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DEPARTMENT OF NATURAL RESOURCES

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EFFECTS OF THE INTRODUCTION OF MUSKELLUNGE AND WALLEYE ON BLUEGILL AND OTHER SPECIES IN CLEAR LAKE, SAWYER COUNTY, WISCONSIN, 1959-1984

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ABSTRACT

Repeated stockings of muskellunge (Esox masquinongy) and walleye (Stizostedion vitreum vitreum) in Clear Lake from 1959-84 did not improve growth or size structure of the overabundant bluegill population. This study evaluated the effects of these stockings on the other species present, especially the most abundant species--bluegill (Lepomis macrochirus). Samples collected by fall electrofishing annually from 1960-67 and in 1975, 1983, and 1984 were used to study changes in species composition (catch per minute by electrofishing or CPE), growth, size, and age structure of bluegills.

Bluegill CPE varied from 8-20 from 1960-75, while in 1983 and 1984 CPE was 6 and 5, respectively. Compared to 1960-67, there were sizeable increases in CPE for most other species in the 1975-84 samples, especially for yellow perch (Perca flavescens) in 1983, rock bass (Ambloplites rupestris) in 1983 and 1984, and largemouth bass (Micropterus salmoides) in 1975, 1983, and 1984. Size and age structure varied considerably in all bluegill samples; however, no increase in growth rate or abundance of quality-sized fish ($\geq$ 6.0 inches) was noted. Average length after five seasons was 3.7 inches (3.5-3.9 range).

Frequent and above-average stocking levels of walleye and muskellunge from 1959-76 did not change the growth or CPE of bluegills. Therefore, I do not believe that the decline in CPE of bluegills in the 1983 and 1984 samples resulted from stocking muskellunge in 1981 and 1984. Rather, the changes in the bluegill population in 1983 and 1984 were due to the low to poor year-class strength for all age groups sampled, particularly during the five consecutive years (1978-82) before the 1983 and 1984 samples. Minimum harvest of muskellunge through 1967, as determined from voluntary registration at the only local resort, was 7% of the number stocked in 1960 and 1961. The stocking of muskellunge and walleye provided additional angling opportunities for Clear Lake.

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CONTENTS

INTRODUCTION AND MANAGEMENT HISTORY

Supplemental stocking of predator species to restore or improve the balance of slow-growing panfish populations has rarely been successful. Few researchers have evaluated the introduction of predators and the predator-prey interaction. Therefore, the effects of predator stocking on the forage base and other predators is poorly understood (Noble 1981). This report reviews the results of stocking two predator species (muskellunge and walleye) in Clear Lake, Wisconsin, which historically has had an extremely abundant and slow-growing bluegill population. Fish populations similar to those in Clear Lake, but usually not as abundant and slow-growing, are common in northwestern Wisconsin (Snow, Wis. Dep. Nat. Resour., unpubl. data). I investigated whether the repeated stockings of muskellunge and walleye affected bluegills and other panfish in Clear Lake.

Clear Lake is a bass-panfish lake, and from 1938-53, it was managed on this basis. During this period, 200-3,000 largemouth bass fingerlings were stocked every year except for 1939 and 1951. Before and during the period 1938-53, there were occasional stockings of black crappie (Pomoxis nigromaculatus), bluegill, sunfish (Lepomis sp.), and also 50 smallmouth bass (Micropterus dolomieui) in 1946. From 1953-59 no fish were stocked in Clear Lake. In 1959, 90 adult largemouth bass (10-17 inches) were removed from the lake for stocking in other waters.

A 1958 fyke-net survey verified several years of complaints from anglers of an overabundant panfish population in Clear Lake. Consequently, since 1959 Clear Lake has been managed to improve the panfish population by stocking predator species. Walleye fingerlings 2-6 inches long were stocked in 1959, 1967, 1968, 1971, and 1976 (26-100 fish per acre). Muskellunge fingerlings 10-13 inches long were stocked in 1960, 1961, 1972, 1973, 1974, 1981, and 1984 (4-6 fish per acre)(Fig. 1). All muskellunge stocked were finclipped for future identification. The 1958 survey also indicated the presence of a remnant population of large walleyes and the possibility (indicated by local anglers) of a remnant population of large muskellunge. These muskellunge are believed to be the result of illegal introductions before 1958.

The objective of this project was to study the effects of stocking muskellunge and walleye on other species in Clear Lake, especially the most abundant species--bluegill. I evaluated the impact of the stockings by comparing growth rates, age distribution, and relative abundance using catch per minute by electrofishing (CPE) for bluegill and other species. The other species included pumpkinseed (Lepomis gibbosus), black crappie, rock bass (Ambloplites rupestris), yellow perch (Perca flavescens), largemouth bass (Micropterus salmoides),

