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NATURAL RETURN TO A BALANCED FISH COMMUNITY IN CASSIDY LAKE AFTER A TOTAL KILL[1]

Philip J. Schneeberger

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

ABSTRACT

The sizes of native warmwater fish populations in Cassidy Lake, principally bluegill (*Lepomis macrochirus*), pumpkinseed (*Lepomis gibbosus*), yellow perch (*Perca flavescens*), and largemouth bass (*Micropterus salmoides*), were estimated in 1964 and again in 1987. The lake was treated with rotenone in 1964 to achieve a total fish kill and an experiment using only yellow perch was conducted until 1969. Subsequently, native fish species were restocked in minimal numbers and the lake was then left unmanaged and scarcely examined for 18 years until the present study. A comparison between the two data sets indicated that the 1964 and 1987 fish communities generally were similar in numbers, survival rates, size at age, and growth patterns of important species, and in relative numbers among species. Fish populations in 1987 also had reattained several characteristics which were associated with lakes identified as being good for fishing. The few exceptions to the similarity of data sets were not compelling. Size and age distributions of yellow perch and largemouth bass appeared to have changed between 1964 and 1987, but at least part of these changes was due to differences in selectivity of the sampling gear used in the two studies. Abundance of some minor species fluctuated between study years, but not to the extent that any patterns or ecological changes could be inferred. Future studies should seek to identify dynamic interactions among the biological, physical, and/or chemical characteristics of lakes to determine how and why fish communities tend toward different states of equilibrium.

INTRODUCTION

Cassidy Lake is a 46-acre lake in Washtenaw County, Michigan (T. 1S., R. 3E., Sec. 33). Maximum depth is 11 feet and most (83%) of the water is less than 5 feet deep, but despite the shallowness, winterkill is not a problem (Schneider 1972). Cassidy Lake is spring fed, has a bottom composed mostly of marl, and offers a diverse variety of fish habitats. Substrates of sand, mud, and packed clay are present, and weed cover (mostly *Chara*) ranges from sparse to dense in different parts of the lake. The water is hard (methyl orange alkalinity of 134 ppm) and the lake is moderately productive of fish (Schneider 1973).

The sizes of fish populations in Cassidy Lake were estimated in 1964 using the mark-and-recapture technique. Fish were caught for marking using seines and trap nets, and recaptures were obtained shortly thereafter when the lake was treated with rotenone to eliminate all fish. Fish species composition, densities, and growth rates were judged to have been fairly typical of warmwater lakes in southern Michigan (Schneider 1973).

Following the chemical treatment of Cassidy Lake, yellow perch (see Table 1 for scientific names of fish) were stocked and a study addressing single-species population dynamics was performed from fall 1964 to spring 1969 (see Schneider 1972 for details). After the conclusion of the yellow perch experiment, Cassidy Lake was known to contain yellow perch, green sunfish, mudminnow, and killifish (Schneider 1972). In June 1969, fish from neighboring Mill Lake were captured and stocked in Cassidy Lake in limited numbers and size ranges (Table 2).

Subsequent to this rather minimal stocking effort, Cassidy Lake was left unmanaged and was scarcely examined for 18 years. Over this time span, other fish may have entered the lake via the outlet during periods of high water. Since the mid-1970s more or less normal fishing pressure was exerted on the fish populations (J. Schneider, personal communication, 1987, Institute for Fisheries Research, Ann Arbor). The lake is nearly surrounded by the grounds of a state correctional institution and fishermen have access only along a fairly short section of shoreline close to Waterloo Road. Consequently, the public's desire to fish and their ability to launch boats during the summer are somewhat limited. Fishing pressure has been relatively high during winter months with the development of a popular ice fishery for perch and bluegill in the 1980s.

Based on observations by the staff of the Institute for Fisheries Research, Michigan Department of Natural Resources, it appeared that fish populations in Cassidy Lake had naturally reestablished themselves in balanced proportions and size distributions. The study described in this report was an effort to quantitatively compare the 1987 fish populations in Cassidy Lake with those present in 1964 and with criteria established to classify Michigan warmwater lakes.

