e^{-Z}$$

$$\frac{Z}{A} = \frac{F}{u}$$

$$Z = M + F$$

$$m = 1 - e^{-F}$$

$$n = 1 - e^{-M}$$

$$A = m + n - mn,$$

where A is the total annual mortality rate; Z, the total instantaneous mortality rate; u, the exploitation rates; F, the instantaneous rate of fishing mortality; M, the instantaneous natural mortality rate; m, the conditional rate of fishing; and n, the conditional rate from natural causes.

RESULTS AND DISCUSSION

Age and Lengths of Smallmouth Bass

In 1974, 509 smallmouth bass, ranging in age from II through XI and 145 to 510 mm in length were captured in fyke nets. A total of 500, or 98 percent of the fish were of ages II through IV and were less than 300 mm long (Figure 1). In 1975, 510 smallmouth bass, ranging in age from I through VI and 89 to 438 mm in length were captured in fyke nets, and 488 or 96 percent were of ages I through IV and were less than 300 mm long (Figure 1.)

Growth

I calculated a linear body-scale relationship for Clear Lake smallmouth bass using a functional regression as described by Ricker (1973). The relationship, which was determined only for the 1974 sample, was:

$$Y = 56.869 + 1.268 X,$$

where Y is total length in millimeters and X is the anterior scale radius (45X) in millimeters (Figure 2). This relationship was used to back calculate the total length at each annulus for a randomly selected sample of 355 measurements; a sample of 75 individual scale samples was randomly selected for each of age classes I through IV, and, for age classes V through XI, all available fish were used. I also calculated a predictive regression for a random sample of 350 individual length and scale radius measurements from 1974. The relationship was:

$$Y = 65.674 + 1.240 X,$$

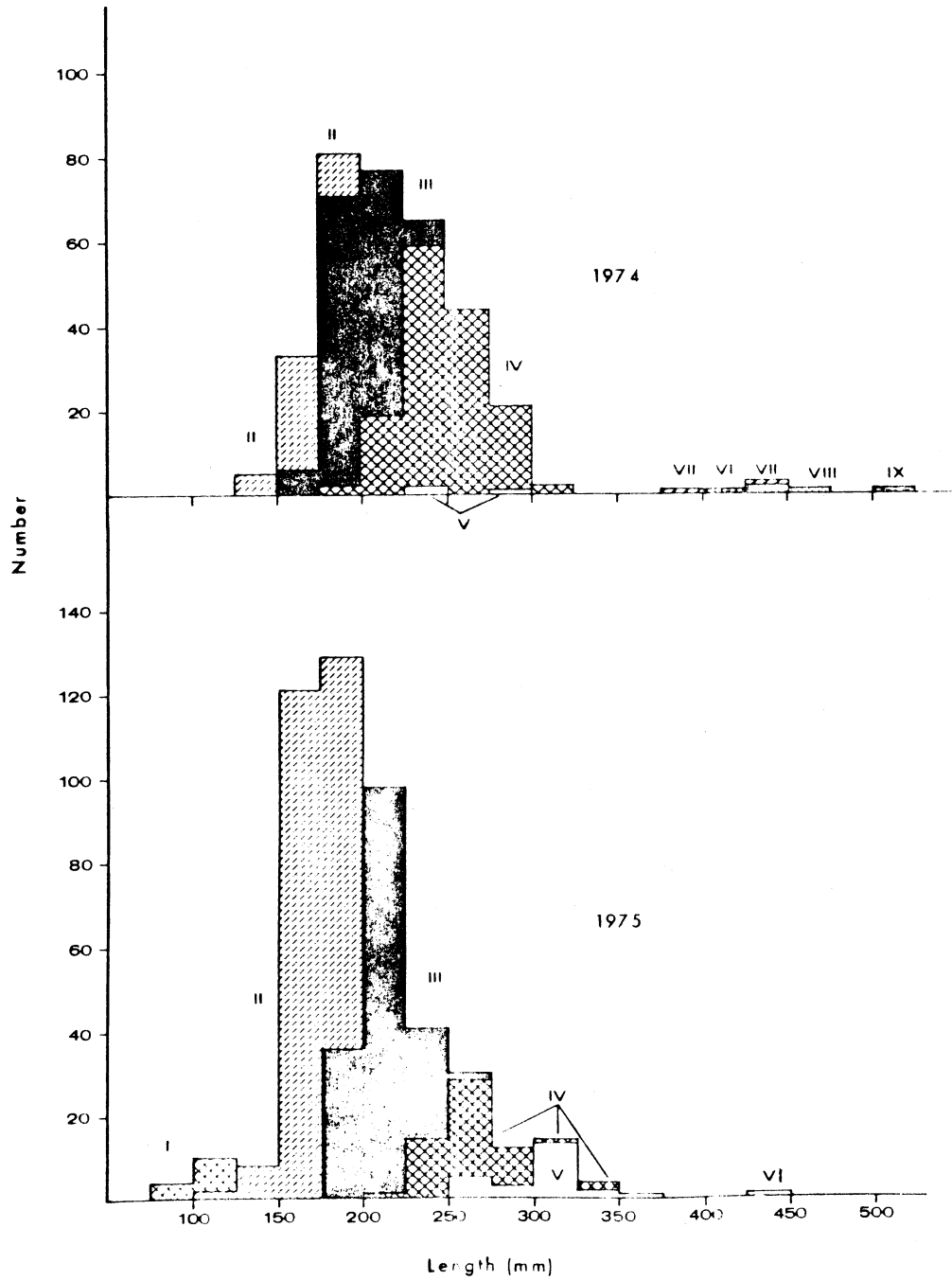


Figure 1.-Length and ages of smallmouth bass captured in fyke nets in Clear Lake, Wisconsin, 1974 and 1975.

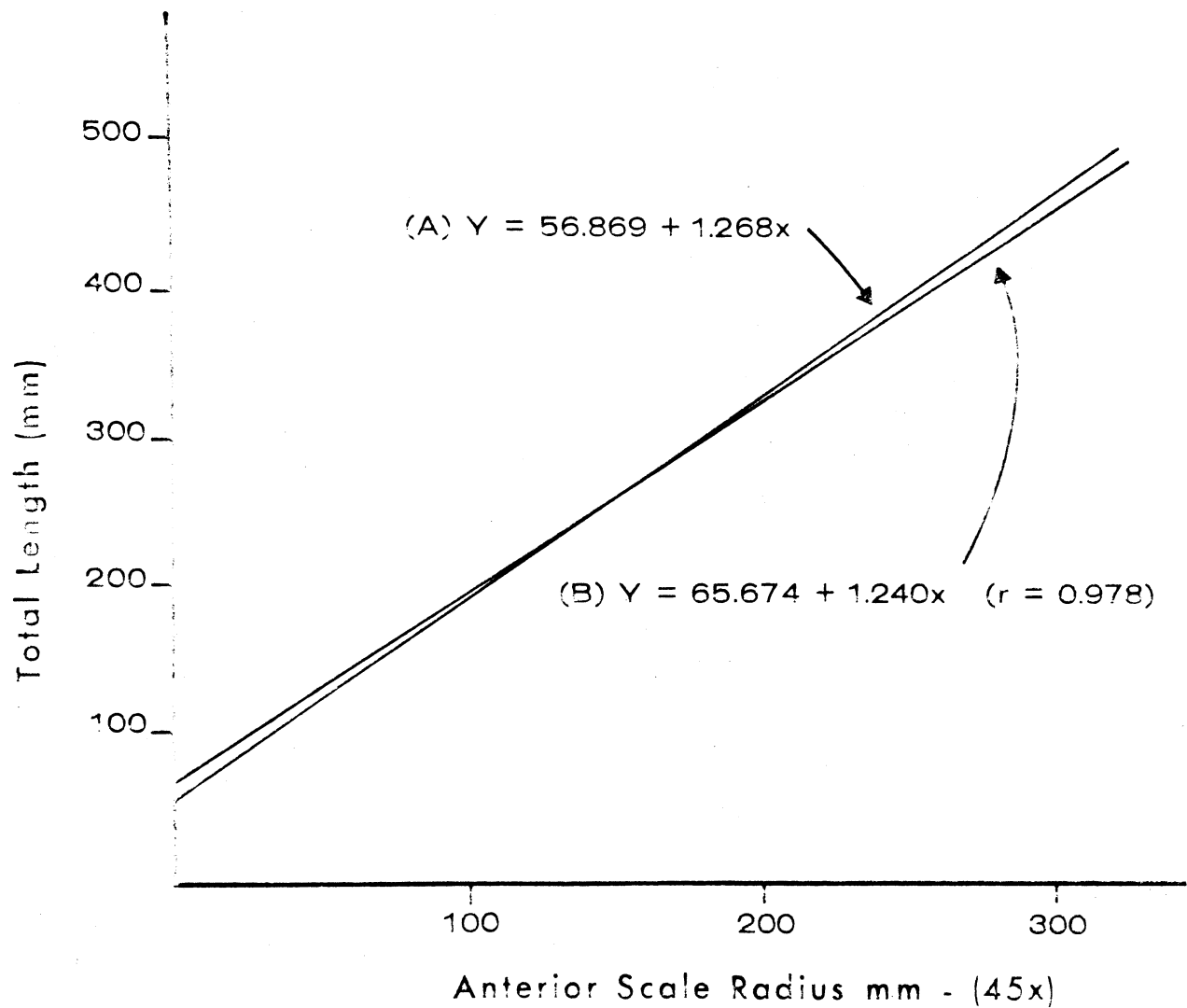


Figure 2.-Relationship between total length (mm) and anterior scale radius for smallmouth bass from Clear Lake, Wisconsin. Line A is the functional regression and line B is the predictive regression equation (r is correlation coefficient).

and the correlation coefficient (r) was 0.978 (Figure 2).

