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RETURNS TO ANGLERS DURING 1953-1955 FROM FALL PLANTINGS

OF HATCHERY BROOK TROUT OF DIFFERENT SIZES IN THREE

LAKES IN MARQUETTE COUNTY, MICHIGAN

By

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The purpose of this study, begun in 1953, was to assess by means of a creel census the benefits derived from planting brook trout of different sizes (3-inch fingerlings, 6-inch sublegals, and 7.5-inch legal-size) in lakes. Catch (by number and by weight), percentage of return to the angler, and quality of the fishing were considered in the evaluation.

Description of the lakes

Swanzy, Airport, and Moccasin lakes are in Marquette County, two to four miles northeast of Gwinn. They lie in an area of rolling, second-growth jack pine plains. All are seepage-basin lakes, without inlet or outlet. Water levels fluctuate considerably, presumably depending upon rainfall and loss by underground seepage. These small lakes support trout throughout the year, have been planted with trout for a decade or more, and contain no warm-water game fish. During the period of study, Swanzy Lake had abundant populations of fathead minnows and Iowa darters, but Airport and Moccasin lakes contained few fish other than brook trout. Moccasin Lake appears to be the most productive; Airport the least. During 1953-1955, the water level dropped steadily at Swanzy

and Moccasin lakes but remained relatively constant at Airport Lake. Swanzy Lake has a single major depression; bottom soils in shallow water are sand and fibrous peat; rooted aquatic plants are common on the shoal areas. Airport is a typical bog lake surrounded by a floating leatherleaf mat which extends for 10 to 15 feet over shoal water; the lake bottom is peat; rooted aquatic plants are sparse; most of the lake is less than 20 feet deep; and in midsummer conditions for trout are marginal. Moccasin Lake (shaped like a moccasin) has two basins connected by a shallow channel; the larger basin has a maximum depth of 26 feet, and the smaller one 10 feet; bottom soils in shallow water are sand and peat; in midsummer rooted aquatic plants become abundant. Physical features and chemical characteristics of the lakes are summarized in Table.1.

Plan of study

The study plan called for fingerling brook trout to be stocked in one lake (Swanzy), sublegals in another (Airport), and legal-size in the third (Moccasin). Sizes of the trout planted were allotted according to the past stocking history of the lake,[1] i.e., in former years Swanzy Lake was usually stocked with fingerling, Airport with sublegal, and Moccasin with legal-size trout. Also, by continuing the "usual" program, recoveries from plants made prior to 1953 could be included in the creel census which was initiated in 1953. After 1951 all trout were planted in the fall, after the close of the trout season, so they spent at least one winter in the lake before they were legally available to anglers. Fish planted in 1951 and 1952 (prior to the initiation of the study) were not marked. When recaptured (in 1953 or later) they were identified with a particular plant according to age as determined from an examination of scales. Those planted in 1953 and 1954 were given a distinctive fin-clip. State-wide fishing regulations for trout lakes (7-inch

[1]The lakes were stocked at a rate (pounds per acre and number per acre) which had given satisfactory results in the past.

Table 1.--Physical features and chemical characteristics of Swanzy, Airport, and Moccasin lakes, Marquette County, Michigan

Lake	Location			Area (acres)	Max-imum depth (feet)	Percentage of area less than 10 feet deep	Methyl-orange alka-linity (range, ppm)	pH (range)
	Town	Range	Section					
Swanzy	45N	25W	13	20.4	45	38	15-24	6.8-7.4
Airport	45N	25W	23	6.7	28	39	5.0	5.4-6.2
Moccasin	45N	24W	7	6.3	26	80	6.0-8.5	5.2-5.9

minimum size, 5-fish creel limit) were in effect throughout the investigation.
Table 2 gives the stocking record for the three lakes.[2] It should be noted
(Table 2) that in 1951 and 1952 there were some deviations from the "usual"
planting schedule; fingerling trout were planted in Swanzy and Airport lakes,
and sublegal trout were planted in Airport and Moccasin lakes. These irregular-
ities did not seriously disrupt the experiment.

Results of the experiment were evaluated by means of a creel census which
was used to obtain estimates of the amount of fishing (pressure), total harvest,
fishing quality, and other information such as baits used and residence of anglers
who fished in the lakes. It would have been desirable to evaluate results on a
cost basis, but production costs for 3-, 6-, and 7.5-inch trout are not available.