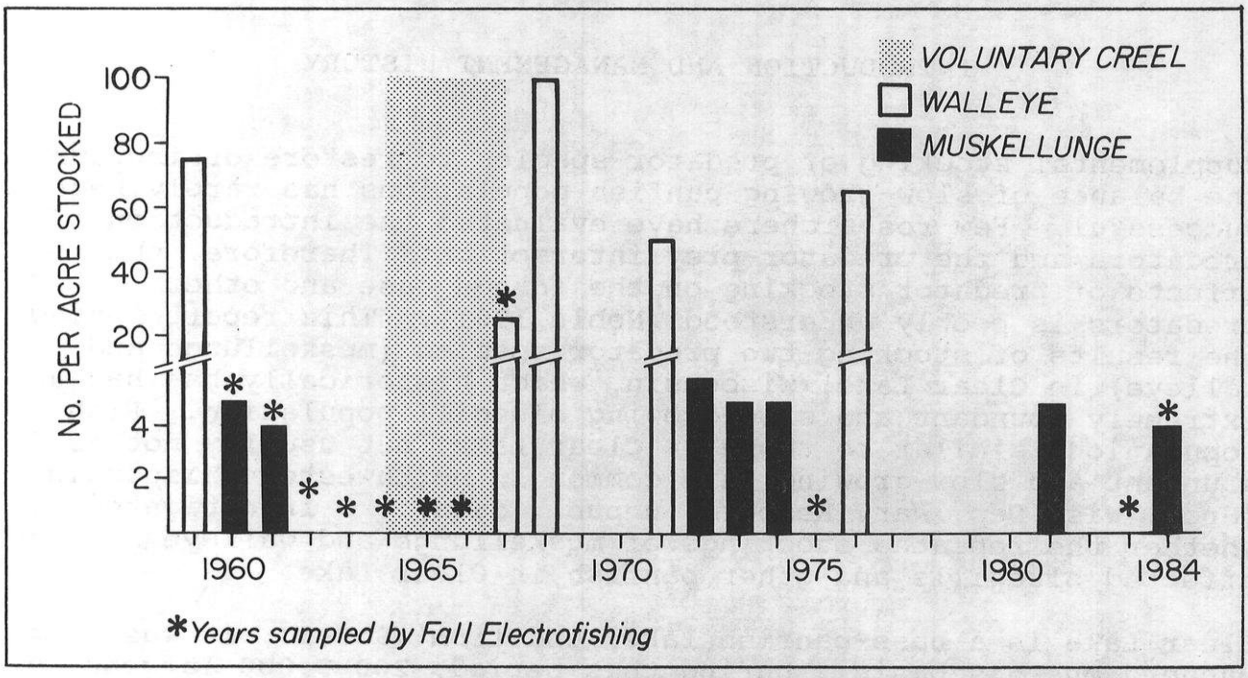

FIGURE 1. Time sequence of muskellunge and walleye stocking and voluntary creel census in Clear Lake, Wisconsin. Asterisks indicate the years of fall sampling by electrofishing.

bullheads (Ictalurus sp.), white suckers (Catostomus commersoni), and redhorse (Moxostoma sp.).

In an earlier paper, I reported the effects of the stockings on bluegill and other species and on the angler harvest of muskellunge through 1967 (Snow 1968). In this paper, I discuss data selected from the 1968 report and evaluate the 5 additional stockings of muskellunge and the 4 of walleye from 1967-84.

DESCRIPTION OF STUDY AREA

Clear Lake is in the heart of native muskellunge country in Sawyer County, Wisconsin, about 15 miles northeast of Hayward (Fig. 2). Clear Lake is a 77-acre, seepage lake with a maximum depth of 32 ft; 27% is over 20 ft deep and 9% is less than 3 ft deep. Total volume is 1,076 acre-feet and the shoreline is 2.2 miles. About 80% of the substrate in the littoral zone consists of sand, while 10% is gravel, and 10% is muck. Aquatic vegetation is relatively sparse but is found in scattered areas along the shore and in the south bay. The lake has one resort and several private cabins or residences. Water samples collected in 1958, 1964, and 1965 indicated a pH range of 6.8-7.8 and methyl purple alkalinity range of 27-35 ppm.