Smallmouth bass in Clear Lake had a slower growth rate than most other populations reported in the literature (Table 2). Growth rates in Tadenac Lake, Ontario (Turner and MacCrimmon 1970) and Baie du Doré, Lake Huron (White 1970) were similar to that in Clear Lake.

The length: weight relationship for smallmouth bass in Clear Lake, also determined as a functional regression, was:

$$Y = 3.179 X - 5.298,$$

where Y is log weight in grams and X is log total length in millimeters. This relationship was used to back calculate weights at annulus formation for a sample of 355 fish (those for which back calculated lengths were available) (Table 3).

I also calculated a predictive regression for 170 individual length and weight measurements from the 1974 sample. The relationship was:

$$Y = 3.15 X - 5.233.$$

Table 3. Back calculated mean weights at annulus formation for a sample of 355 Clear Lake smallmouth bass captured in 1974 and 1975. Numbers in parenthesis indicate sample size. Weight in grams.

	AGE										
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
Weight	11	35	85	193	374	645	902	1163	1395	1600	1759
	(75)	(75)	(75)	(75)	(75)	(8)	(5)	(4)	(1)	(1)	(1)

The length: weight regression for smallmouth bass in Clear Lake was comparable to the relationship for older bass in Tadenac Lake, Ontario (Turner and MacCrimmon 1970), which was found to be:

Table 2. Mean total length (mm) at each annulus for smallmouth bass from Clear Lake, Wisconsin and 21 other populations. Numbers in parenthesis indicate sample size.

Water	AGE															Source and comments	
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV		
Clear Lake, Wisconsin (355)	92	142	185	240	297	354	394	427	453	473	487						This study, mean back calculated lengths
Plover River, Wisconsin	91	158	220	297	366	410	440	455	476								Paragamian (1973), average back calculated lengths
Red Cedar River, Wisconsin	100	190	274	329	383	407	424	444									Paragamian (1973), average back calculated lengths
Wisconsin waters	135	208	269	318	358	389	424	447	465	480							Bennett(1938), average for all waters, back calculated
Baie du Doré, Ontario	140	178	211	246	274	305	330	351	368	391	396	411	414	457			White (1970), mean length of age groups captured
South Bay, Lake Huron			234	264	295	325	353	371	399	404	432	450					Fraser (1955) ^a , mean length of age groups captured
Door County, WI (outlying waters)			234	264	302	333	381	404	414	445							Wiegert (1966), mean back calculated lengths
Waugoshance Point, L. Michigan (1892)	99	160	205	246	292	335	371	401	427	442	455	447					Latta (1963), mean back calculated lengths

--Table 2 Continued--

Water	AGE															Source and comments
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	
Oneida Lake, New York	94	173	249	307	346	373	394	409	422	432						Forney (1972), mean back calculated lengths
Cayuga Lake, New York (3025)		163	213	262	307	348	373	396	424	432	457					Webster (1954), mean lengths at end of growing season
East Charity Shoal, Lake Ontario (201)				267		295	295		333	330	348	368	381	396		Stone, et al (1954), mean lengths of age groups captured
Wilson Bay, Lake Ontario (520)				297	302	323	348	356	366	394	409	429	422			Stone, et al (1954), mean lengths of age groups captured
Tadenac Lake, Ontario	90	163	189	230	291	315	362				412					Turner and MacCrimmon (1970) mean lengths of age classes captured
Georgian Bay, Ontario (95)			173	254	267	300	323	363	384							Doan (1940) ^a , mean length of age groups captured
Lake Erie (308)	165	251	267	318	345	376	396									Doan (1940) ^a , mean length of age groups captured
Eel Bay, St. Lawrence River (331)				262	279	295	300	325	371	401	434	452	472	483		Stone, et al (1954), mean lengths of age groups captured

--Table 2 Continued--

AGE

Water	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	Source and comments
Des Moines River, Iowa (270)	119	229	297	349	389	411										Reynolds (1965), mean back calculated lengths
Norris Reservoir Tennessee (599)	117	259	358	411	444	457	472									Stroud (1948), average calculated lengths at end of each year
Hiwassee Reservoir Tennessee (73)	91	231	318	356	391											Stroud (1949), mean length of age groups captured
Courtois Creek, Missouri	79	150	213	272	330	381	419	442	495							Fajen (1975), mean back calculated lengths
Little Miami River, Ohio (213)	74	150	224	279	323	353	368	384								Brown (1960), average calculated lengths
Massie Creek, Ohio (718)	74	145	216	274	315	351	373	384								Brown (1960), average calculated lengths

^afork length

$$Y = 3.2047 X - 5.1220.$$

For other Wisconsin populations of smallmouth bass, Paragamian (1973) found relationships of:

$$Y = 3.061 X - 5.011 \text{ for the Plover River and}$$

$$Y = 3.183 X - 5.230 \text{ for the Red Cedar River.}$$

Spawning

Smallmouth bass spawned when the water temperature rose to 19°C. In 1974, nesting activity was first noted on June 27, when the water temperature was 18°C. In 1975, when there was a warm period in late May and water temperature reached 18°C, nesting activity was observed. However, this activity ceased when the water temperature fell to 16°C in early June. Nesting resumed when water temperature rose again to 18°C in the third week in June. Turner and MacCrimmon (1970) observed nesting activity in June, when water reached 18°C.

Food Habits

Crayfish was the most important food item of smallmouth bass caught by anglers (Table 4). Stomachs were removed from fish ranging in length from 147 to 350 mm. Of the 59 stomachs, 21 were empty. The crayfish, Orconectes propinquus, was found in 28 of the 38 stomachs containing food; it comprised 74 percent by number and 65 percent by volume of the contents of stomachs containing food. Cyprinids and Percids made up 50 percent by number and 22 percent by volume of stomach contents. Other invertebrates found in stomachs of five smallmouth bass (172, 187, 212, 306, 350 mm long) belonged to the orders Ephemeroptera, Odonata, Lepidoptera and Plecoptera. They

made up 13 percent by number and volume of stomach contents.

Table 4. Food items from 59 Clear Lake smallmouth bass, 147 through 350 mm long, captured by anglers, August, 1974 through August, 1975.

Food item	Number of stomachs containing item	Percent occurrence in stomachs with food	Percent of total food volume (78ml)
Empty	21		
Crayfish	28	74	65
Fish	19	50	22
Other invertebrates	5	13	13

Food habits of Clear Lake smallmouth bass were similar to those reported for other populations (Reynolds 1965, Forney 1972, Doan 1940, Paragamian 1973).

Mortality Rates

The total annual mortality rate for smallmouth bass in Clear Lake, estimated from catch curves, was 78 percent in 1974 and 77 percent in 1975 (Figure 3); the mean, 77.5 percent, was used in further calculations. The estimate is for fish of age classes III and older because age class II bass were not fully vulnerable to anglers. The total annual mortality rate was greater than values reported for 9 other populations (Table 5), but was similar to that for smallmouth bass in Nebish Lake, Wisconsin, where Kempinger found total annual mortality rates as high as 78 percent (personal communication).