The creel census

A stratified random sampling procedure was used in obtaining fishing records
on Swanzy, Airport, and Moccasin lakes. The census clerk visited each lake on a
prearranged schedule which allotted more time to Saturdays, Sundays, and holidays
(heavy fishing pressure) than it did to weekdays (lighter pressure). Two
procedures were used by the clerk for obtaining the basic information desired:
anglers fishing on the lakes were counted at hourly intervals (anglers in boats
were counted separately from those fishing from shore) and many of the anglers
were interviewed by the clerk at the conclusion of their fishing trip. The
counts of anglers were used to estimate the amount of fishing, and from the
interviews the clerk was able to obtain information on the duration of the
fishing trip (hours), fishing methods (boat or shore, type of bait used),
number, size, and marking of fish caught, and residence of angler. Approximately

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[2] To eliminate the influence of a particular lake on the results, a replication of
the experiment was planned for 1956-1958. The stocking schedule would be modi-
fied so as to rotate the different sizes of planted trout among at least two
lakes.

Table 2.--Record of brook trout plantings in Swanzy, Airport, and Moccasin

lakes, Marquette County, Michigan

Lake	Season and year	Number planted[1]	Average length (inches)	Number per acre	Pounds per acre	Age (months)
Swanzy	Before 1951	2,000-3,000	...	...	...	...
	Fall, 1951	2,000	5.8	...	...	...
	Fall, 1952	3,000	3.0	147	1.8	9
	Fall, 1953	3,000	3.5	147	2.1	9
	Fall, 1954	2,971	4.2	146	4.3	9
Airport	Before 1951	1,000-3,000	...	...	...	...
	Fall, 1951	2,000	3.5	299	4.2	9
	Fall, 1952	None	...	...	...	...
	Fall, 1953	750	6.5	112	11.2	20
	Fall, 1954	750	6.0	112	9.0	21
Moccasin	Before 1951	750-1,800	...	...	...	...
	Fall, 1951	750	7.0	...	...	...
	Fall, 1952	750	6.5	119	14.3	21
	Fall, 1953	750	7.5	119	19.0	20
	Fall, 1954	750	7.6	119	19.0	30

[1]Underlined figures are the plantings for which returns were measured by the creel census of 1953-1955. Figures for years before 1951 are number planted per year.

equal coverage was given to each lake; during the 3-year period the sample
included about 37 percent of the estimated hours of fishing on Swanzy Lake,
38 percent on Airport Lake, and 45 percent on Moccasin Lake. Since fishing
effort (pressure) and fishing quality were not uniform, the season was divided
into four periods: the first week end, the next 17 days, midseason, and the
last two to four weeks. Total fishing pressure was the sum of the estimated
pressures, and total catch (harvest) was the sum of the catches, for the four
seasonal strata. Catch for each stratum was the product of angler-hours and
the mean catch per hour (as obtained from anglers interviewed in that stratum).
Fishing quality was measured in terms of catch per hour as determined from
interviews. The data secured in the census were subjected to statistical
analyses. Detailed information on procedures and methods of computation and
analysis is given in the appendix.

Amount of fishing

Estimates of total fishing pressure and total catch, by lake and by year,
are presented in Table 3. Fishing pressure varied among the three lakes, and
by year and seasonal period at each lake. Pressure, in terms of hours per acre,
was lightest at Swanzy (the largest lake) and heaviest at Moccasin (the smallest).
At Swanzy Lake pressure ranged from about 1,500 hours (73 hours per acre) in
1953 to 1,900 hours (94 hours per acre) in 1954. At Airport Lake pressure
ranged from 650 hours (97 hours per acre) in 1955 to about 770 hours (115 hours
per acre) in 1953. Fishing pressure at Moccasin Lake was even more variable:
500 hours (79 hours per acre) in 1954 to 1,560 hours (248 hours per acre) in
1953. At the three lakes, each year, fishing pressure was most intense early
in the season; at Swanzy and Airport lakes about 50 percent of all fishing was

Table 3.--Estimated hours of fishing (boat and shore fishermen separately) and total catch of brook trout during each of four seasonal periods at Swanzy, Airport, and Moccasin lakes, 1953-1955