METHODS

On April 2, 1987, six standard-mesh (1.5-inch stretched measure) and two small-mesh (0.75-inch stretched measure) trap nets were deployed at suitable locations in Cassidy Lake. Nets were lifted five times and removed on April 8. The lake was allowed to "rest" from April 9–12. Schneider (1972) recommended such a "rest" period between sampling sessions of mark-and-recapture studies to allow fish to resume their normal behavior patterns and distributions in the lake. The eight trap nets were deployed again between April 13–17 and were lifted four times. During collection periods, one to three nets were moved on five different occasions in an attempt to cover all possible habitats. Prior to release, each fish was measured to inch group (e.g., 2-inch group = 2.0 to 2.9 inches; 3-inch group = 3.0 to 3.9 inches; etc.) and the top lobe of its caudal fin was clipped. Scale samples were taken for up to 30 specimens within each inch group for bluegill, pumpkinseed, yellow perch, largemouth bass, and northern pike; these fish were measured to 0.1 inch.

Between April 21–24 and from May 4–8, 13 electrofishing (boom-shocking) sessions (7 days and 6 nights) were conducted for approximately 4 hours per session. The boom-shocking boat was of standard design: 220 volts with 3-phase AC current were delivered from an on-board generator to five flexible electrodes which were suspended from booms off the bow of the boat. Stunned fish were caught in scap nets and handled as before except that the bottom lobe of the caudal fin was clipped rather than the top.

Marked and unmarked catches for each day of sampling were stratified by species and inch group. A computer program was created which calculated population estimates and 95% confidence limits (Appendix 1). When possible, separate estimates were made for each inch group of a species to compensate for size selectivity of fishing methods as described by Latta (1959) and Laarman and Ryckman (1980). Catches of two or more inch groups were pooled when recapture data were insufficient to make estimates for individual inch groups; estimates for individual inch groups within a pooled data set were then made, based on relative catch frequencies.

If fish were collected in adequate numbers by both trap nets and electrofishing gear, estimates were computed using the formulae given by Bailey as a modification of the Petersen single-census method (Ricker 1958). In these instances, fish caught in trap nets constituted the marked population and fish caught by electrofishing were used to obtain the recapture ratio. However, some species or size groups within species were decidedly more vulnerable to one type of collecting gear than the other. Under these circumstances populations were estimated from data collected with the most efficient gear using the Schumacher and Eschmeyer modification of the Schnabel multiple-census method (Ricker 1958). As recommended by Ricker, confidence limits for these estimates were computed using the DeLury method. Schumacher equations were also used to calculate population numbers from catch data of both gears combined when appropriate. When possible, comparisons were made among estimates calculated by different methods for a given species and size group. One estimate was then chosen as "best" according to relative tightness of confidence limits or from biological insights regarding the accuracy of estimates.

Scale samples were read to determine growth and age structure of the game fish populations. Size distributions of fish aged in this manner (Appendix 2) were used to partition estimates for numbers of fish in an age group from inch-group estimates. Average survival rates (S) were calculated using the following general formula:

$$S = \sum_{i=2}^{n} N_i \Big/ \sum_{i=1}^{n-1} N_i,$$

where N_i is the number of fish of age i, and n is the oldest age group for which an abundance estimate was available.

Length-weight regression formulae (Appendix 3) were used to calculate biomass estimates by inch group and by age group for bluegill, largemouth bass, pumpkinseed, and yellow perch. Inch-group biomass estimates were calculated from the mid-point of the length interval in question while age-group biomass estimates were calculated using mean length at age. Length-weights plots adapted from Carlander (1969) and mean-length values for estimate intervals were applied to obtain biomass estimates for bowfin, brown bullhead, grass pickerel, green sunfish, lake chubsucker, and yellow bullhead.

Population numbers, growth, age-group structures, biomass estimates, and survival rates were compared to the findings of the 1964 Cassidy Lake study (some of the 1964 data were recalculated using the methodologies and formulae employed in the present study to ensure appropriateness of comparisons) and to data from other lakes. Size-at-age data for principal species were compared to seasonally adjusted state averages to compute growth indices (Merna et al. 1981).

RESULTS

The predominant species of fish in Cassidy Lake in 1987 was the bluegill, which constituted 65% of the total number and 47% of the total biomass of fish sampled by the gear. Other important species were largemouth bass, pumpkinseed, yellow perch, lake chubsucker, brown and yellow bullhead, grass pickerel, bowfin, and green sunfish (Table 3).

The estimated total number and pounds per acre of fish were low in 1987 compared with 1964. This was probably due to underestimation in 1987 of age-I to -III bluegills, age-I to -III pumpkinseeds, age-I to -III yellow perch, and perhaps age-V to -VI largemouth bass (Tables 4–7).