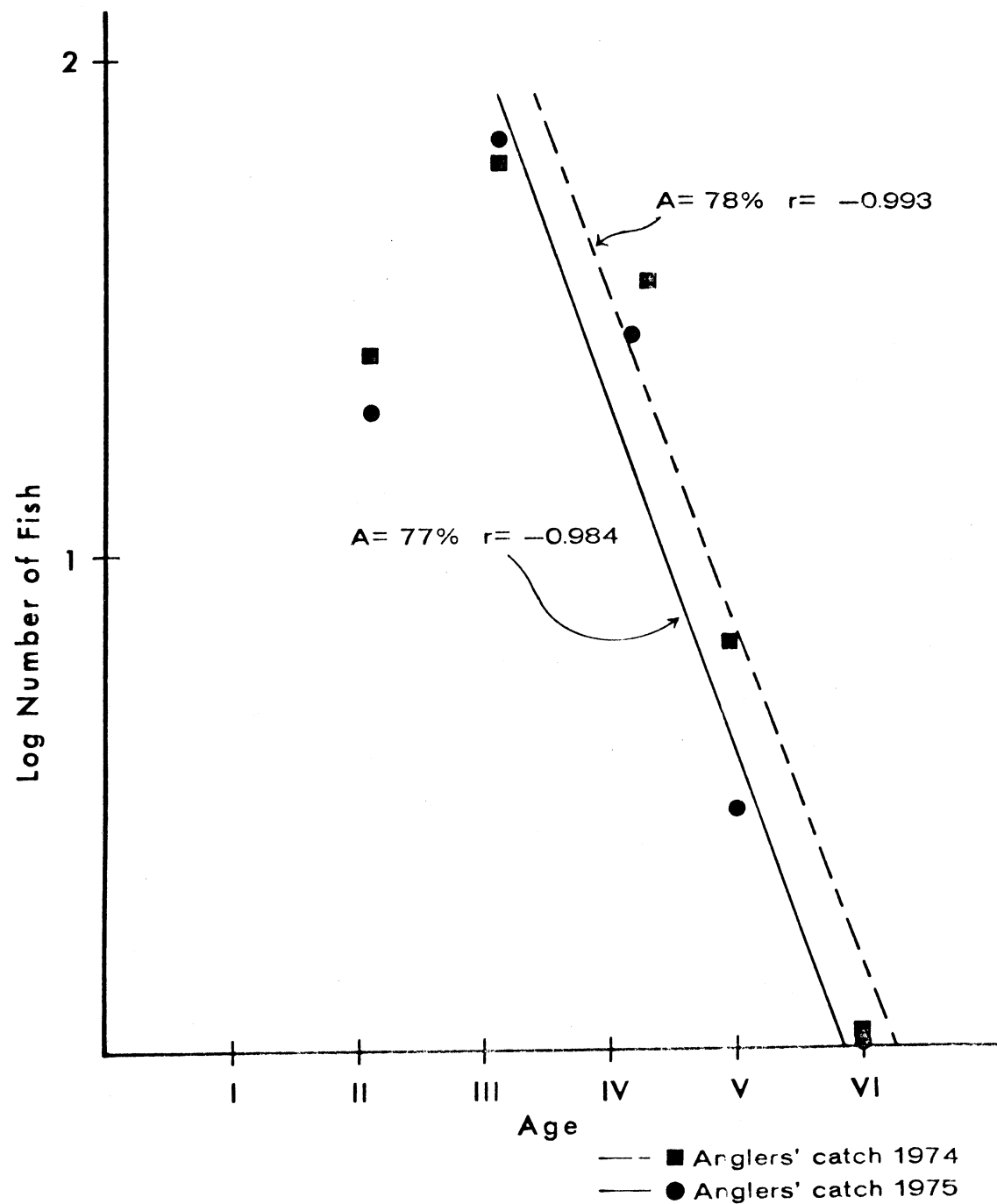


Figure 3.-Catch curves from creel survey data for smallmouth bass in Clear Lake, Wisconsin, 1974 and 1975. A is total annual mortality rate. Lines placed by the method of least squares.

Table 5. Total annual mortality rates in this study and for 9 smallmouth bass populations reported by Coble 1975.

Total annual mortality rate (percent)	Locality	Source
77.5	Clear Lake, Wisconsin	This study
43	Oneida Lake, New York	Forney 1972
58	Waugoshance Point, Lake Michigan	Latta 1963
57	Baie du Dore, Lake Huron	White 1970
51	South Bay, Lake Huron	Fry 1964
65	Plover River, Wisconsin	Paragamian 1973
55	Red Cedar River, Wisconsin	Paragamian 1973
65	Courtois Creek, Missouri	Fajen 1972
66	Huzzah Creek, Missouri	Fajen 1972
53	Lake Opeongo, Ontario	Christie 1957

The estimated exploitation rate was 42 percent, with data combined for both years and all sizes of bass over 225 mm long. Exploitation rates were calculated from number of tags returned by anglers, which was corrected for tag loss, and added to the returns obtained during the creel survey. Nonresponse was considered to be negligible because the number of tags returned by anglers exceeded the number predicted by the ratio:

$$\frac{\text{Number of tags seen in creel}}{\text{Number of bass seen in creel}} = \frac{X}{\text{Estimated harvest (from expansion of creel survey data),}}$$

where X is the predicted number of tag returns.

During 1974, 72 recaptured smallmouth bass were observed, 65 captured in fyke nets and 7 seen in the creel survey. Two of the fish (3 percent) had lost tags. Fifty-five tags were returned voluntarily out of the 166 smallmouth bass tagged in 1974. This number (55) was corrected for 3 percent tag loss yielding 57 tags returned and added to the 7 observed in the creel survey for a total of 64 tag returns. The exploitation rate (percent recaptured of those tagged) for 1974 was 39 percent for bass over 225 mm long (Table 6).

Tag loss was found to be 4 percent (2 of 72 recaptured bass) in 1975. The 43 tags returned voluntarily by anglers were corrected for tag loss giving a total of 45 tag returns and added to the 9 tags seen in the creel survey for a total of 54 returned tags out of 113 fish tagged. The estimated exploitation rate for 1975 was 48 percent for smallmouth bass over 225 mm long (Table 6).

I also calculated exploitation rates after separating bass into three length groups. Exploitation rates, estimated as above, for length groups 225 - 305 mm, 306 - 357 mm, and 358 mm and longer were 37, 85, and 43 percent, respectively. In 1974, anglers voluntarily returned 44 tags from fish ranging in length from 225 to 305 mm (age classes III and IV). This value was corrected for 3 percent tag loss, which gave 45 returns, and added to 7 tags obtained in the creel survey. Thirty tags were received in 1975 from fish of this length group and this number (30) was corrected for 4 percent tag loss, which gave 31 returns, and added to 6 tags seen in the creel survey. Returns from 1974 and 1975 were combined for a total of 89 tags returned from 243 tagged fish of 225 to 305 mm long. The exploitation rate was 37 percent (Table 7).

Anglers returned 6 tags in 1974 from the 306 to 357 mm length group (age class V). This number was corrected for 3 percent tag loss to yield a total of 6 tags (no tags were seen in the creel survey). In 1975, 3 tags were seen in the creel survey and 12 were returned by anglers. When this value (12) was corrected for 4 percent tag loss, and added to creel survey returns, a total of 16 tags was estimated to be recovered. Combined with 1974 results, 22 of 26 tags were returned, for an exploitation rate of 85 percent for fish between 306 and 357 mm long (Table 7).

Only 7 fish over 357 mm were tagged in both 1974 and 1975. In 1974, 2 tags were returned; in 1975, 1 tag was returned. These values were corrected for tag loss. The total of 3 returns from the 7 tagged fish yielded an exploitation rate of 43 percent for fish greater than 357 mm (age classes VI and older) (Table 7).

Table 6. Number of smallmouth bass tagged in Clear Lake, estimated number captured by anglers, and estimated exploitation rates, 1974 and 1975.

Year	Number tagged	Tag loss	Number recaptured	Exploitation rate (percent)
1974	166	3%	64	39
1975	113	4%	54	48
1974 & 1975	279		118	42

The trend of exploitation rates for smallmouth bass in Baie du Doré, Lake Huron (White 1970) was similar to that in Clear Lake, although the rates were much lower in Baie du Doré. Exploitation rates at ages 4 through 9 were 33, 21, 20, 9, 10, and 11 percent, respectively.

Table 7. Number of smallmouth bass tagged in Clear Lake, estimated number captured by anglers, and estimated exploitation rates for three length and age groups, 1974 and 1975 combined.

Length (mm)	Age	Number tagged	Number recaptured	Exploitation rate (percent)
225 - 305	III, IV	243	89	37
306 - 357	V	26	22	85
358 +	VI+	7	3	43

Other exploitation rates reported in the literature were 29 percent for Red Cedar River smallmouth bass (Paragamian 1973), 22 percent at Waugoshance Point, Lake Michigan (Latta 1963), 57 percent at Folsom Lake, California (Rawstron 1967), and minimal estimates of 5 to 21 percent for Oneida Lake, New York (Forney 1961).

The total annual mortality rate and the exploitation rates for each length group were used in formulae of Ricker (1975) to calculate instantaneous mortality rates and conditional fishing and natural mortality rates (Table 8).

Table 8. Instantaneous mortality rates (Z, M, and F) and conditional mortality rates (A, m, and n) for smallmouth bass in Clear Lake, 1974 and 1975.

	Entire population	225 - 306 mm (ages III-IV)	307 - 357 mm (age V)	358 mm + (ages VI+)
Z	1.492	1.492	1.492	1.492
F	.814	.705	1.492	.826
M	.678	.787	.000	.666
A	.775	.775	.775	.775
m	.557	.506	.775	.562
n	.492	.545	.000	.486

Fishing mortality is a major factor in total mortality of smallmouth bass populations. In five of the seven populations for which data were available, fishing mortality exceeded natural mortality (Table 9). Fishing and natural mortality rates for Clear Lake smallmouth bass were greater than for other populations studied (Table 9). Angling pressure is higher on Clear Lake than many other populations (Table 11), and could explain the high fishing mortality rate.

It is difficult to compare fishing mortality rates without information about data collection and analysis. The effort involved in recovering tags will influence the estimates of exploitation rates, as will the manner in which data are treated (i.e. tag loss, correction for angler nonresponse). The values presented are those available from published literature.

Table 9. Annual fishing and natural mortality rates (percent) of smallmouth bass in seven northern populations. Data for populations other than Clear Lake from Coble 1975.

Fishing (m)	Natural (n)	Locality	Source
56	49	Clear Lake, Wisconsin	This study
34	31	Red Cedar River, Wisconsin	Paragamian 1973
35	24	South Bay, Lake Huron	Fry 1964
35	12.5	Oneida Lake, New York	Forney 1972
38	25	Lake Opeongo, Ontario	Christie 1957
22 ^a	44 ^a	Baie du Doré, Lake Huron	White 1970
28	41	Waugoshance Point, Lake Michigan	Latta 1963

^a Mean value for length groups. These values differ from those given by Coble 1975 because he reported an erroneous value in White's thesis. Values listed here are corrected.