Period 1--first week end of trout season
Period 2--the next 17 days
Period 3--midseason
Period 4--the last 2 to 4 weeks of the season

Lake and period	1953			1954			1955		
	Shore hours	Boat hours	Catch	Shore hours	Boat hours	Catch	Shore hours	Boat hours	Catch
Swanzy									
1	89.9	45.0	18	764.6	119.6	248	384.0	19.0	8
2	397.3	55.8	23	287.6	27.3	37	191.3	11.6 ⎞	20
3	616.2	185.9 ⎞	18	444.9	218.7	20	241.8	311.6 ⎠	
4	83.9	20.9 ⎠		32.3	12.6	0	195.4	177.6	206
Totals	1,494.9		59	1,907.6		305	1,532.4		234
Confidence limits[1]	±21.6%		±30.5%	±23.9%		±32.5%	±32.4%		±56.2%
Hours per acre	73.3		...	93.5		...	75.1		...
Airport									
1	64.5	2.0	68	128.2	0.0	79	109.1	12.5	13
2	357.9	36.4	159	178.8	23.4	117	112.0	25.2	86
3	209.4	93.5 ⎞	22	203.0	63.4	162	254.9	124.1 ⎞	119
4	8.1	0.0 ⎠		38.7	33.0	28	12.2	0.0 ⎠	
Totals	771.8		249	668.5		375	650.0		218
Confidence limits[1]	±27.2%		±54.6%	±33.8%		±46.1%	±33.5%		±41.2%
Hours per acre	115.2		...	99.8		...	97.0		...
Moccasin									
1	251.5	10.0	180	304.0	12.8	181	433.9	22.2	369
2	960.9	59.2	273	100.1	6.5	5	249.6	42.8	47
3	107.8	78.7 ⎞	74	32.4	4.8	0	147.6	135.2	54
4	17.1	75.3 ⎠		37.8	0.0	24	33.2	13.6	3
Totals	1,560.5		527	498.4		210	1,078.2		476
Confidence limits[1]	±27.2%		±30.4%	±20.8%		±32.2%	±31.7%		±48.2%
Hours per acre	247.7		...	79.1		...	173.6		...

[1]With 95 percent confidence limits expressed in terms of percentage of estimate.

done in the first three weeks of the season while at Moccasin Lake more than 70 percent of all fishing was done in the first three weeks. Few fishermen visited the lakes during the last part of the season, except for Swanzy Lake in 1955.

Fishing pressure was closely associated with the quality of the fishing available--the better the fishing, the more effort was expended. Most of the trout were caught early in the season and fishing effort was most intense then, when anglers had a reasonable expectation of success. Swanzy Lake, which offers swimming and picnic sites in addition to trout fishing, was an exception to this general pattern. When the weather was suitable, anglers brought their families to the lake and did considerable fishing in midsummer, even when fishing was not at its best. The fingerlings planted at Swanzy Lake in 1954 were large (4.2-inch average) and many of them reached a length of 7 inches before the end of the 1955 fishing season. That year, because good fishing was available, many anglers fished near the end of the season. In fact, most of the year's catch (206 of 234 trout) was made late in the season (Table 3).

The catch and fishing quality

Total estimated catch (by number and by weight) and percentage of return are summarized in Table 4. Average sizes of the trout in the catch are given in Table 5. In Table 6 estimated returns from each lot of planted trout are shown along with year of recapture. Data (catch per hour, fish per trip, etc.) obtained in interviews of anglers at the three lakes are presented in Table 7.

Fingerlings.--Plants of 2,000 (Airport, 1951), 3,000 (Swanzy, 1952), and 2,971 (Swanzy, 1954) fingerlings provided a return of 268, 322, and 520 trout. Average percentage of return for these three plantings of fingerling brook trout was 13.9 percent.[3] For these three plantings, conditions for survival

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[3]At Swanzy Lake in October, 1953, 98 trout from the planting made in 1952 were collected by angling and gill nets. Apparently, survival to late 1953 was high, but anglers did not take advantage of it (Table 3).