Growth of fish was generally close to state averages for the species aged from scale samples (Tables 8-11). In general, according to 1987 data, bluegill, pumpkinseed, and largemouth bass grew more slowly during early years of life, but more quickly as older fish compared to state averages. Yellow perch displayed the opposite trend, growing above state average at young ages but slowing down after age IV. Growth indices were identical for bluegill in 1964 and 1987. Pumpkinseed and largemouth bass exhibited better growth in 1964 than 1987 but the opposite was true for yellow perch.

Average adult survival rates were similar during both studies for bluegill, pumpkinseed, and largemouth bass (Table 12). Survival of yellow perch was difficult to evaluate and a comparison between years was probably not meaningful.

DISCUSSION

Fish communities present in Cassidy Lake in 1964 and 1987 were generally quite similar. With some exceptions, similarity between data sets of the two studies was indicated by: (1) similar population estimates (number and biomass) and average survival rates for the size and age groups which were considered well sampled (i.e., disregarding estimates of number and biomass which were overtly unreasonable); (2) comparable size-at-age and growth indices; and (3) similar ratios among number, size, and biomass of various species. Also noteworthy, fish stock present in Cassidy Lake in 1964 and 1987 compared well with populations in other lakes and exhibited qualities considered characteristic of lakes which were typified as good for fishing by Schneider (1981). Estimates of small, young fish generally were not similar but these fish for the most part were deemed to have been underestimated in 1987.

Bluegill were estimated to have a similar number and biomass in 1964 and 1987 for ages IV-VII (Table 4). Age-I fish were not estimated and age-VIII fish were not present in 1964, while estimates for ages I-III were considered unreasonably low in 1987. Average size at age was approximately the same for the two data sets and overall growth indices were identical (Table 8). Average survival rates were similar for both studies (Table 12). The proportion of the total fish population comprised of bluegill was 52% by number and 45% by weight in 1964 and 65% by number and 47% by weight in 1987. The number of bluegill per acre measuring 6 inches or greater was 122 in 1964 and 125 in 1987.

Reasonable and similar estimates of pumpkinseeds were obtained for a fairly narrow range of ages in the two study years. No estimates were made for age-I pumpkinseed and no fish older than age VI were collected in 1964, while 1987 estimates seemed unacceptably low for ages I-III (Table 5). In general, pumpkinseeds caught in 1964 were slightly larger than those caught in 1987, and overall growth indices differed by 0.5 inch, but mean size at age was equal by the time fish were 6 years old (Table 9). Average survival rates of adult pumpkinseed were similar (Table 12), but the comparison was probably not very meaningful, because, for the

1987 estimates, some young age groups were less abundant than older ones. Catchable pumpkinseed (6 inches or greater) numbered 15 per acre in 1964 and 13 per acre in 1987.

Data for yellow perch were quite variable and difficult to interpret (Table 6). Perch were apparently short-lived in 1964, as few fish older than age III were collected. From 1987 data, it appeared that relatively strong year classes in 1982, 1983, and 1984 may have suppressed subsequent year-class strength and limited the numbers of 1- and 2-year olds in the population. Schneider (1972) observed a dramatic domination by an unusually strong year class of yellow perch in Cassidy Lake in the late 1960s. This confounds efforts to calculate and compare estimates of numbers and biomasses (Table 6), and survival rates (Table 12), because it is difficult to distinguish between an underestimated age group and one that is suppressed by a dominant year class. However, it seems that the mean age of the 1987 perch population was greater than the mean age of the 1964 population.

Mean size-at-age data indicated that yellow perch were larger in 1987 than 1964 for ages I and II, but smaller for ages III-V. An unusually warm spring in 1987 may have influenced the abundance of food suitable for growth of young perch. The number of yellow perch 7 inches and larger was calculated at 4 per acre in 1964, and 16 per acre in 1987. In 1987, most (92%) of the perch for which sex could be distinguished were males, and no females less than 8 inches were observed. This indicates different behaviors and susceptibility to fishing gear between the sexes which could have greatly affected population and size-at-age estimates.

The 1987 estimates of largemouth bass were considered reasonable for young (ages I-IV) and old (ages IX-XIII) fish, but the middle age groups (V-VIII) were probably underestimated. In 1964, yearling bass were scarce or relatively less vulnerable to the different types of sampling gear than older bass. Comparison of 1964 and 1987 data sets showed that there was a larger number of bass in 1987 but a slightly greater biomass of bass in 1964 (Table 7); most of these differences were probably artifacts of the size distribution of the fish sampled. Fish collected in 1987 generally exhibited smaller size at age compared with bass sampled in 1964 (Table 11). Bass 10 inches and larger were more abundant in 1964 (9 per acre) than 1987 (4 per acre). Average survival rates were similar in 1964 and 1987 (Table 12).