Fishing Pressure, Catch Rate, Harvest of Smallmouth Bass and Other Species

Estimates of total fishing pressure were 49 and 36 hours per hectare in 1974 and 1975, respectively (Appendices D and E). During the creel survey period 8 June through 20 October, 1974, 1274 anglers that were interviewed had fished for 3254 hours. They creeled 155 smallmouth bass, for an average catch rate of 5 smallmouth bass per 100 hours fishing (Table 10). This catch rate does not include released fish. In 1975, 1387 anglers interviewed between 23 May and 10 October fished for 3507 hours and creeled 240 smallmouth bass. The catch rate in 1975 was 7 bass per 100 hours (Table 10). These rates should be considered annual rates because the creel survey covered what is considered to be the entire fishing year for smallmouth bass on Clear Lake. Mean length of smallmouth bass creeled was 220 mm in both 1974 and 1975.

Estimates from creel survey data of fishing pressure and angler harvest must be considered minimum estimates. The creel survey clerk could not interview every angler because there were two access points used on Clear Lake. I believe that over 90 percent of the anglers were interviewed during creel survey hours.

Reported values of catch rate of smallmouth bass in other populations ranged from 150 bass per 100 hours at Tadenac Lake, Ontario (Turner and MacCrimmon 1970) to 1 bass per 100 hours at Laura Lake

in Vilas County, Wisconsin (McKnight and Serns 1974). Values for Clear Lake fell within this range and were comparable to other Wisconsin populations (Table 11).

The catch of smallmouth bass was not concentrated at any one time during the summers of the two years (Table 10), and catch per unit effort tended to increase through September in both 1974 and 1975 as the summer progressed. Catches early in the year were irregular, perhaps being influenced by the varying weather conditions in late spring and early summer in Northern Wisconsin.

Table 10. Number creeled, estimated harvest, and observed catch rate of smallmouth bass in Clear Lake by month, 1974 and 1975.

Year	Month	Number seen in creel	Estimated number harvested	Number harvest- ed/100 hours
1974	May	0	0	0
	June	1	6	0
	July	87	269	6
	August	56	272	5
	September	11	182	6
	October	0	0	0
	Total	155	279	--
	per ha	---	2.1	--
Mean	---	---	5	
1975	May	6	35	2
	June	60	241	6
	July	52	169	6
	August	112	259	9
	September	10	94	9
	October	0	0	0
	Total	240	798	--
	per ha	---	2.3	--
Mean	---	---	7	

Table 11. Harvest, mean length of harvested smallmouth bass, number harvested per unit effort, and angling pressure for 11 smallmouth bass populations.

Water	Harvest (number/ha)	Mean length (mm)	Catch rate (number/100 hours)	Angling pressure (hours/ha)	Source
Clear Lake, Wisconsin	2.1	220	5	49	This study, 1974 and 1975
	2.3	220	7	36	
Stormy Lake, Wisconsin	4.4	---	11	6.6	McKnight and Serns 1974
Black Oak Lake, Wisconsin	1.4	---	3	7.7	McKnight and Serns 1974
Laura Lake, Wisconsin	0.5	---	1	8.2	McKnight and Serns 1974
Red Cedar River, Wisconsin	21	262	7	318	Paragamian 1973
Baie du Doré, Ontario	---	---	74	--	White 1970, six year average
Waugoshance Point, Lake Michigan	---	287-300	12-111	--	Latta 1963, 254 mm length limit
South Bay, Lake Huron	.19	---	---	--	Fraser 1955

--Table 11 Continued--

Water	Harvest (number/ha)	Mean length (mm)	Catch rate (number/100 hours)	Angling pressure (hours/ha)	Source
Lake Opeongo, Ontario	.18 .14	351 343	--- ---	-- --	Doan 1940 1936 and 1937
Tadenac Lake, Ontario	---	---	80-150	--	Turner and MacCrimmon 1970
Courtois Creek, Missouri	37	---	10	363	Fleener 1975, Ten year average

Most anglers were in the area vacationing. Only 7 percent of the anglers interviewed lived within 50 miles of Clear Lake; 30 percent came from 51 to 150 miles away; 30 percent came from 151 to 250 miles away; 26 percent came from 251 to 350 miles away; and 8 percent came from over 351 miles distant. The mean number in a fishing party was 2.37 in 1974 and 2.23 in 1975. The average length of a fishing trip was 2.56 and 2.46 hours for 1974 and 1975, respectively. Most (99 percent) anglers fished from a boat. Worms were used by 52 percent of the anglers, who caught 67 percent of the smallmouth bass seen in the creel; 21 percent used minnows and caught 15 percent of the bass creeled; and 12 percent used artificial bait and caught 7 percent of the bass creeled. Combinations of the above baits or some other form were used by 15 percent of the anglers, who creeled 11 percent of the smallmouth bass.

Creel survey data were expanded to an estimate of 729 (2.1/ha or 0.28 kg/ha) smallmouth bass harvested in 1974, and 798 (2.3/ha or 0.30 kg/ha) in 1975 (Appendices D and E). Total harvest was also estimated by multiplying population estimates by the exploitation rates for 1974 and 1975. These estimates will be presented in a later section, and the values compared with those above.

Harvest of smallmouth bass from Clear Lake was similar to harvest from Stormy and Black Oak Lakes in Wisconsin (Table 11). The range was wide of values for fishing pressure and harvest of smallmouth bass for populations reported in the literature (Table 11). Fishing pressure was highest at Courtois Creek, Missouri, at 363 angler hours per hectare (Fleener 1975), followed by 318 angler hours per hectare for the Red Cedar River, Wisconsin (Paragamian 1973).

These values probably are not comparable to those reported for lake populations because the surface area of lakes is large in comparison with study sections in rivers. The entire surface area of a lake does not necessarily contain suitable smallmouth bass habitat, nor do anglers fish over the whole area.

The anglers' harvest of smallmouth bass consisted of young, small fish. Fish under 300 mm (age classes II through IV) made up 98 percent of the anglers' harvest in 1974 and 97 percent in 1975. Of these fish, 12 and 11 percent were age class II, 49 and 52 percent were age class III, and 39 and 37 percent were age class IV in 1974 and 1975, respectively.

The age class composition of creel smallmouth bass in Clear Lake was similar to several populations, but differed from Great Lakes populations. For example, Paragamian (1973) and Funk and Fleener (1966) found age classes II and III to be 78 and 62 percent of the smallmouth bass harvest, respectively. Fleener (1975) reported that 83 percent of the bass harvested from Courtois Creek were less than 5 years old. In some Great Lakes populations smallmouth bass age IV and older made up the bulk of anglers' catches (Fraser 1955, Latta 1963, and White 1970).

Daytime catch rates for other species creel in Clear Lake ranged from a low of 5 and 6 per 10,000 hours of fishing effort, in 1974 and 1975, for muskellunge to a high of 28 and 31 per 100 hours of fishing, in 1974 and 1975, for yellow perch (Table 12). Mean lengths of walleye

Table 12. Number of various species observed in the creel, estimated number harvested, and number harvested per 100 hours of effort in Clear Lake, 1974 and 1975.

Year	Species	Number creeled	Estimated number	Estimated harvest number/ha	Catch rate (number/100 hours)
1974	<u>Micropterus dolomieu</u>	155	729	2.1	5
	<u>Stizostedion vitreum</u>	140	789	2.3	4
	<u>Micropterus salmoides</u>	20	113	0.3	1
	<u>Perca flavescens</u>	912	5138	15.0	28
	<u>Lepomis macrochirus</u>	558	3144	9.2	17
	<u>Ambloplites rupestris</u>	501	2823	8.3	15
	<u>Pomoxis nigromaculatus</u>	10	56	0.2	0.3
	<u>Lepomis gibbosus</u>	37	208	0.6	1
	<u>Esox masquinongy</u>	2	11	0.03	0.06
	Total	2335	13,011	38.0	72
1975	<u>Micropterus dolomieu</u>	240	798	2.3	7
	<u>Stizostedion vitreum</u>	160	630	1.8	5
	<u>Micropterus salmoides</u>	38	150	0.4	1
	<u>Perca flavescens</u>	1064	4189	12.2	31
	<u>Lepomis macrochirus</u>	517	2035	6.0	15
	<u>Ambloplites rupestris</u>	586	2307	6.7	17
	<u>Pomoxis nigromaculatus</u>	8	31	0.1	0.2
	<u>Lepomis gibbosus</u>	21	83	0.2	1
	<u>Esox masquinongy</u>	2	8	0.02	0.05
	Total	2636	10,231	29.9	75

creeled for 1974 and 1975 were 308 and 321 mm, and their catch rate was similar to that for smallmouth bass at 4 and 5 per 100 hours of fishing effort for the two years. Largemouth bass were caught less frequently than smallmouth bass; one per 100 hours of effort was creeled in both years. The mean length of largemouth bass creeled was 293 mm in 1974 and 277 mm in 1975. Catch rates were based on a total value for angler hours fished, and did not reflect species-specific effort.

Population Estimates and Estimated Total Harvest

Population estimates were made from the creel survey data. The recapture of 7 of 166 tagged bass in a total catch of 155 yielded a population estimate of 3237 smallmouth bass over 225 mm long in 1974. In 1975, there were 9 recaptures (of 113 tagged) in a total catch of 240 fish, yielding a population estimate of 2723 smallmouth bass over 225 mm long. The mean value was 2980 or 8.7 smallmouth bass/ha (1.1 kg/ha) (Table 13). A Poisson distribution was assumed for calculating confidence intervals (Ricker 1975:78) because proportions of recaptures to catches were low (0.05 and 0.04) (Seber 1973:63).