Table 4.--Estimated catch (number and pounds) and percentage return from trout of three sizes planted in Swanzy,

Airport, and Moccasin lakes, Marquette County, 1953-1955

		Planting record					Catch record				
Size of fish, and year	Lake	Number	Rate per acre	Average length (inches)	Total weight (pounds)		Number caught[1]	Percent-age returned	Total pounds	Pounds per acre	Pounds caught per pound planted
Fingerling											
1951	Airport	2,000	299	3.5	28	268	±50.4%	13.4	71.1	10.6	2.5
1952	Swanzy	3,000	147	3.0	36	322	±30.1%	10.7	143.2	7.1	4.0
1953	Swanzy	3,000	147	3.5	42	10	±90.0%	0.0[2]	7.6	0.4	0.2
1954	Swanzy	2,971	147	4.2	87	520	±29.2%	17.5[3]	168.3	8.2	1.9
Total or average		10,971	185	3.6	193	1,120		13.9[4]	390.2	6.6	2.0
Sublegal											
1952	Moccasin	750	119	6.5	90	444	±33.8%	59.2	107.9	17.1	1.2
1953	Airport	750	112	6.5	75	360	±42.5%	48.0	71.9	10.7	1.0
1954	Airport	750	112	6.0	60	220	±40.5%	29.3	46.4	6.9	0.8
Total or average		2,250	114	6.3	225	1,024		45.5	226.2	11.6	1.0
Legal-size											
1953	Moccasin	750	119	7.7	120	222	±30.6%	29.6	78.8	12.5	0.7
1954	Moccasin	750	119	7.6	120	529	±42.4%	70.5	217.4	34.5	1.8
Total or average		1,500	119	7.6	240	751		50.0	296.2	23.5	1.2

[1]With 95 percent confidence limits expressed in terms of percentage of estimate.

[2]Less than 0.05 percent.

[3]Includes 304 fish caught during 1956.

[4]The 1953 plant is not included.

Table 5.--Length and weight of brook trout caught by anglers in Swanzy,

Airport, and Moccasin lakes, Marquette County, 1953-1955

Planting record				Catch record		
Size of fish, and year	Lake	Number	Average length (inches)	Number	Average length (inches)	Average weight (pounds)
Fingerling						
1951	Airport	2,000	3.5	268	8.9	0.27
1952	Swanzy	3,000	3.0	322	10.4	0.44
1953	Swanzy	3,000	3.5	10[1]	11.9	0.76
1954	Swanzy	2,971	4.2	520[2]	9.5	0.32
Average		2,743	3.6	370[2]	9.6	0.35
Sublegal						
1952	Moccasin	750	6.5	444	8.4	0.24
1953	Airport	750	6.5	360	8.0	0.20
1954	Airport	750	6.0	220	8.1	0.21
Average		750	6.3	341	8.2	0.22
Legal-size						
1953	Moccasin	750	7.7	222	9.1	0.35
1954	Moccasin	750	7.6	529	9.9	0.41
Average		750	7.6	376	9.7	0.39

[1] 1953 plant not included in average of numbers recovered but is included in computation of average lengths and weight.

[2] Includes 304 fish caught during 1956.

Table 6.--Yearly distribution of returns from each lot of trout planted in

Swanzy, Airport, and Moccasin lakes

(Estimated weight in pounds in parentheses)

Planting record				Number recaptured, by year				
Size of fish, and lake	Year	Number of trout	Average length (inches)	1953	1954	1955	1956[1]	Total
Fingerling								
Airport	1951	2,000	3.5	246 (53.9)	22 (17.2)	...	...	268 (71.1)
Swanzy	1952	3,000	3.0	18 (3.4)	296 (119.7)	8 (20.1)	...	322 (143.2)
Swanzy	1953	3,000	3.5	...	...	10 (7.6)	...	10 (7.6)
Swanzy	1954	2,971	4.2	...	...	216 (39.0)	304 (129.3)	520 (168.3)
Sublegal								
Moccasin	1952	750	6.5	442 (104.2)	2 (3.7)	...	...	444 (107.9)
Airport	1953	750	6.5	...	353 (65.7)	7 (6.2)	...	360 (71.1)
Airport	1954	750	6.0	...	...	211 (39.6)	9 (6.8)	220 (46.4)
Legal-size								
Moccasin	1953	750	7.7	...	208 (66.5)	14 (12.3)	...	222 (78.8)
Moccasin	1954	750	7.6	...	...	462 (142.2)	67 (75.2)	529 (217.4)

[1]To obtain an essentially complete record for trout planted in 1954, creel census data for 1956 are included.