Other species of fish varied in abundance between study years. Lake chubsucker and bowfin were caught in greater numbers in 1987 but were of relatively smaller average size compared to fish caught in 1964; consequently, total biomass of both species was about the same in both years (Table 3). There were fewer bullheads (brown, yellow, and a few black) and green sunfish in 1987 than 1964 for unknown reasons. It is somewhat ironic that the numbers of green sunfish appeared to be down in 1987 because contamination by numerous green sunfish was a concern during the single-species yellow perch experiment in the 1960s (Schneider 1972). Apparently, the healthy bluegill and pumpkinseed populations have suppressed green sunfish in Cassidy Lake since the experiment ended. Only seven northern pike (24.7–36.0 inches) were caught in 1987 (none in 1964) and lack of recaptures prevented any estimation of population size for this species. No small pike were captured and it appeared that reproduction of northern pike has not been occurring recently. Very small populations of black crappie, rock bass, and golden shiner were present in 1964 but none of these species was collected in 1987 even though a few black crappies and rock bass had been restocked in 1969 (Table 2).

The 1964 and 1987 surveys revealed that the composition of the Cassidy Lake fish community was typical of other warmwater lakes (Schneider 1981). Typical characteristics on a biomass basis are 37–61% bluegill, around 15% largemouth bass, and about 6% each of pumpkinseed and yellow perch. The bluegill population had characteristics which typically produce good fishing. Typical characteristics are: (1) combined bluegill and pumpkinseed biomass less than 78% of the total fish biomass; (2) some bluegills in the 8-inch class; (3) for bluegills 3 inches and greater, more than 6% are larger than 6 inches; and (4) bluegill growth at or above the state average rate. Conformity to these criteria should be viewed with the caveat that some of the 1987 percentages would likely be different if the small fish in Cassidy Lake had been estimated with greater accuracy. The general conclusions based on these criteria probably would not change, however.

The numbers of small, young bluegill, pumpkinseed, and yellow perch seem in general to have been underestimated in 1987. The fairly tight confidence limits associated with the estimates for these fish (Appendix 1) may have been artificially narrow for reasons that are not clear.

Trap nets were a sampling gear common to both studies, but seines and rotenone used in 1964 were more effective than electrofishing in 1987 for collecting small bluegill, pumpkinseed, and yellow perch. Electrofishing, however, was quite effective at collecting small (3–4 inch) largemouth bass. Therefore, the estimates of young fish were probably more accurate in 1964 than 1987, except for largemouth bass. It is possible that the game fish in Cassidy Lake experienced a series of poor year classes and that the 1987 population sizes for the young age groups of these species were truly low in number. However, this seems unlikely because conditions have been suitable enough in the past few years for reproduction of these species in other lakes in the area, and it seems improbable that bluegill, pumpkinseed, and yellow perch would all simultaneously suffer 3–4 consecutive years of poor recruitment in Cassidy Lake.

The overall picture presented by a comparison of the data indicates that the fish communities (numbers and species' balance) in Cassidy Lake were similar in 1964 and 1987, and that fish population structures and growth patterns during both years were comparable to those of other warmwater lakes considered to be favorable to good quality fishing. It is assumed that interacting biological, physical, and/or chemical characteristics of Cassidy Lake naturally drove the system back to a balanced state, since no management strategies (aside from minimal restocking) had been undertaken between study years. In contrast, other lakes support fish communities which consist of the same species mix as that of Cassidy Lake but which seem to tend naturally toward stunted, unbalanced (from the viewpoint of the fishing community) states in spite of the best efforts of fisheries managers. Studies by Schneider (1975, 1981) have related fish abundance and distribution with some limnological, climatic, and biological characteristics of Michigan lakes, and Diana (1987) has investigated some ecological mechanisms important to fish stunting, but further work is required to identify the dynamic interactions of lake systems which drive fish communities toward different states of equilibrium.

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Table 1. Common and scientific names of fish species found in Cassidy Lake, Washtenaw County, Michigan, 1964 and/or 1987.