Table 13. Petersen population estimates (N) of smallmouth bass 225 mm and longer, and statistics used in their calculation for Clear Lake, 1974 and 1975.

Year	Marked	Recap- tured	Catch	N	95 percent confidence interval	Standing stock number/ha	kg/ha
1974	166	7	155	3237	1453-8002	9.5	1.2
1975	113	9	240	2723	1342-5885	8.0	1.0

Published values for smallmouth bass population estimates vary widely. At Baie du Doré, Lake Huron (White 1970) estimates of bass greater than 241 mm were 11.9/ha, 14.1/ha and 7.0/ha in 1966 through 1968, respectively. Estimates ranged from 0.35/ha to 0.74/ha for the period 1947 through 1950 at South Bay, Lake Huron (Fraser 1955). Paragamian (1973) found 132 smallmouth bass per hectare in the Red Cedar River, Wisconsin.

It is difficult to compare population estimates because (1) different estimates refer to different size ranges of fish; (2) estimates of exploited populations are not of the stock at carrying capacity, but of carrying capacity minus the harvest; therefore, estimates will vary with differences associated with the carrying capacity among populations plus differences in the magnitude of the harvest; and (3) the area used by various authors will contain different proportions of suitable smallmouth bass habitat (Paragamian and Coble 1975).

Total harvest of smallmouth bass 225 mm and longer, estimated from the population estimate multiplied by the exploitation rate, was similar to values obtained by expanding the creel survey data (Table 14). In 1974, the population estimate times an exploitation rate of 39 percent yielded an estimated total harvest of 1262 or 3.6 fish/ha. The population estimate times exploitation rate (48 percent) in 1975 yielded an estimated total harvest of 1307 or 3.8 fish/ha (Table 14).

Table 14. Estimated total harvest of smallmouth bass in Clear Lake, 1974 and 1975, by two methods of data analysis. Numbers in parenthesis are 95 percent confidence intervals.

Creel survey data	Year	
	1974	1975
Total harvested	729	798
Number/ha	2.1	2.3
kg/ha	0.28	0.30
Population estimate X exploitation rate		
Total harvested	1262 (567-3121)	1307 (644-2825)
Number/ha	3.6 (1.7-9.1)	3.8 (1.9-8.3)
kg/ha	0.47 (0.22-1.2)	0.49 (0.25-1.1)

Production and Equilibrium Yield per Unit Recruitment

Production per unit recruitment for smallmouth bass in Clear Lake was comparable to that for fish from Baie du Doré, Lake Huron, and substantially less than that for the Red Cedar River, Wisconsin, based on my calculations from the data of White (1970) and Paragamian (1973). Production per unit recruitment was calculated from values of average biomass multiplied by instantaneous growth rates (Appendix F). Production in Clear Lake was estimated to be 1265 grams per 1000 grams recruitment. Data taken from White (1970) and Paragamian (1973) yielded values of 1373 grams and 14,328 grams per 1000 grams recruitment. Production was higher in the Red Cedar River because the growth rate of smallmouth bass in the Red Cedar River was greater than for Clear Lake and Baie du Doré bass, and mortality rates were lower in the Red Cedar River than in Clear Lake and Baie du Doré.

A minimum length regulation on smallmouth bass in Clear Lake should increase the harvest, in weight, to the sport fishery. I calculated equilibrium yield by the method of Ricker (1975:238). Instantaneous growth, fishing and natural mortality rates were not considered to occur uniformly throughout a year. Ninety percent of the growth and fishing mortality were considered to occur in the period May 1 through September 1, with the remaining 10 percent occurring from September 1 through January 1. No growth or fishing mortality were assigned to January 1 through May 1. Natural mortality was assigned arbitrarily in the following manner: 10 percent from January 1 through May 1; 80 percent from May 1 to September 1; and 10 percent from September 1 to January 1.

Equilibrium yield was calculated under the present no limit regulation and with simulated length limits of 240, 297, 322 and 354 mm. (Fishing mortality was reduced to zero for ages 3, 4, 4½, and 5, respectively.) A length limit of 240 mm would increase the weight harvested by 6 percent over the present no limit regulation (Appendices F and G). Length limits of 297, 322 and 354 mm would increase weight harvested by 13.5 percent, 13.8 percent and 14.4 percent, respectively (Appendices H, I and J).

The length limit could result in changes in growth and natural mortality rates of the population, and survival rates of released, sublegal fish. No reports on hooking mortality of smallmouth bass were available in the literature, however, studies with trout (Salmo spp.) indicate that hooking may not be a substantial source of mortality. Hunsacker, et al (1970) found no significant mortality of Yellowstone cutthroat trout (Salmo clarki lewisi) except for those deeply hooked, and survival of such fish may exceed 50 percent if the line is cut

leaving the hook in the fish (Mason and Hunt 1967). If a length limit were implemented, the population should continue to be monitored to determine the extent of changes and their impact on the predicted results.

The implementation of a 297 mm or longer length limit on smallmouth bass would limit the number of fish available to anglers in the first year of the new regulation. Using population estimates and the percentage of fish greater than 297 mm seen in the creel survey, I estimated numbers of catchable-size bass available to anglers under the length limit regulations. In the first year of the regulation, about 90 smallmouth bass would exceed 297 mm. Assuming the growth rate remained the same, within a year, 650 more bass would reach 297 mm, and the number should increase in subsequent years. A 354 mm length limit would leave about 25 fish available in the first year, and by the second year the number would increase to 90 fish, with further increases in subsequent years.

I would recommend a 354 mm (about 14-inch) length limit on smallmouth bass in Clear Lake. Whereas equilibrium yield calculations indicated no substantial difference between 297, 322 and 354 mm length limits, the exploitation rate of the 306 - 357 mm length group was high, and a 354 mm length limit would help protect this group from high angler exploitation. Also, if it became desirable to change to another length later, it would be easier to reduce than to increase the length limit. A 354 mm length limit would severely limit the number of fish available in the first few years of the new regulation, but the number of legal smallmouth bass should increase substantially in subsequent years.

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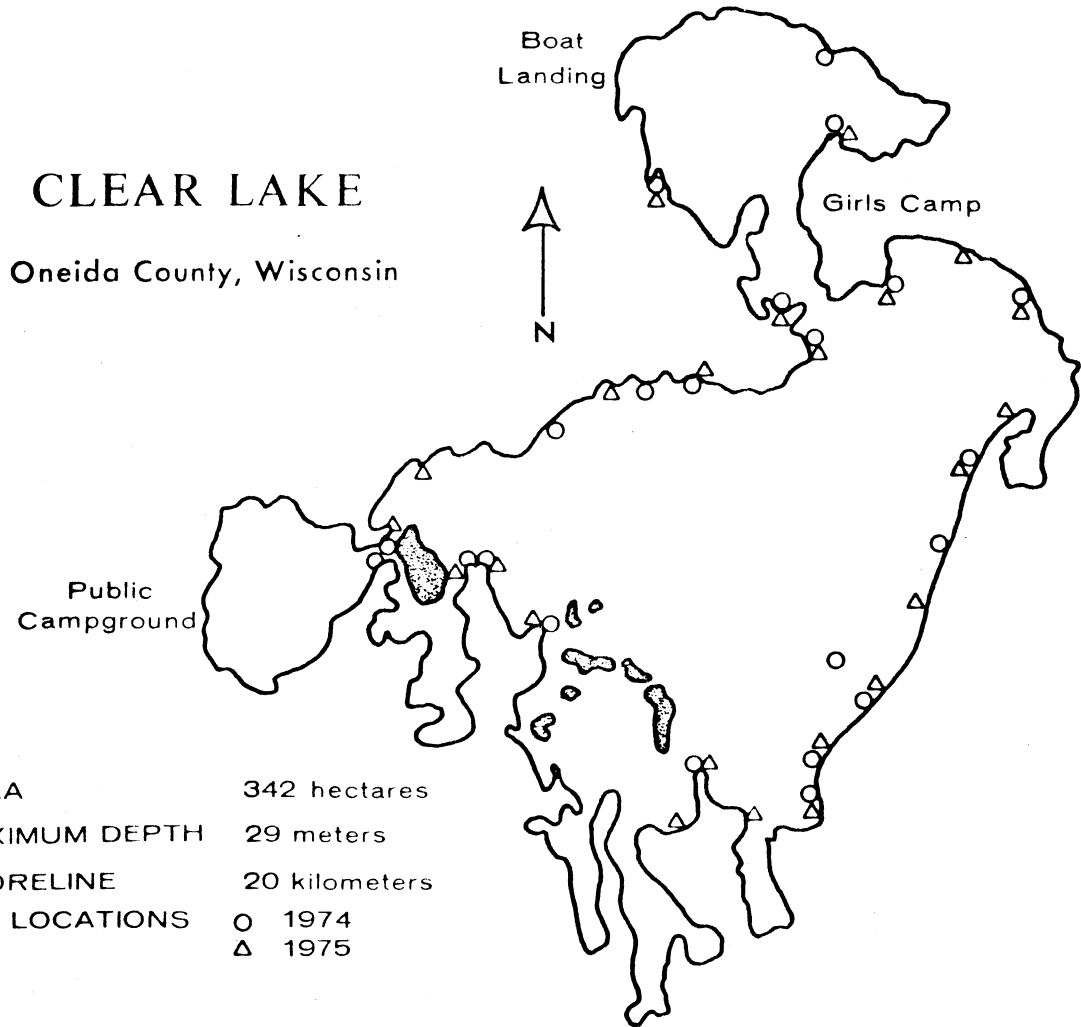
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APPENDICES