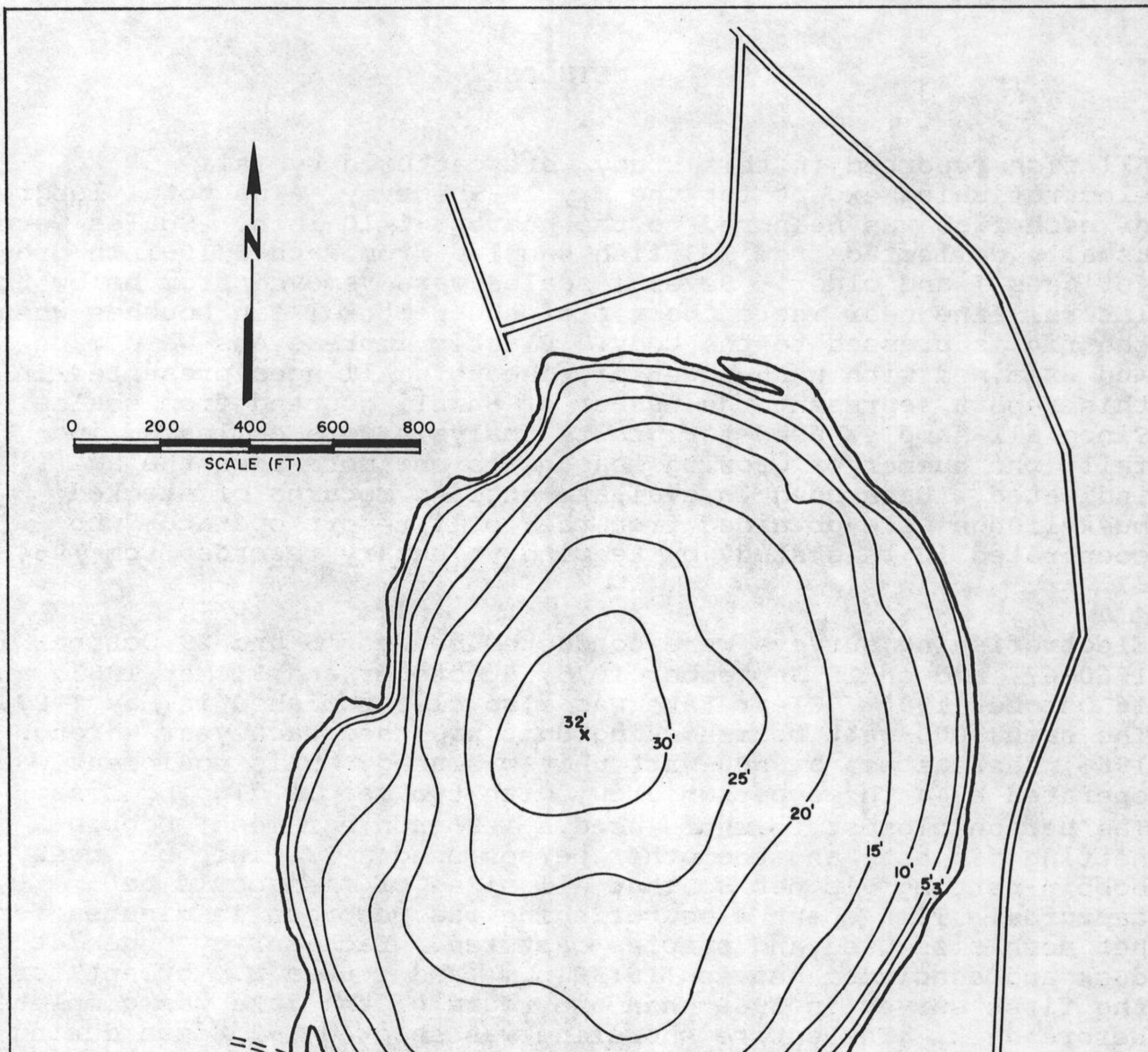

FIGURE 2. Hydrographic map of Clear Lake, Sawyer County, Wisconsin.

METHODS

All fish reported in this study were captured by fall electrofishing, except for the May 1983 survey. The total length of each fish was measured to the nearest 1/10-inch. Scales were usually collected from 1-3 fish sampled from each 1/10-inch group for ages I and older. Several scales were removed from below the lateral line near where the tip of the pectoral fin touches when the fin is pressed to the body. Plastic impressions were made and examined with a 35-power microscope. All ages presented in this report represent the number of annuli counted from scales. Since all samples used for growth analysis were collected in fall, the number of growing seasons is one more than the age indicated. Data used to evaluate angling returns of stocked muskellunge were obtained from the local resort operator who cooperated in this study by keeping voluntary records from 1964-67.

Electrofishing surveys were conducted between 5 and 29 October in 1960-67, and on 15 September 1975, 5 October and 31 May 1983, and 16 October 1984. Clear Lake was also electrofished in May 1983. The same 3000-watt boomshocking unit was used each year through 1966; thereafter, a 3500-watt unit was used. This equipment was operated by a three-person crew, with two people dipping fish. The person closest to shore used a 1/8-inch bar mesh, bobbin-netting dip net, and the other person used a 3/8-inch bar mesh, bobbin-netting dip net so that all sizes of fish could be captured. Time spent electrofishing was recorded in minutes for net mesh size used and species captured. Each survey began at dusk and concluded between 10:30 p.m. and 1:00 a.m., except for the first survey in 1960 when one round of the lake was completed before dark. The entire shoreline was shocked 1-2 times during each survey.

The impact of muskellunge and walleye stocking on the panfish population was evaluated by comparing growth rates, age distribution, and relative abundance (CPE) throughout the study period. Because bluegill dominated the catch in all samples, I concentrated on this species in studying the impact of the stockings.

RESULTS

Muskellunge

Recommended stocking rates for 8.0-13.0 inch muskellunge fingerlings range from 1-2 fish per acre. Actual stocking varies considerably depending on expected annual muskellunge production. On this basis, Clear Lake, which received 4.7 fish per acre in 1960 (total of 365 fish) and 3.9 in 1961 (total of 300 fish), was stocked at 2-5 times the normal rate. Despite this high rate of stocking, only 39 muskellunge were captured during annual electrofishing surveys from 1960-67 (Table 1). The stocked fish grew rapidly, with some fish attaining the legal length of 30.0 inches in the fifth summer. In 1964 the local resort operator began recording muskellunge catch. Through 1967, 7% of the original number stocked were reported caught as legal fish (Table 2). The average length of the muskellunge caught in Clear Lake was 32.0 inches, indicating that anglers were cropping these fish soon after they attained legal size. Because this record was voluntary and did not include all the anglers on Clear Lake, the actual percentage of muskellunge caught was probably higher.

TABLE 1. Muskellunge from the 1960 and 1961 stockings captured during electrofishing surveys on Clear Lake, October 1961-67.