Common name	Scientific name
Black crappie	*Pomoxis nigromaculatus*
Black bullhead	*Ictalurus melas*
Bluegill	*Lepomis macrochirus*
Bowfin	*Amia calva*
Brown bullhead	*Ictalurus nebulosus*
Golden shiner	*Notemigonus crysoleucas*
Grass pickerel	*Esox americanus*
Green sunfish	*Lepomis cyanellus*
Killifish	*Fundulus* sp.
Lake chubsucker	*Erimyzon sucetta*
Largemouth bass	*Micropterus salmoides*
Mudminnow	*Umbra limi*
Northern pike	*Esox lucius*
Pumpkinseed	*Lepomis gibbosus*
Rock bass	*Ambloplites rupestris*
Yellow bullhead	*Ictalurus natalis*
Yellow perch	*Perca flavescens*

Table 2. Fish stocked in Cassidy Lake in June 1969.

Species	Number	Size range (inches)
Bluegill	71	1–8
Pumpkinseed	23	6–8
Largemouth bass	16	8–15
Black crappie	10	3–11
Rock bass	3	8–9
Northern pike	2	17–23

Table 3. Estimated number, pounds per acre, size range, and relative biomass of important fish species in Cassidy Lake, 1964 and 1987.

Species	Number of fish		Pounds per acre		Size range (inches)		Biomass relative to total (percent)	
	1964	1987	1964	1987	1964	1987	1964	1987
Bluegill	52,054	12,064	59.2	31.4	3–8	2–8	44.6	47.3
Largemouth bass	779	1,899	9.7	9.2	3–21	3–20	7.3	13.8
Pumpkinseed	7,875	1,254	13.2	4.3	3–8	2–8	9.9	6.5
Yellow perch	33,063	997	19.7	3.3	3–12	2–10	14.8	5.0
Black crappie	125	—	0.5	—	6–9	—	0.4	—
Bowfin	81	197	5.3	5.1	7–26	9–26	4.0	7.7
Brown bullhead	900	427	12.5	8.3	12–13	8–13	9.4	12.5
Grass pickerel	356	307	0.8	0.7	6–13	4–11	0.6	1.0
Green sunfish	3,400	287	2.9	0.2	2–6	2–7	2.2	0.3
Lake chubsucker	450	960	2.5	2.4	5–13	3–10	1.9	3.6
Rock bass	30	—	0.8	—	2–7	—	0.6	—
Yellow bullhead	1,730	138	5.7	1.5	2–13	6–11	4.3	2.3
Total	100,843	18,530	132.8	66.4	—	—	100.0	100.0

Table 4. Estimated numbers and pounds per acre of bluegill in Cassidy Lake, 1964 and 1987.

	Number		Pounds per acre[1]	
Strata	1964	1987	1964	1987
Inch group				
2	—	1,819	—	0.3
3	33,603	1,279	16.5	0.6
4	7,418	915	8.2	1.0
5	5,398	2,314	11.5	4.9
6	4,537	4,114	16.6	15.1
7	1,082	1,597	6.3	9.3
8	16	26	0.1	0.2
Total	52,054	12,064	59.2	31.4
Age group				
I	—	255	—	<0.1
II	33,714	2,898	16.5	0.9
III	10,323	1,087	16.1	1.4
IV	4,373	4,870	11.7	13.8
V	1,713	2,115	8.0	11.3
VI	1,409	607	7.5	3.5
VII	522	184	3.2	1.3
VIII	—	48	—	0.3
Total	52,054	12,064	63.0	32.5

[1] Totals for pounds per acre differ between inch-group estimates and age-group estimates due to different methods of calculation. See Methods.

Table 5. Estimated numbers and pounds per acre of pumpkinseed in Cassidy Lake, 1964 and 1987.

Strata	Number		Pounds per acre[1]	
	1964	1987	1964	1987
Inch group				
2	—	173	—	<0.1
3	3,416	384	2.1	0.2
4	2,115	44	2.9	0.1
5	1,648	64	4.4	0.2
6	489	272	2.2	1.2
7	175	238	1.3	1.7
8	32	79	0.3	0.9
Total	7,875	1,254	13.2	4.3
Age group				
I	—	14	—	<0.1
II	4,051	540	5.2	0.2
III	3,181	61	7.9	0.1
IV	463	179	2.2	0.6
V	134	281	0.9	1.6
VI	46	143	0.4	1.2
VII	—	32	—	0.3
VIII	—	4	—	<0.1
Total	7,875	1,254	16.6	4.0

[1] Totals for pounds per acre differ between inch-group estimates and age-group estimates due to different methods of calculation. See Methods.

Table 6. Estimated numbers and pounds per acre of yellow perch in Cassidy Lake, 1964 and 1987.