	Page
Appendix A. Clear Lake, Oneida County, Wisconsin.....	39
Appendix B. Creel census report form.....	40
Appendix C. Number of smallmouth bass of each age class from 1974 and 1975 anglers' catches and the regression formulae for the catch curves shown in Figure 3.....	41
Appendix D. Percent of total time surveyed from June through October, 1974, observed and estimated number of smallmouth bass harvested and fishing pressure in Clear Lake, Wisconsin.....	42
Appendix E. Percent of time surveyed from May through October, 1975, observed and estimated number of smallmouth bass harvested and fishing pressure in Clear Lake, Wisconsin.....	44
Appendix F. Computation of equilibrium yield and production per unit recruitment for smallmouth bass in Clear Lake, Wisconsin, under present conditions of no size limit.....	46
Appendix G. Computation of equilibrium yield per unit recruitment with a 240 mm (about 10 inches) length limit for smallmouth bass in Clear Lake, Wisconsin.....	49
Appendix H. Computation of equilibrium yield per unit recruitment with a 297 mm (about 12 inches) length limit for smallmouth bass in Clear Lake, Wisconsin.....	52
Appendix I. Computation of equilibrium yield per unit recruitment with a 322 mm (about 13 inches) length limit for smallmouth bass in Clear Lake, Wisconsin.....	55
Appendix J. Computation of equilibrium yield per unit recruitment with a 354 mm (about 14 inches) length limit for smallmouth bass in Clear Lake, Wisconsin.....	58

APPENDIX A



APPENDIX B -- CREEL CENSUS REPORT

40.

Date: ___/___/___

Time: 0600-1400 ___
1400-2200 ___

Water Temperature: ___

Location: _____

Start: _____

Finish: _____

Total: _____

Distance Traveled: _____

Bait - Artificial: ___
Live - ___
Worms: ___
Minnows: ___
Other: ___

Fished From: Boat __, Shore __, Waders __, Ice __.

Number in Party: __

Area Fished: _____

	Length	Tag or Mark	Length	Tag or Mark	Length	Tag or Mark	Length	Tag or Mark	Length	Tag or Mark
MB:	(1) _____	_____	(2) _____	_____	(3) _____	_____	(4) _____	_____	(5) _____	_____
AE:	(1) _____	_____	(2) _____	_____	(3) _____	_____	(4) _____	_____	(5) _____	_____
FE:	(1) _____	_____	(2) _____	_____	(3) _____	_____	(4) _____	_____	(5) _____	_____
MB:	(1) _____	_____	(2) _____	_____	(3) _____	_____	(4) _____	_____	(5) _____	_____

Number Released:

	<7"	>7"
MB:	---	---
	<10"	>10"
FE:	---	---
AE:	---	---
MB:	---	---

Other Species Caught:

	No.
1.	_____
2.	_____
3.	_____
4.	_____

Number Fish Released: No. _____

APPENDIX C

Number of smallmouth bass of each age class from the 1974 and 1975 anglers' catches and the regression formulae for the catch curves shown in Figure 3.

Age class	Number	
	1974	1975
I	2	0
II	17	22
III	75	73
IV	27	38
V	3	6
VI	1	1

1974: $Y = 3.91 - 0.66 X$, for ages III - VI,
where X is age class and Y is log
abundance of the age class.

1975: $Y = 3.93 - 0.64 X$, for ages III - VI.

APPENDIX D

Percent of total time surveyed from June through October, 1974, observed and estimated number of smallmouth bass harvested and fishing pressure in Clear Lake, Wisconsin.

Month-Date	Percent surveyed	Number of smallmouth bass observed	Estimated harvest	Observed effort (angler hrs)	Estimated total effort
June					
2-8	4	0	0	43.50	350.9 ^a
9-15	3	0	0	133.75	1029.9 ^a
16-22	15	0	0	137.75	1131.8 ^a
22-29	16	1	6	215.25	1131.8 ^a
Totals		1	6	530.25	3644.4
July					
30-8	21	1	5	194.50	926.2
7-13	26	2	8	147.25	566.4
14-20	36	41	114	397.50	1104.2
21-27	36	38	106	480.25	1231.4
28-3	30	13	36	285.75	945.8
Totals		95	269	1505.25	4774.0
August					
4-10	33	17	56	321.50	974.2
11-17	25	11	44	264.75	1059.0
18-24	27	14	52	285.50	1057.4
25-31	5	6	120	82.75	1655.0
Totals		48	272	945.50	4745.6
September					
1-7	4	4	100	52.25	1306.3
8-14	4	1	25	27.00	675.0
15-21	10	4	40	55.50	555.0
22-28	12	2	17	63.00	524.9
Totals		11	182	197.75	3061.2

^a Mean value for 1974 and 1975.

--APPENDIX D CONTINUED--

Month-Date	Percent surveyed	Number of smallmouth bass observed	Estimated harvest	Observed effort (angler hrs)	Estimated total effort	
October						
29-5	12	0	0	55.50	462.5	
6-12	9	0	0	11.00	122.2	
13-19	10	0	0	0	0	
20-26	4	0	0	0	0	
		Totals	0	0	66.50	584.7
		GRAND TOTALS	155	729	3254.25	16,809.9

APPENDIX E

Percent of time surveyed from May through October, 1975,
observed and estimated number of smallmouth bass harvested and
fishing pressure in Clear Lake, Wisconsin.

Month-Date	Percent surveyed	Number of smallmouth bass observed	Estimated harvest	Observed effort (angler hrs)	Estimated total effort
May					
18-24	14	4	29	79.25	566.07
25-31	36	2	6	183.75	510.42
Totals		6	35	263.00	1076.49
June					
1-7	36	5	14	100.50	279.20
8-14	29	9	31	241.25	831.90
15-21	29	4	14	284.25	980.18
22-28	36	21	58	263.00	730.56
29-5	29	36	124	299.50	1032.77
Totals		75	241	1188.50	3854.61
July					
6-12	30	17	57	341.75	1139.16
13-19	26	9	35	166.25	639.43
20-26	23	7	30	201.00	873.90
27-2	36	17	47	160.25	445.14
Totals		50	169	869.25	3097.63
August					
3-9	36	31	86	265.25	736.81
10-16	36	24	67	241.75	671.53
17-23	36	10	28	233.00	647.23
24-30	36	28	78	277.75	771.53
Totals		93	259	1017.75	2827.10

--APPENDIX E CONTINUED--

Month-Date	Percent surveyed	Number of smallmouth bass observed	Estimated harvest	Observed effort (angler hrs)	Estimated total effort
<hr/>					
September					
31-6	17	16	94	131.75	775.00
7-13	8	0	0	21.00	262.50
14-20	7	0	0	0	0
21-27	4	0	0	16.00	400.00
	Totals	16	94	168.75	1437.5
<hr/>					
October					
28-4	8	0	0	0	0
5-11	2	0	0	0	0
	Totals	0	0	0	0
<hr/>					
	GRAND TOTALS	240	798	3507.25	12,293.30

APPENDIX F

Computation of equilibrium yield and production per unit recruitment for smallmouth bass in Clear Lake, Wisconsin, under present conditions of no size limit. G, M, and F are instantaneous rates of growth, natural mortality, and fishing mortality.

Date	Age	Length	Weight	G	M	F	G-M-F	Weight change factor	Weight of stock	Mean weight	Yield	Production
May 1	I	92	11						--			
Sept. 1		137	33	--	--	--	--	--	--	--	--	--
Jan. 1		142	35	--	--	--	--	--	--	--	--	--
May 1	II	142	35	--	--	--	--	--	1000			
Sept. 1		181	80	0.8266	0.6300	0.6340	-0.4373	0.6457	645.7	822.8	521.7	680.2
Jan. 1		185	85	0.0606	0.0790	0.0710	-0.0893	0.9145	590.5	618.1	43.8	37.4
May 1	III	185	85	0.0000	0.0790	0.0000	-0.0790	0.9240	545.6	568.1	0	0
Sept. 1		235	182	0.7613	0.6300	0.6340	-0.5026	0.6049	330.1	437.8	277.6	333.3
Jan. 1		240	193	0.0586	0.0790	0.0710	-0.0913	0.9127	301.2	315.7	22.4	18.5
May 1	IV	240	193	0.0000	0.0790	0.0000	-0.0790	0.9240	278.4	289.8	0	0
Sept. 1		291	356	0.6122	0.6300	0.6340	-0.6517	0.5211	145.0	211.7	134.2	129.6
				0.0493	0.0790	0.0710	-0.1006	0.9042		138.1	9.8	6.8