	October 1960 (365 stocked)			October 1961 (300 stocked)			
Year of Recapture	No. Fish	Length Range (inches)	Mean Length	No. Fish	Length Range (inches)	Mean Length	Total Captured
1961	4	11.8-22.8	16.9	9	8.0-12.0 at time of stocking	Not measured	13
1962	3	21.8-28.7	25.3	6	11.2-19.0	16.9	9
1963	3	19.6-27.4	23.3	3	20.1-23.2	21.7	6
1964*	3	22.6-30.6	26.2	2	25.7-27.5	26.6	7
1965	2	22.8-31.1	27.0	--	--	--	2
1966	1	36.0	36.0	--	--	--	1
1967**	--	--	--	--	--	--	1
Total	16			20			39

* Two additional muskellunge were captured (26.8 and 24.5 inches long) in 1964 with no recognizable finclip. Regeneration may have occurred, or these fish may have been part of the remnant muskellunge population.

** No stocked fish were captured in 1967; however, one 24.0-inch native fish was captured.

TABLE 2. Muskellunge from the 1960 and 1961 stockings (total of 665 fish) caught by anglers in Clear Lake.

Length Group (inches)	Year of Capture 1964	1965	1966	1967
30.0 - 30.9	2	6	2	2
31.0 - 31.9	3	8	5	--
32.0 - 32.9	3	5	--	--
33.0 - 33.9	3	--	--	--
34.0 - 34.9	--	2	--	--
35.0 - 35.9	1	1	--	1
36.0 - 36.9	--	1	--	--
37.0 - 37.9	--	--	1	--
38.0 - 38.9	--	--	--	--
39.0 - 39.9	--	--	--	--
40.0 - 40.9	--	--	--	1
Total no.	12	23	8	4

Total for all years = 47

Short term survival of the 1960 and 1961 stockings of muskellunge was not determined. Short-term survival (mark and recapture estimates) of stocked muskellunge fingerlings in Clear Lake in 1972-74 and 1981 averaged 50% (19-34 days) (Johnson 1982, Hanson et al. 1986). However, because 1960 and 1961 were the first 2 years of stocking, I believe that muskellunge survival was equal to or greater than the later stockings. Positive evidence of natural reproduction of muskellunge was obtained in 1983 when 2 unmarked fingerlings were captured.

Walleye

I believe that survival of stocked walleye was low. Mortality of control samples (held in enclosures) in 1959 was high, and only 19 fish (3.7-27.3 inches) were captured during all 11 fall electrofishing samples. Despite high initial mortality, enough walleye survived to provide a small harvest, often of large fish, as reported at the local resort. There was no evidence that walleye reproduced naturally.

Bluegill

Clear Lake has continually had the slowest growing population of bluegills of over 100 lakes sampled in northwestern Wisconsin (Snow, unpubl. data). Mean lengths for all 11 fall samples for age groups 0-IX ranged from 1.4-6.2 inches. Although mean length varied annually for the age groups, there were no trends of increasing or decreasing growth rates throughout the study (Table 3). Age group IV, for example, averaged 3.7 inches in length and varied from 3.5-3.9 inches, while age group VI averaged 4.9 inches and varied from 4.5-5.4 inches (Fig. 3).

Although Clear Lake bluegills grew extremely slowly, the length frequency distribution varied considerably within the sizes captured (1-6 inches) (Fig. 4). In samples of 343-800+ bluegills, I found an average of 7 fish ≥6.0 inches long per sample; in these samples, there were from 1-24 bluegill of this size. The proportional stock density (PSD) at a stock size of 3.0 inches was ≤3% in all samples.

Much of the variation in length frequency can be attributed to differences in year-class strength. During the early years of the study (1960-67) and in 1975, there were many strong year-classes, especially in odd-numbered years (Fig. 5). In 1983 and 1984 this trend changed; samples showed weak year-classes for all age groups represented and exceptionally weak year-classes for the 5 consecutive years from 1978-82 (Fig. 5). These weak year-classes are reflected in the low CPE and the small numbers of bluegills captured in 1983 and 1984 (355 and 343 fish, respectively).

TABLE 3. Mean total length and sample size of bluegills from Clear Lake at the end of the growing season.