	Number		Pounds per acre[1]	
Strata	1964	1987	1964	1987
Inch group				
2	—	4[2]	—	<0.1
3	14,364	52[2]	4.1	<0.1
4	14,665	15[2]	9.5	<0.1
5	3,448	29[2]	4.3	<0.1
6	416	166	0.9	0.4
7	134	525	0.5	1.8
8	12	194	0.1	1.0
9	9	10	0.1	0.1
10	15	2	0.2	<0.1
Total	33,063	997	19.7	3.3
Age group				
I	14,355	70	3.3	<0.1
II	18,011	69	15.5	0.1
III	687	438	2.4	1.3
IV	6	257	0.1	1.1
V	4	161	0.1	0.8
VI	—	2	—	<0.1
Total	33,063	997	21.4	3.3

[1] Totals for pounds per acre differ between inch-group estimates and age-group estimates due to different methods of calculation. See Methods.

[2] Actual number caught – estimations were not possible.

Table 7. Estimated numbers and pounds per acre of largemouth bass in Cassidy Lake, 1964 and 1987.

	Number		Pounds per acre[1]	
Strata	1964	1987	1964	1987
Inch group				
3	36	357	<0.1	0.1
4	13	623	<0.1	0.5
5	3	41	<0.1	0.1
6	81	285	0.2	0.7
7	111	95	0.4	0.4
8	62	114	0.4	0.7
9	79	177	0.7	1.5
10	—	129	—	1.5
11	—	34	—	0.5
12	—	4	—	0.1
13	—	2	—	0.1
15	—	4	—	0.2
16	—	2	—	0.1
17	—	6	—	0.4
18	—	8	—	0.6
19	—	10	—	0.9
20	—	8	—	0.8
10–20	394	207	8.0	5.2
Total	779	1,899	9.7	9.2
Age group				
I	66	1,013	<0.1	0.6
II	320	375	1.5	1.1
III	124	173	1.6	1.0
IV	147	294	2.7	3.2
V	82	4	1.9	0.1
VI	38	6	1.0	0.2
VII	—	6	—	0.3
VIII	1	4	0.1	0.3
IX	1	8	—	0.6
X	—	10	—	0.8
XI	—	2	—	0.2
XII	—	2	—	0.2
XIII	—	2	—	0.2
Total	713	1,899	8.8	8.8

[1] Totals for pounds per acre differ between inch-group estimates and age-group estimates due to different methods of calculation. See Methods.

Table 8. Age and growth of bluegill in Cassidy Lake, 1964 and 1987. All lengths in inches.

Age	N 1964	N 1987	Range 1964	Range 1987	Mean 1964	Mean 1987	State average	Deviation 1964	Deviation 1987
I	—	5	—	2.0–2.5	—	2.3	2.4	—	-0.1
II	6	66	3.4–4.0	2.5–4.4	3.5	3.0	3.8	-0.3	-0.8
III	99	33	4.0–6.0	4.2–5.5	5.0	4.7	5.0	0.0	-0.3
IV	45	55	4.9–6.5	4.9–7.5	5.9	6.0	5.9	0.0	+0.1
V	35	38	6.3–7.5	5.7–8.2	7.0	7.3	6.7	+0.3	+0.6
VI	35	15	6.7–8.2	6.7–8.1	7.3	7.5	7.3	0.0	+0.2
VII	20	10	6.7–8.2	7.2–8.4	7.6	7.9	7.8	-0.2	+0.1
VIII	—	1	—	7.6	—	7.6	8.2	—	—[1]
Growth index								0.0	0.0

[1]Not included in growth index calculation since fewer than five fish in age group.

Table 9. Age and growth of pumpkinseed in Cassidy Lake, 1964 and 1987. All lengths in inches.

Age	N 1964	N 1987	Range 1964	Range 1987	Mean 1964	Mean 1987	State average	Deviation 1964	Deviation 1987
I	—	3	—	1.8–2.3	—	2.1	2.4	—	—[1]
II	14	64	3.3–4.8	2.4–4.5	4.4	3.2	3.8	+0.6	-0.6
III	103	26	4.3–6.6	3.7–5.9	5.4	4.9	4.9	+0.5	0.0
IV	61	43	5.7–7.6	4.4–7.4	6.6	5.8	5.6	+1.0	+0.2
V	34	39	6.7–7.8	6.3–8.0	7.3	7.0	6.2	+1.1	+0.8
VI	8	26	7.6–8.5	7.5–8.4	7.9	7.9	6.6	+1.3	+1.3
VII	—	6	—	7.8–8.5	—	8.0	7.1	—	+0.9
VIII	—	1	—	8.2	—	8.2	7.5	—	—[1]
Growth index								+0.9	+0.4

[1]Not included in growth index calculation since fewer than five fish in age group.