--APPENDIX F CONTINUED--

Date	Age	Length	Weight	G	M	F	G-M-F	Weight change factor	Weight of stock	Mean weight	Yield	Production
Jan. 1		297	374						131.1			
May 1	V	297	374	0.0000	0.0790	0.0000	-0.0790	0.9240	121.2	126.2	0	0
Sept. 1		348	618	0.5022	0.0000	1.3430	-0.8407	0.4313	52.2	86.7	116.5	43.5
Jan. 1		354	645	0.0427	0.0000	0.1490	-0.1062	0.8992	47.0	49.6		
May 1	VI	354	645	0.0000	0.0000	0.0000	0.0000	1.0000	47.0	47.0	0	0
Sept. 1		390	876	0.3061	0.5320	0.7430	-0.9688	0.3795	17.8	32.4	24.0	9.9
Jan. 1		394	902	0.0292	0.0670	0.0830	-0.1207	0.8862	15.8	16.8	1.3	0.4
May 1	VII	394	902	0.0000	0.0670	0.0000	-0.0670	0.9351	14.7	15.3	0	0
Sept. 1		424	1137	0.2315	0.5320	0.7430	-1.0434	0.3522	5.2	10.0	7.4	2.3
Jan. 1		427	1163	0.0226	0.0670	0.0830	-0.1273	0.8803	4.5	4.8	0.4	0.1
May 1	VIII	427	1163	0.0000	0.0670	0.0000	-0.0670	0.9351	4.2	4.4	0	0
Sept. 1		450	1372	0.1652	0.5320	0.7430	-1.1097	0.3296	1.4	2.8	2.1	0.4
Jan. 1		453	1395	0.0166	0.0670	0.0830	-0.1333	0.8751	1.2	1.3	0.1	0.0
May 1	IX	453	1395	0.0000	0.0670	0.0000	-0.0670	0.9351	1.1	1.1	0	0
				0.1245	0.5320	0.7430	-1.1504	0.3164		0.7	0.5	0.0

--APPENDIX F CONTINUED--

Date	Age	Length	Weight	G	M	F	G-M-F	Weight change factor	Weight of stock	Mean weight	Yield	Production
Sept. 1		471	1580						0.3			
Jan. 1		473	1600	0.0125	0.0670	0.0830	-0.1374	0.8716	0.3	0.3	0.0	0.0
May 1	X	473	1600	0.0000	0.0670	0.0000	-0.0670	0.9351	0.2	0.3	0.0	0.0
Sept. 1		486	1743	0.0856	0.5320	0.7430	-1.1893	0.3044	0.0	0.1	0.1	0.0
Jan. 1		487	1759	0.0091	0.0670	0.0830	-0.1408	0.8686	0.0	0.0	0.0	0.0
May 1	XI	487	1759	0.0000	0.0670	0.0000	-0.0670	0.9351		0.0	0.0	0.0
										TOTALS	1169.9	1265.2

APPENDIX G

Computation of equilibrium yield per unit recruitment with a 240 mm (about 10 inches) length limit for smallmouth bass in Clear Lake, Wisconsin. G, M, and F are instantaneous rates of growth, natural mortality, and fishing mortality.

Date	Age	Length	Weight	G	M	F	G-M-F	Weight change factor	Weight of stock	Mean weight	Yield
May 1	II	142	35						1000		
Sept. 1		181	80	0.8266	0.6300	0.0000	0.1966	1.2173	1217.3	1108.6	0.0
Jan. 1		185	85	0.0606	0.0790	0.0000	-0.0183	0.9817	1195.1	1206.2	0.0
May 1	III	185	85	0.0000	0.0790	0.0000	-0.0790	0.9240	1104.4	1149.7	0.0
Sept. 1		235	182	0.7613	0.6300	0.0000	0.1313	1.1403	1259.4	1181.9	0.0
Jan. 1		240	193	0.0586	0.0790	0.0000	-0.0203	0.9798	1234.0	1246.7	0.0
May 1	IV	240	193	0.0000	0.0790	0.0000	-0.0790	0.9240	1140.3	1187.2	0.0
Sept. 1		291	356	0.6122	0.6300	0.6340	-0.6517	0.5211	594.2	867.3	549.8
Jan. 1		297	374	0.0493	0.0790	0.0710	-0.1006	0.9042	537.3	565.8	40.1
May 1	V	297	374	0.0000	0.0790	0.0000	-0.0790	0.9240	496.5	516.9	0.0
Sept. 1		348	618	0.5022	0.0000	1.3430	-0.8407	0.4313	214.1	355.3	477.2
				0.0427	0.0000	0.1490	-0.1062	0.8992		203.4	30.3

--APPENDIX G CONTINUED--

Date	Age	Length	Weight	G	M	F	G-M-F	Weight change factor	Weight of stock	Mean weight	Yield
Jan. 1		354	645						192.6		
May 1	VI	354	645	0.0000	0.0000	0.0000	0.0000	1.0000	192.6	192.6	0.0
Sept. 1		390	876	0.3061	0.5320	0.7430	-0.9688	0.3795	73.0	132.8	98.7
Jan. 1		394	902	0.0292	0.0670	0.0830	-0.1207	0.8862	64.7	68.9	5.7
May 1	VII	394	902	0.0000	0.0670	0.0000	-0.0670	0.9351	60.5	62.6	0.0
Sept. 1		424	1137	0.2351	0.5320	0.7430	-1.0434	0.3522	21.3	40.9	30.4
Jan. 1		427	1163	0.0226	0.0670	0.0830	-0.1273	0.8803	18.7	20.0	1.6
May 1	VIII	427	1163	0.0000	0.0670	0.0000	-0.0670	0.9351	17.5	18.1	0.0
Sept. 1		450	1372	0.1652	0.5320	0.7430	-1.1097	0.3296	5.7	11.6	8.6
Jan. 1		453	1395	0.0166	0.0670	0.0830	-0.1333	0.8751	5.0	5.4	0.4
May 1	IX	453	1395	0.0000	0.0670	0.0000	-0.0670	0.9351	4.7	4.9	0.0
Sept. 1		471	1580	0.1245	0.5320	0.7430	-1.1504	0.3164	1.5	3.1	2.3
Jan. 1		473	1600	0.0125	0.0670	0.0830	-0.1374	0.8716	1.3	1.4	0.1
May 1	X	473	1600	0.0000	0.0670	0.0000	-0.0670	0.9351	1.2	1.2	0.0
				0.0856	0.5320	0.7430	-1.1893	0.3044		0.7	0.5

--APPENDIX G CONTINUED--

Date	Age	Length	Weight	G	M	F	G-M-F	Weight change factor	Weight of stock	Mean weight	Yield
Sept. 1		486	1743						0.3		
				0.0091	0.0670	0.0830	-0.1408	0.8686		0.3	0.0
Jan. 1		487	1759						0.3		
				0.0000	0.0670	0.0000	-0.0670	0.9351		0.3	0.0
May 1	XI	487	1759								
									TOTAL YIELD		1246.3

APPENDIX H

Computation of equilibrium yield per unit recruitment with a 297 mm (about 12 inches) length limit for smallmouth bass in Clear Lake, Wisconsin. G, M, and F are instantaneous rates of growth, natural mortality, and fishing mortality.

Date	Age	Length	Weight	G	M	F	G-M-F	Weight change factor	Weight of stock	Mean weight	Yield
May 1	II	142	35						1000		
Sept. 1		181	80	0.8266	0.6300	0.0000	0.1966	1.2173	1217.3	1108.6	0.0
Jan. 1		185	85	0.0606	0.0790	0.0000	-0.0183	0.9817	1195.1	1206.2	0.0
May 1	III	185	85	0.0000	0.0790	0.0000	-0.0790	0.9240	1104.4	1149.7	0.0
Sept. 1		235	182	0.7613	0.6300	0.0000	0.1313	1.1403	1259.4	1181.9	0.0
Jan. 1		240	193	0.0586	0.0790	0.0000	-0.0203	0.9798	1234.0	1246.7	0.0
May 1	IV	240	193	0.0000	0.0790	0.0000	-0.0790	0.9240	1140.3	1187.2	0.0
Sept. 1		291	356	0.6122	0.6300	0.0000	-0.0177	0.9823	1120.2	1130.3	0.0
Jan. 1		297	374	0.0493	0.0790	0.0000	-0.0296	0.9707	1087.5	1103.9	0.0
May 1	V	297	374	0.0000	0.0790	0.0000	-0.0790	0.9240	1004.9	1046.2	0.0
Sept. 1		348	618	0.5022	0.0000	1.3430	-0.8407	0.4313	433.5	719.2	965.8
				0.0427	0.0000	0.1490	-0.1062	0.8992		411.6	61.3

--APPENDIX H CONTINUED--

Date	Age	Length	Weight	G	M	F	G-M-F	Weight change factor	Weight of stock	Mean weight	Yield
Jan. 1		354	645						389.8		
May 1	VI	354	645	0.0000	0.0000	0.0000	0.0000	1.0000	389.8	389.8	0.0
Sept. 1		390	876	0.3061	0.5320	0.7430	-0.9688	0.3795	147.9	268.8	199.7
Jan. 1		394	902	0.0292	0.0670	0.0830	-0.1207	0.8862	131.1	139.5	11.5
May 1	VII	394	902	0.0000	0.0670	0.0000	-0.0670	0.9351	122.6	126.8	0.0
Sept. 1		424	1137	0.2351	0.5320	0.7430	-1.0434	0.3522	43.1	82.8	61.5
Jan. 1		427	1163	0.0266	0.0670	0.0830	-0.1273	0.8803	38.0	40.6	3.3
May 1	VIII	427	1163	0.0000	0.0670	0.0000	-0.0670	0.9351	35.5	36.7	0.0
Sept. 1		450	1372	0.1652	0.5320	0.7430	-1.1097	0.3296	11.7	23.6	17.5
Jan. 1		453	1395	0.0166	0.0670	0.0830	-0.1333	0.8751	10.2	10.9	0.9
May 1	IX	453	1395	0.0000	0.0670	0.0000	-0.0670	0.9351	9.5	9.9	0.0
Sept. 1		471	1580	0.1245	0.5320	0.7430	-1.1504	0.3164	3.0	6.3	4.6
Jan. 1		473	1600	0.0125	0.0670	0.0830	-0.1374	0.8716	2.6	2.8	0.2
				0.0000	0.0670	0.0000	-0.0670	0.9351		2.5	0.0

--APPENDIX H CONTINUED--

Date	Age	Length	Weight	G	M	F	G-M-F	Weight change factor	Weight of stock	Mean weight	Yield
May 1	X	473	1600						2.4		
				0.0856	0.5320	0.7430	-1.1893	0.3044		1.6	1.1
Sept. 1		486	1743						0.7		
				0.0091	0.0670	0.0830	-0.1408	0.8686		0.7	0.0
Jan. 1		487	1759						0.6		
				0.0000	0.0670	0.0000	-0.0670	0.9351		0.6	0.0
May 1	XI	487	1759						0.6		
										TOTAL YIELD	1328.2

APPENDIX I

Computation of equilibrium yield per unit recruitment with a 322 mm (about 13 inches) length limit for smallmouth bass in Clear Lake, Wisconsin. G, M, and F are instantaneous rates of growth, natural mortality, and fishing mortality.