Year	Mean Total Length and Sample Size	Age Group 0*	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
1960	Length**	1.3	2.2	2.5	3.4	3.9	4.4	5.4	5.7	6.8	0	0	0
	No.	8	2	8	25	2	16	7	3	1	0	0	0
1961	Length	1.5	2.3	2.8	3.2	3.9	4.8	5.2	6.1	6.8	7.3	0	0
	No.	23	14	18	31	125	29	56	15	3	2	0	0
1962	Length	1.3	2.2	2.8	3.2	3.5	4.3	5.2	5.6	6.0	0	0	0
	No.	23	12	9	16	16	61	14	42	6	0	0	0
1963	Length	1.3	2.1	2.7	3.3	3.7	4.2	4.8	5.4	6.0	6.9	0	0
	No.	16	13	18	17	10	19	46	9	9	1	0	0
1964	Length	1.5	2.1	2.6	3.1	3.7	4.0	4.5	4.9	5.4	5.7	0	0
	No.	1	7	11	21	11	7	18	21	3	3	0	0
1965	Length	1.6	2.1	2.5	3.1	3.9	3.9	4.9	5.0	5.3	5.8	0	0
	No.	4	4	24	14	23	8	3	12	11	3	0	0
1966	Length	1.4	0	2.5	3.1	3.8	4.3	5.0	5.3	5.9	0	6.8	0
	No.	36	0	3	30	15	11	9	8	5	0	1	0
1967	Length	1.2	2.1	0	2.7	3.5	4.0	4.8	5.0	5.8	6.0	0	0
	No.	14	6	0	1	24	5	12	6	7	1	0	0
1975	Length	1.2	1.8	2.6	3.2	3.5	4.3	5.0	5.3	5.6	6.1	6.2	6.8
	No.	211	9	26	8	8	41	4	10	13	6	2	3
1983	Length	1.5	2.2	2.7	3.3	3.9	4.2	4.5	5.2	5.8	0	0	0
	No.	80	11	15	19	5	5	20	27	4	0	0	0
1984	Length	1.2	2.1	2.8	3.5	3.9	0	4.5	5.2	5.5	5.8	5.8	0
	No.	7	13	25	12	14	0	9	24	16	6	1	0
Total Mean Length		1.4	2.1	2.7	3.2	3.7	4.2	4.9	5.4	5.8	6.2	6.3	6.8

* Length of 0 age determined from scales and length frequency.
** Inches.

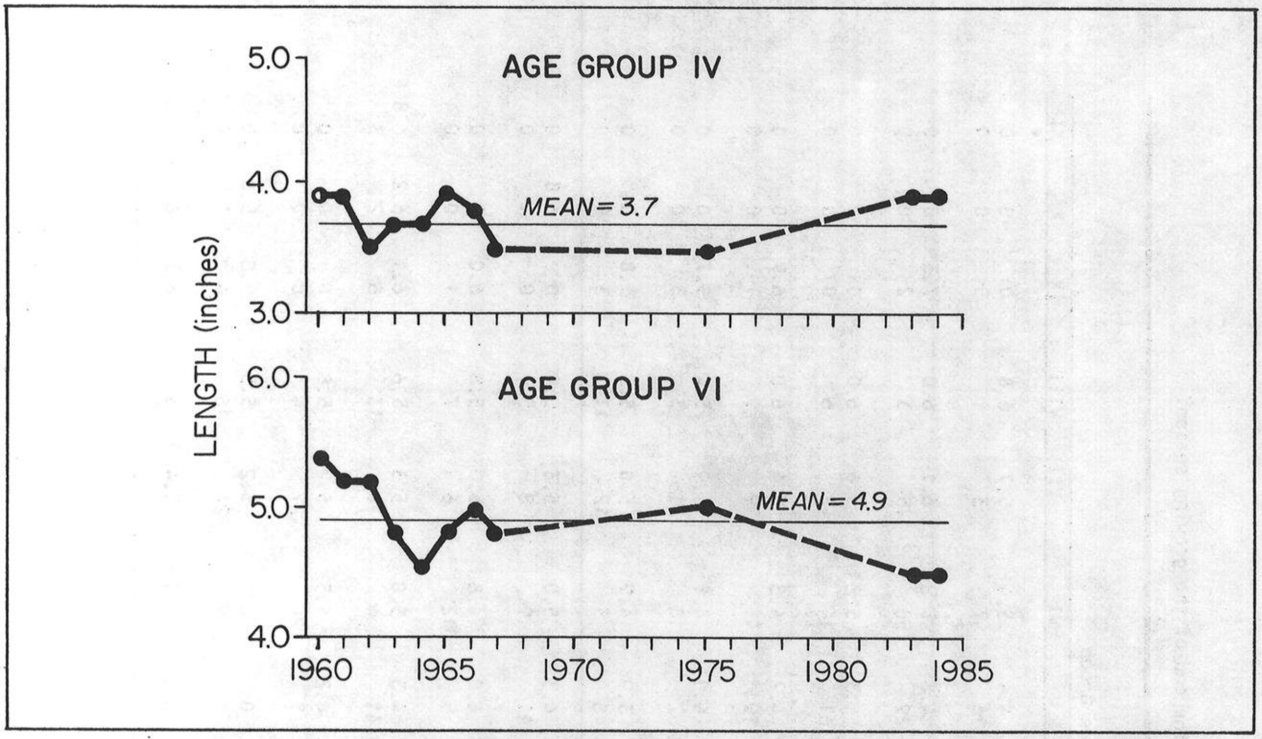

FIGURE 3. Mean lengths of bluegills in age groups IV and VI. Samples were collected annually from 1960-67, and in 1975, 1983, and 1984.

Total Catch per Minute by Electrofishing (CPE)

Total CPE for all species captured averaged 13 fish and varied from 7 fish in 1984 to 22 fish in 1975 (Table 4). The CPE for bluegills averaged 12 and varied from 5-20. In the annual samples collected from 1960-67, bluegill CPE varied from 8-19, increased to 20 in 1975, then decreased to 6 in 1983 and 5 in 1984 (Fig. 6). CPE for yellow perch and all centrachids other than bluegills, although relatively low throughout the study, did increase in one or more of the last 3 samples (1975, 1983, and 1984). The CPE results for bluegill from the May 1983 survey were almost identical to the CPE results for October 1983.