Table 7.--Summary of creel census data for anglers interviewed on Swanzy, Airport, and

Moccasin lakes, 1953-1955

| Type of angler, lake, and year | Anglers inter- viewed | Angling hours | | Catch of brook trout | | | | | Percentage of anglers successful |
		Total	Average per trip	Number	Average length (inches)	Average weight (pound)	Trout per trip*	Catch per hour*	
Shore anglers									
Swanzy									
1953	240	397.0	1.66	18	...	...	0.08	0.04	...
1954	302	553.5	1.83	95	...	...	0.31*	0.17*	...
1955	292	543.5	1.86	39	...	...	0.13	0.07	...
Airport									
1953	176	252.0	1.43	117	...	...	0.66*	0.46*	...
1954	109	160.0	1.47	100	...	...	0.92	0.62	...
1955	146	232.0	1.59	69	...	...	0.47	0.30	...
Moccasin									
1953	241	445.0	1.85	182	...	...	0.76	0.41	...
1954	137	240.0	1.75	109	...	...	0.80	0.45	...
1955	277	449.0	1.62	266	...	...	0.96	0.59	...
Boat anglers									
Swanzy									
1953	64	101.0	1.55	9	...	...	0.14	0.09	...
1954	54	83.0	1.54	2	...	...	0.04	0.02	...
1955	74	143.0	1.93	24	...	...	0.32	0.17	...
Airport									
1953	24	54.5	2.27	4	...	...	0.17	0.07	...
1954	13	34.5	2.65	10	...	...	0.77	0.29	...
1955	21	57.5	2.74	14	...	...	0.67	0.24	...
Moccasin									
1953	42	85.5	2.04	17	...	...	0.40	0.20	...
1954	7	14.5	2.07	10	...	...	1.43	0.69	...
1955	35	72.0	2.06	37	...	...	1.06	0.51	...

(Table concluded next page)

*In the section under "Shore anglers," figures on trout per trip and catch per hour which are marked by an asterisk are significantly different (statistically) from corresponding figures for boat anglers. Under "All anglers," figures on trout per trip which are marked by an asterisk are significantly different from corresponding figures for the same lake for other years.

Table 7, concluded

Type of angler, lake, and year	Anglers inter- viewed	Angling hours		Catch of brook trout					Percentage of anglers successful
		Total	Average per trip	Number	Average length (inches)	Average weight (pound)	Trout per trip*	Catch per hour*	
All anglers									
Swanzy									
1953	304	498.0	1.64	27	12.8	0.96	0.09	0.05	7.2
1954	356	636.5	1.79	97	10.5	0.43	0.27*	0.15	14.0
1955	366	686.5	1.88	63	9.0	0.34	0.17	0.09	7.4
Airport									
1953	200	306.5	1.53	121	8.5	0.22	0.60	0.39	25.5
1954	122	194.5	1.59	110	8.3	0.22	0.93*	0.58	33.0
1955	167	289.5	1.73	83	8.1	0.22	0.50	0.29	25.7
Moccasin									
1953	283	530.5	1.87	199	9.2	0.34	0.70	0.38	27.2
1954	144	254.5	1.77	119	8.9	0.28	0.83	0.47	26.0
1955	312	521.0	1.67	303	9.3	0.31	0.97*	0.58	31.4
All anglers (1953-55)									
Swanzy	1,026	1,821.0	1.77	187	...	...	0.18	0.10	10.7
Airport	489	790.5	1.62	314	...	...	0.64	0.40	28.7
Moccasin	739	1,306.0	1.77	622	...	...	0.84	0.48	29.6

*In the section under "Shore anglers," figures on trout per trip and catch per hour which are marked by an asterisk are significantly different (statistically) from corresponding figures for boat anglers. Under "All anglers," figures on trout per trip which are marked by an asterisk are significantly different from corresponding figures for the same lake for other years.

were apparently good. In contrast, the 3,000 fingerlings planted at Swanzy

Lake in 1953 provided almost no return (Table 4), apparently due to a combina-

tion of the following unfavorable circumstances. Fathead minnows were especially

abundant at Swanzy Lake in 1954 and presumably they competed with the planted

fingerlings for food. Survival of fingerlings planted in 1952 was high (as

shown by collecting in October, 1953) and these survivors may have greatly

reduced survival of the fingerlings planted in 1953 through competition for

food and predation. Also, predators (loons and otters) were reported by the

creel census clerk to be more numerous in 1954 than in 1953 or 1955. Numerous

investigators have reported that the survival of planted fingerling trout may

be affected by competition for food and by predation.