Date	Age	Length	Weight	G	M	F	G-M-F	Weight change factor	Weight of stock	Mean weight	Yield
May 1	II	142	35						1000		
Sept. 1		181	80	0.8266	0.6300	0.0000	0.1966	1.2173	1217.3	1108.6	0.0
Jan. 1		185	85	0.0606	0.0790	0.0000	-0.0183	0.9817	1195.1	1206.2	0.0
May 1	III	185	85	0.0000	0.0790	0.0000	-0.0790	0.9240	1104.4	1149.7	0.0
Sept. 1		235	182	0.7613	0.6300	0.0000	0.1313	1.1403	1259.4	1181.9	0.0
Jan. 1		240	193	0.0586	0.0790	0.0000	-0.0203	0.9798	1234.0	1246.7	0.0
May 1	IV	240	193	0.0000	0.0790	0.0000	-0.0790	0.9240	1140.3	1187.2	0.0
Sept. 1		291	356	0.6122	0.6300	0.0000	-0.0177	0.9823	1120.2	1130.3	0.0
Jan. 1		297	374	0.0493	0.0790	0.0000	-0.0296	0.9707	1087.5	1103.9	0.0
May 1	V	297	374	0.0000	0.0790	0.0000	-0.0790	0.9240	1004.9	1046.2	0.0
Sept. 1		348	618	0.5022	0.0000	0.6710	-0.1687	0.8447	848.8	926.8	621.9
				0.0427	0.0000	0.1490	-0.1062	0.8992		806.0	120.1

--APPENDIX I CONTINUED--

Date	Age	Length	Weight	G	M	F	G-M-F	Weight change factor	Weight of stock	Mean weight	Yield
Jan. 1		354	645						763.3		
May 1	VI	354	645	0.0000	0.0000	0.0000	0.0000	1.0000	763.3	763.3	0.0
Sept. 1		390	876	0.3061	0.5320	0.7430	-0.9688	0.3795	289.6	526.4	391.1
Jan. 1		394	902	0.0292	0.0670	0.0830	-0.1207	0.8826	256.7	273.2	22.6
May 1	VII	394	902	0.0000	0.0670	0.0000	-0.0670	0.9351	240.0	248.4	0.0
Sept. 1		424	1137	0.2351	0.5320	0.7430	-1.0434	0.3522	84.5	162.3	120.6
Jan. 1		427	1163	0.0266	0.0670	0.0830	-0.1273	0.8803	74.4	79.5	6.5
May 1	VIII	427	1163	0.0000	0.0670	0.0000	-0.0670	0.9351	69.6	72.0	0.0
Sept. 1		450	1372	0.1652	0.5320	0.7430	-0.1097	0.3296	22.9	46.2	34.3
Jan. 1		453	1395	0.0166	0.0670	0.0830	-0.1333	0.8751	20.0	21.5	1.7
May 1	IX	453	1395	0.0000	0.0670	0.0000	-0.0670	0.9351	18.7	19.4	0.0
Sept. 1		471	1580	0.1245	0.5320	0.7430	-1.1504	0.3164	5.9	12.3	9.1
Jan. 1		473	1600	0.0125	0.0670	0.0830	-0.1374	0.8716	5.1	5.5	0.4
				0.0000	0.0670	0.0000	-0.0670	0.9351		5.0	0.0

--APPENDIX I CONTINUED--

Date	Age	Length	Weight	G	M	F	G-M-F	Weight change factor	Weight of stock	Mean weight	Yield
May 1	X	473	1600						4.8		
				0.0856	0.5320	0.7430	-1.1893	0.3044		3.1	2.3
Sept. 1		486	1743						1.4		
				0.0091	0.0670	0.0830	-0.1408	0.8686		1.3	0.1
Jan. 1		487	1759						1.2		
				0.0000	0.0670	0.0000	-0.0670	0.9351		1.2	0.0
May 1	XI	487	1759						1.1		
									TOTAL YIELD		1331.4

APPENDIX J

Computation of equilibrium yield per unit recruitment with a 354 mm (about 14 inches) length limit for smallmouth bass in Clear Lake, Wisconsin. G, M, and F are instantaneous rates of growth, natural mortality, and fishing mortality.

Date	Age	Length	Weight	G	M	F	G-M-F	Weight change factor	Weight of stock	Mean weight	Yield
May 1	II	142	35						1000		
Sept. 1		181	80	0.8266	0.6300	0.0000	0.1966	1.2173	1217.3	1108.6	0.0
Jan. 1		185	85	0.0606	0.0790	0.0000	-0.0183	0.9817	1195.1	1206.2	0.0
May 1	III	185	85	0.0000	0.0790	0.0000	-0.0790	0.9240	1104.4	1149.7	0.0
Sept. 1		235	182	0.7613	0.6300	0.0000	0.1313	1.1403	1259.4	1181.9	0.0
Jan. 1		240	193	0.0586	0.0790	0.0000	-0.0203	0.9798	1234.0	1246.7	0.0
May 1	IV	240	193	0.0000	0.0790	0.0000	-0.0790	0.9240	1140.3	1187.2	0.0
Sept. 1		291	356	0.6122	0.6300	0.0000	-0.0177	0.9823	1120.2	1130.3	0.0
Jan. 1		297	374	0.0493	0.0790	0.0000	-0.0296	0.9707	1087.5	1103.9	0.0
May 1	V	297	374	0.0000	0.0790	0.0000	-0.0790	0.9240	1004.9	1046.2	0.0
Sept. 1		348	618	0.5022	0.0000	0.0000	0.5022	1.6524	1660.5	1332.7	0.0
				0.0427	0.0000	0.0000	0.0427	1.0436		1696.8	0.0

--APPENDIX J CONTINUED--

Date	Age	Length	Weight	G	M	F	G-M-F	Weight change factor	Weight of stock	Mean weight	Yield
Jan. 1		354	645						1733.0		
May 1	VI	354	645	0.0000	0.0000	0.0000	0.0000	1.0000	1733.0	1733.0	0.0
Sept. 1		390	876	0.3061	0.5320	0.7430	-0.9688	0.3795	657.7	1195.3	888.1
Jan. 1		394	902	0.0292	0.0670	0.0830	-0.1207	0.8826	582.9	620.3	51.5
May 1	VII	394	902	0.0000	0.0670	0.0000	-0.0670	0.9351	545.1	564.0	0.0
Sept. 1		424	1137	0.2351	0.5320	0.7430	-1.0434	0.3522	192.0	368.5	273.8
Jan. 1		427	1163	0.0266	0.0670	0.0830	-0.1273	0.8803	169.0	180.5	14.9
May 1	VIII	427	1163	0.0000	0.0670	0.0000	-0.0670	0.9351	158.0	163.5	0.0
Sept. 1		450	1372	0.1652	0.5320	0.7430	-0.1097	0.3296	52.1	105.1	78.0
Jan. 1		453	1395	0.0166	0.0670	0.0830	-0.1333	0.8751	45.6	48.8	4.0
May 1	IX	453	1395	0.0000	0.0670	0.0000	-0.0670	0.9351	42.6	44.1	0.0
Sept. 1		471	1580	0.1245	0.5320	0.7430	-1.1504	0.3164	13.4	28.0	20.8
Jan. 1		473	1600	0.0125	0.0670	0.0830	-0.1374	0.8716	11.7	12.6	1.0
				0.0000	0.0670	0.0000	-0.0670	0.9351		11.3	0.0

--APPENDIX J CONTINUED--

Date	Age	Length	Weight	G	M	F	G-M-F	Weight change factor	Weight of stock	Mean weight	Yield
May 1	X	473	1600						11.0		
				0.0856	0.5320	0.7430	-1.1893	0.3044		7.1	5.3
Sept. 1		486	1743						3.3		
				0.0091	0.0670	0.0830	-0.1408	0.8686		3.1	0.2
Jan. 1		487	1759						2.9		
				0.0000	0.0670	0.0000	-0.0670	0.9351		2.8	0.0
May 1	XI	487	1759						2.7		
									TOTAL YIELD		1338.1