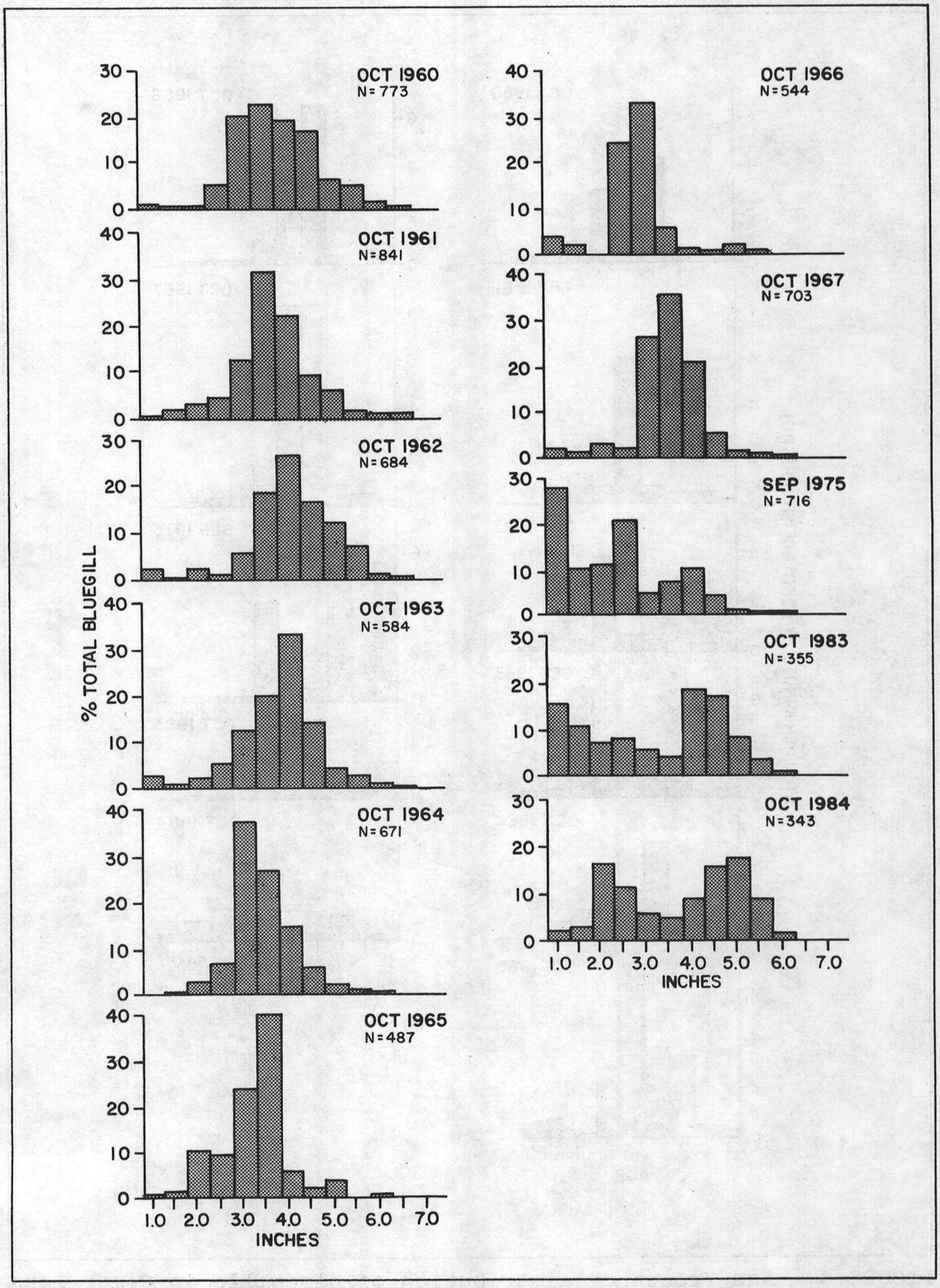

FIGURE 4. Length frequency distribution of bluegills captured by electrofishing in Clear Lake.