Table 10. Age and growth of yellow perch in Cassidy Lake, 1964 and 1987. All lengths in inches.

Age	N 1964	N 1987	Range 1964	Range 1987	Mean 1964	Mean 1987	State average	Deviation 1964	Deviation 1987
I	49	61	2.9–3.6	2.8–4.6	3.2	3.6	3.3	-0.1	+0.3
II	70	33	4.1–6.5	4.4–6.5	4.9	5.7	5.2	-0.3	+0.5
III	16	46	5.9–10.2	6.3–8.4	7.5	7.1	6.5	+1.0	+0.6
IV	2	30	11.3–11.4	6.8–9.3	11.4	7.9	7.5	—[1]	+0.4
V	2	26	11.7–12.4	7.3–10.3	12.0	8.5	8.5	—[1]	0.0
VI	—	2	—	9.2	—	9.2	9.4	—	—[1]
Growth index								+0.2	+0.4

[1]Not included in growth index calculation since fewer than five fish in age group.

Table 11. Age and growth of largemouth bass in Cassidy Lake, 1964 and 1987. All lengths in inches.

Age	N 1964	N 1987	Range 1964	Range 1987	Mean 1964	Mean 1987	State average	Deviation 1964	Deviation 1987
I	2	71	3.4	3.3–5.5	3.4	4.1	4.2	—[1]	-0.1
II	31	54	6.1–9.8	5.6–7.7	7.9	6.8	7.1	+0.8	-0.3
III	15	39	9.9–11.9	7.7–10.4	10.9	8.4	9.4	+1.5	-1.0
IV	12	72	10.8–12.6	8.7–11.8	12.0	10.2	11.6	+0.4	-1.4
V	9	4	12.5–13.8	12.2–12.6	13.0	12.4	13.2	-0.2	—[1]
VI	6	3	12.6–14.2	13.7–15.2	13.4	14.7	14.7	-1.3	—[1]
VII	—	3	—	16.5–17.6	—	17.1	16.3	—	—[1]
VIII	1	2	18.2	17.9–19.2	18.2	18.6	17.4	—[1]	—[1]
IX	—	4	—	18.3–19.4	—	18.8	18.3	—	—[1]
X	—	5	—	18.4–20.0	—	19.2	19.3	—	-0.1
XI	1	1	20.8	20.5	20.8	20.5	—	—[1]	—[1]
XII	—	1	—	20.2	—	20.2	—	—	—[1]
XIII	—	1	—	20.9	—	20.9	—	—	—[1]
Growth index								+0.2	-0.6

[1]Not included in growth index calculation since fewer than five fish in age group.

Table 12. Average annual adult survival rates for selected fish species in Cassidy Lake, 1964 and 1987. Ages used in calculations are in parentheses.

Species	1964	1987
Bluegill	0.45 (IV-VII)	0.38 (IV-VIII)
Largemouth bass	0.55 (II-VI)	0.46 (I-VI)
Pumpkinseed	0.48 (II-VI)	0.56 (II-VIII)
Yellow perch	0.04 (II-V)	0.49 (II-VI)

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Appendix 1. Estimates of population size with 95% confidence limits and method of calculation for selected fish species collected in Cassidy Lake, April-May 1987 (ES = electroshocking; TN = trap net; Both = ES and TN).