By weight, fingerlings provided a good return. Including the almost complete

failure of the 1953 plant, fingerlings provided a harvest of 2.0 pounds for each

pound planted (Table 4).[4] At recapture, the average trout from fingerling plantings

was 9.6 inches long and weighed 0.35 pound (Table 5).

At Swanzy Lake the average catch per hour was 0.10 fish, and 10.7 percent

of the anglers succeeded in catching at least one trout (Table 7). Fishing

success was better in 1954 than in 1953 or 1955.

Fingerlings planted at a length less than 4 inches usually first entered

the catch at the beginning of the second season after planting. When larger

fingerlings were planted (4.2-inch fish planted in Swanzy Lake in the fall of

1954) they made a substantial contribution to the catch during the latter part

of the following season, as mentioned above.

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[4] If the unsuccessful 1953 planting is excluded, the return was 2.5 pounds for
each pound planted.

The quality of fishing provided by the planting of fingerlings was poorer than that provided by plants of larger trout. It is doubtful that fishing quality was entirely a function of size of trout planted however, because there is evidence that the size of the lake itself probably had a considerable effect. The percentage of successful anglers was about the same at Airport Lake in 1953 (25.5 percent) following a plant of fingerlings in 1951 as it was in 1954 and 1955 (average 28.7 percent) following plants of sublegal trout in 1953 and 1954 (Table 7).

Sublegals.--Sublegal brook trout (750 per planting) were stocked in Moccasin Lake in 1952 and in Airport Lake in 1953 and 1954. These plants gave returns of 444, 360, and 220 trout (Table 4), for an average of 372 trout (45.5 percent) per plant.

By weight, the return from plants of sublegal trout was less than for fingerling or legal-size trout. From the three plantings of 6- to 6.5-inch (sublegal) trout anglers caught 1.0 pound for each pound stocked (Table 4). The fish caught had an average length of 8.2 inches, and an average weight of 0.22 pound (Table 5).

At Airport Lake anglers caught 0.40 fish per hour, and 28.7 percent of the anglers caught one or more trout in 1954-1955.[5] Again it appears that fishing quality was not entirely dependent upon size of fish planted. When sublegal trout were planted in Moccasin Lake in 1952, they gave a better return (by number, by weight, and percentage) than did sublegals planted in Airport Lake in 1953 and 1954 (Table 4).

Sublegal trout entered the catch the season following planting but many (perhaps most) had not reached a length of 7 inches by the opening of the trout season. Consequently, the fishing for them was spread over much of the trout

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[5] A 2-year period because in 1953 the census at Airport Lake covered returns from fingerlings planted at the lake in 1951.

season, and in this respect sublegals had some advantage over fingerling and legal-size trout. Very few sublegal trout survived to provide fishing for more than one season (Table 6).

Legal-size.--Of 750 legal-size trout planted in Moccasin Lake in 1953 and in 1954, 222 and 529, respectively, (average, 375) were caught. The average percentage of return was 50 percent. The relatively poor return from the 1953 planting was caused, at least in part, by an abrupt drop in fishing effort after the opening week end of 1954. Anglers who regularly fish at Moccasin Lake abandoned it after the first week end, either because fishing was poor or because a nearby lake offered better fishing for larger trout.

Anglers caught 1.2 pounds for each pound of legal-size trout planted. The trout which were creeled averaged 9.7 inches and 0.39 pound.

The average catch per hour at Moccasin Lake was 0.48 fish, and 29.6 percent of the anglers caught at least one trout. Success was better in 1955 than in 1953 or 1954 (Table 7).