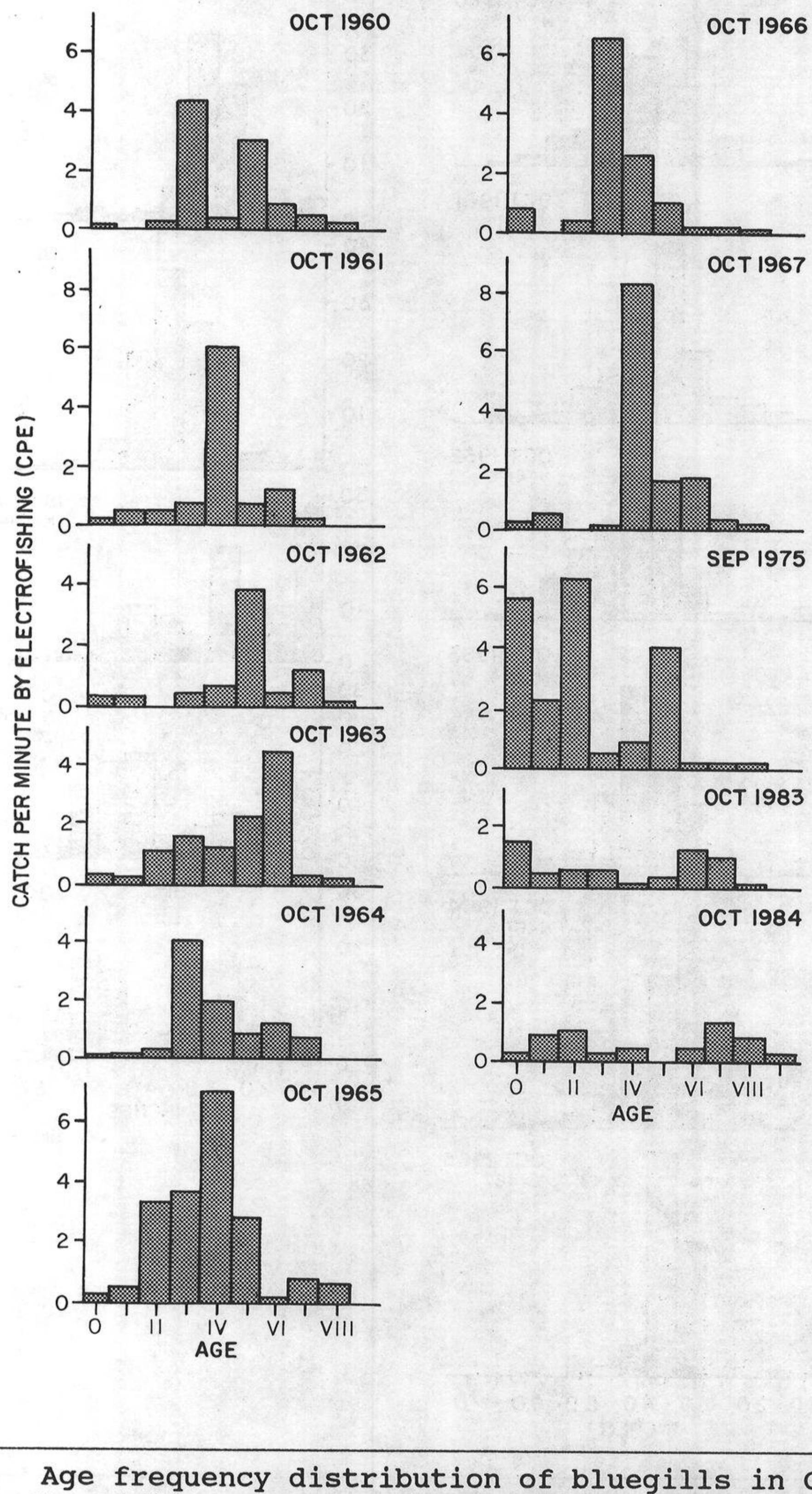

FIGURE 5. Age frequency distribution of bluegills in Clear Lake from 1960-67 and in 1975, 1983, and 1984.

TABLE 4. Catch per minute by electrofishing (CPE) in Clear Lake.

	Species**									
Year*	BG	PS	CR	RB	P	LMB	MU	WE	Other	Total
1960	9.66	0.04	0.06	0.03	0.28	0.09	--[a]	0	0.03	10.19
1961	10.51	0.06	0.02	0.01	0.15	0.12	0.09	0.09	0.02	11.07
1962	7.60	0.02	0.07	0.05	0.15	0.03	0.06	0.06	0.02	8.06
1963	11.68	0.03	0.01	0.02	0.54	0.04	0.07	0.07	0	12.46
1964	10.32	0.13	0.01	0.02	0.37	0.01	0.06	0.06	0	10.98
1965	19.48	0.04	0.11	0.09	0.36	0.33	0.03	0.03	0.04	20.51
1966	12.09	0.09	0.09	0.05	0.28	0.10	0.01	0.01	0.02	12.74
1967	15.62	0.05	0.06	0.03	0.27	0.11	0.01	0.03	0.03	16.21
1975	20.46	0.06	0.19	0.19	0.34	0.32	0.26	0.02	0	21.84
1983[b]	5.83	0.12	0.03	0.92	0.24	1.16	0.11	0	0	8.41
1983[c]	5.92	0.13	0.13	0.30	1.82	0.40	0.07	0.03	0.04	8.84
1984	5.28	0.11	0.12	0.28	0.19	0.31	0.22	0.03	0	6.54
Mean	11.69	0.07	0.08	0.10	0.43	0.17	0.09	0.04	0.02	12.68

* All samples were collected between 5 and 29 October, except in 1983 when samples were also collected on 31 May and in 1975 when samples were collected on 15 September.

** Species abbreviations: BG-bluegill, PS-pumpkinseed, CR-black crappie, RB-rock bass, P-yellow perch, LMB-largemouth bass, MU-muskellunge, WE-walleye, Other-includes bullhead sp., white sucker, and redhorse.

[a] Muskellunge were not sampled in 1960 because they had just been stocked.

[b] 31 May sample.

[c] October sample.