Species	Inch group	Number of fish	95% confidence limits	Method (gear)
Bluegill	2	1,819	1,243–3,388	Schumacher (ES)
	3	1,279	970–1,875	Schumacher (ES)
	4	915	388–1,443	Peterson (Both)
	5–6	6,428	5,217–7,638	Peterson (Both)
	7	1,597	1,327–2,006	Schumacher (Both)
	8	26	17–54	Schumacher (TN)
Bowfin	9–12	71	45–169	Schumacher (ES)
	13–16	86	61–142	Schumacher (Both)
	17–19	22	16–34	Schumacher (Both)
	20–26	18	10–75	Schumacher (Both)
Brown bullhead	10	42	31–65	Schumacher (TN)
	11	265	247–285	Schumacher (TN)
	12–13	120	103–144	Schumacher (TN)
Grass pickerel	6–7	181	98–1,184	Schumacher (ES)
	8–9	126	84–252	Schumacher (ES)
Green sunfish	4–5	287	213–438	Schumacher (ES)
Lake chubsucker	4	257	190–398	Schumacher (ES)
	5	465	275–1,496	Schumacher (ES)
	6	71	52–109	Schumacher (ES)
	7–8	119	69–169	Petersen (Both)
	9–10	48	25–71	Petersen (Both)
Largemouth bass	3–5	1,021	779–1,480	Schumacher (ES)
	6–7	380	263–680	Schumacher (ES)
	8	114	66–428	Schumacher (Both)
	9–11	340	178–502	Petersen (Both)
	12–20	45	9–81	Petersen (Both)
Pumpkinseed	2–3	557	410–865	Schumacher (ES)
	4–5	108	47–168	Petersen (Both)
	6	272	107–437	Petersen (Both)
	7–8	317	234–495	Schumacher (Both)
Yellow bullhead	8	14	8–48	Schumacher (TN)
	9	62	51–78	Schumacher (TN)
	10	45	38–56	Schumacher (TN)
	11	17	13–22	Schumacher (TN)
Yellow perch	6–8	885	718–1,153	Schumacher (TN)
	9–10	12	8–25	Schumacher (TN)

Appendix 2. Length-age frequency (percent) for important fish species caught in Cassidy Lake, 1987.

Species and inch group	N	Age I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
Bluegill														
2	36	14	86	—	—	—	—	—	—	—	—	—	—	—
3	33	—	100	—	—	—	—	—	—	—	—	—	—	—
4	32	—	6	91	3	—	—	—	—	—	—	—	—	—
5	37	—	—	11	86	3	—	—	—	—	—	—	—	—
6	33	—	—	—	67	30	3	—	—	—	—	—	—	—
7	36	—	—	—	6	50	30	11	3	—	—	—	—	—
8	18	—	—	—	—	50	17	33	—	—	—	—	—	—
Largemouth bass														
3	30	100	—	—	—	—	—	—	—	—	—	—	—	—
4	33	100	—	—	—	—	—	—	—	—	—	—	—	—
5	10	80	20	—	—	—	—	—	—	—	—	—	—	—
6	33	—	100	—	—	—	—	—	—	—	—	—	—	—
7	22	—	86	14	—	—	—	—	—	—	—	—	—	—
8	27	—	—	96	4	—	—	—	—	—	—	—	—	—
9	33	—	—	24	76	—	—	—	—	—	—	—	—	—
10	35	—	—	6	94	—	—	—	—	—	—	—	—	—
11	13	—	—	—	100	—	—	—	—	—	—	—	—	—
12–17	11	—	—	—	—	37	27	27	9	—	—	—	—	—
18–20	13	—	—	—	—	—	—	—	8	30	38	8	8	8
Pumpkinseed														
1	1	100	—	—	—	—	—	—	—	—	—	—	—	—
2	25	8	92	—	—	—	—	—	—	—	—	—	—	—
3	38	—	97	3	—	—	—	—	—	—	—	—	—	—
4	22	—	18	64	18	—	—	—	—	—	—	—	—	—
5	33	—	—	33	67	—	—	—	—	—	—	—	—	—
6	36	—	—	—	42	58	—	—	—	—	—	—	—	—
7	32	—	—	—	6	47	38	9	—	—	—	—	—	—
8	21	—	—	—	—	14	67	14	5	—	—	—	—	—
Yellow perch														
2	4	100	—	—	—	—	—	—	—	—	—	—	—	—
3	43	100	—	—	—	—	—	—	—	—	—	—	—	—
4	15	93	7	—	—	—	—	—	—	—	—	—	—	—
5	24	—	100	—	—	—	—	—	—	—	—	—	—	—
6	34	—	23	74	3	—	—	—	—	—	—	—	—	—
7	33	—	—	58	27	15	—	—	—	—	—	—	—	—
8	34	—	—	6	56	38	—	—	—	—	—	—	—	—
9	9	—	—	—	11	67	22	—	—	—	—	—	—	—
10	2	—	—	—	—	100	—	—	—	—	—	—	—	—

Appendix 3. Length-weight regression coefficients for selected fish species where: $\log_{10}$ Weight = $\log_{10}$ a + b $\log_{10}$ Length (length in inches, weight in pounds; adapted from Schneider 1971).

Species	$\log_{10}$ a	b	Length range
Bluegill	−3.41415	3.24900	2.5–8.5
Largemouth bass	−3.57458	3.23972	3.2–17.2
Pumpkinseed	−3.29968	3.22233	2.5–8.7
Yellow perch	−3.65772	3.26644	3.0–10.2