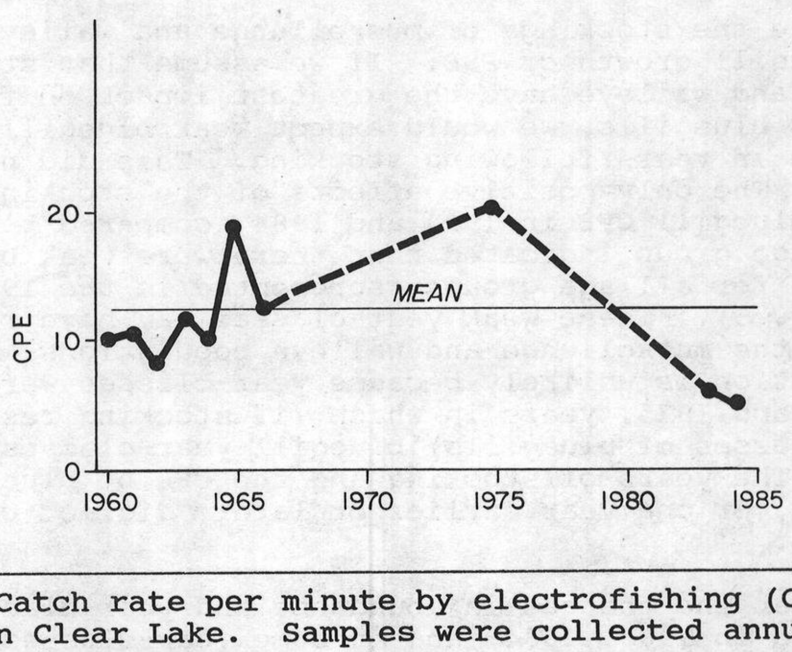

FIGURE 6. Catch rate per minute by electrofishing (CPE) of bluegills in Clear Lake. Samples were collected annually from 1960-67, and in 1975, 1983, and 1984.

DISCUSSION and CONCLUSIONS

Stocking of predator species has been an important management procedure in inland waters for many years. Predators are often successfully stocked to provide an additional fishery, while at other times, they are stocked to control overabundant prey species.

In Clear Lake the 7% harvest of stocked muskellunge within 7 years indicated that an additional fishery was provided. The percentage of legal muskellunge caught in Murphy Flowage, Rusk County (180 acres), with a complete creel census, was only 0.8% of those stocked over a 15-year period (1955-70) (Margenau and Snow 1984). In Murphy Flowage 200 large muskellunge fingerlings were stocked (1.1/acre) annually for 10 years, and 1,000, 2.0-3.0 inch fingerlings were stocked at the beginning of this period. Based on this comparison, the harvest of legal-sized stocked muskellunge in Clear Lake was high.

The survival of stocked muskellunge has been studied extensively (Johnson 1982, Hanson et al. 1986, Serns and Andrews 1986); the interaction between muskellunge and other predators has also been studied, although to a lesser extent (Dombeck et al. 1986, Inskip 1986, Mooradian et al. 1986). Little research, however, has focused on the impact of predators on the forage base under natural conditions (Ney 1981, Noble 1981).

In Clear Lake the stockings of muskellunge and walleye did not improve bluegill growth or PSD. If we assume that stocked muskellunge and walleye have the greatest impact on fingerling and yearling bluegills, we would expect weak bluegill year-classes in years following stocking. This did not occur in Clear Lake. The only positive effects of the stockings were a decline in bluegill CPE in 1983 and 1984, compared to 1960-75. The CPE by age group indicated that there were weak bluegill year-classes for all age groups represented in the 1983 and 1984 samples (Fig. 5). These weak year-classes may have resulted from build-up of the muskellunge and walleye populations. However, this explanation is unlikely because year-classes were strong in 1970, 1973, and 1975, years in which (if stocking resulted in weak year-classes of bluegills) bluegill year-classes should have been weak. The years of stocking and the CPE of bluegill hatched in that year, or one year earlier or later, did not correlate (Figs. 1, 5).

I believe that the changes in abundance and year-class strength that occurred in 1983, 1984, and in some year-classes in earlier samples, were more the result of the high density of the bluegill population than of stocking. An extremely strong year-class one year may suppress successful reproduction the next year or two. This factor, along with abiotic variables such as water temperature, water level, and weather conditions (either alone or in combination), may have had a greater impact on the abundance of small bluegills than the stocking of predator species.

Bluegills were so abundant in Clear Lake that the numbers or biomass of predators necessary for control may have exceeded the spatial carrying capacity of the lake. In small lakes such as Clear Lake, the maximum carrying capacity of the predator species appears to be more limited than that of the prey species. Therefore, beyond some unknown threshold density of stunted bluegills, no amount of predator stocking is effective for bluegill control. Exceptionally high stocking will result in exceptionally high mortality of the stocked species and will have little, if any, impact on bluegills (Snow 1974, 1978). For control of stunted panfish, the predator-prey ratio, rather than only the numbers of predators stocked or the status of the prey population, should be considered (Swingle 1950, Jenkins 1979).

MANAGEMENT RECOMMENDATIONS

In dense prey populations, such as those in Clear Lake, the probability for improving growth and number of larger bluegills would be increased if the bluegill population could be reduced by other methods simultaneously with predator stocking. I recommend reducing the number of intermediate-sized (3.0-5.0 inches) bluegills by 50% or more. During the same season, predator species should be stocked to increase the predator-prey ratio between bluegills and muskellunge or walleye. This technique would lower the stocking needs and increase the chances of success. For managers, the challenge is to use predator stocking with stunted prey populations to improve the quality of the sport fishery.

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