Legal-size trout planted in Moccasin Lake entered the catch at the beginning of the trout season following planting, and contributed to the fishery for about three weeks. Few survived to provide fishing for a second season (Table 6). In 1954 and 1955, 86 and 78 percent, respectively, of the year's catch was made in the first two days of the season. From a management standpoint such heavy removal in the first two days of the season is unsatisfactory.

Comparison of returns from plantings of fish of different sizes.--Results in 1953-1955 suggest some tentative conclusions; these may be confirmed or modified by the replication in 1956-1958. Plantings of fingerlings provided a good return, by number and by weight. As might be expected the percentage of return was much lower than for sublegal or legal-size trout. Fingerlings did not provide as good fishing (catch per hour; percentage of successful

anglers) as sublegal or legal-size trout. When fingerlings entered the catch, they furnished fishing for the early part of the season only (there was an exception at Swanzy Lake in 1955). Planting of sublegal trout gave one advantage over fingerling or legal-size trout: the resulting fishing lasted through most of the season. Most legal-size trout were harvested immediately after the opening of the season. Differences in fishing quality following plantings of fish of the different size classes were probably due, at least in part, to inherent differences in the lakes.

Fishing methods and effectiveness of baits

Method of fishing (from shore or from boats) did not greatly influence success. Statistical analyses revealed two instances where some difference was apparent; anglers who fished from shore were more successful at Airport Lake in 1953 and at Swanzy Lake in 1954 (Table 7). At Swanzy Lake boat anglers and shore anglers fished for about the same number of hours per trip, but at Airport and Moccasin lakes boat anglers fished for more hours per trip. Presumably the reason was that it is easy to launch a boat at Swanzy Lake but more difficult at the other two lakes; consequently boat anglers were reluctant to leave Airport or Moccasin lakes soon after arriving.

Type of lure (worm, fly, or varied lures) had no statistically significant effect on fishing success. Information obtained from interviews on the use of various lures is summarized in Table 8. More than 85 percent of all anglers used worms, or tried various types of bait. Only 3 to 9 percent of the anglers used flies or artificial lures exclusively.

Residence of anglers

Information on residence and sex of anglers is summarized in Table 9. More than 90 percent of all anglers who fished the lakes were from the Upper

Table 8.--Catch of brook trout, related to type of lure used by anglers at

Swanzy, Airport, and Moccasin lakes, 1953-1955

Lake and year	Lure	Number of anglers	Trout caught	Catch per hour per angler	
				Average	Two standard errors
Swanzy 1953	Worms	202	17	0.04	±0.03
	Flies	22	1	0.02	±0.05
	Plugs	19	0	0.00	....
	Combination	60	9	0.07	±0.05
1954	Worms	204	59	0.11	±0.05
	Flies	11	2	0.11	±0.14
	Plugs	20	7	0.28	±0.40
	Combination	121	30	0.12	±0.07
1955	Worms	201	42	0.08	±0.05
	Flies	5	2	0.21	±0.26
	Plugs	39	1	0.02	±0.03
	Combination	121	18	0.05	±0.04
Airport 1953	Worms	177	119	0.40	±0.11
	Flies	5	0	0.00	....
	Plugs	2	0	0.00	....
	Combination	16	2	0.08	±0.17
1954	Worms	83	95	0.64	±0.25
	Flies	4	6	0.50	±0.64
	Plugs	1	0	0.00	....
	Combination	34	9	0.10	±0.12
1955	Worms	125	67	0.29	±0.13
	Flies	4	4	0.53	±0.65
	Plugs	12	1	0.03	±0.06
	Combination	26	11	0.19	±0.17
Moccasin 1953	Worms	203	128	0.35	±0.01
	Flies	25	36	0.75	±0.42
	Plugs	7	2	0.14	±0.26
	Combination	47	32	0.26	±0.21
1954	Worms	103	86	0.46	±0.19
	Flies	11	4	0.27	±0.30
	Plugs	1	0	0.00	....
	Combination	29	29	0.48	±0.40
1955	Worms	185	222	0.90	±0.27
	Flies	28	31	0.81	±0.76
	Plugs	27	10	0.20	±0.16
	Combination	72	41	0.26	±0.16

Table 9.--Residence (by county in Michigan) and sex of the anglers interviewed by the creel census clerk, at Swanzy, Airport, and Moccasin lakes, 1953-1955

Residence and sex	Swanzy			Airport			Moccasin		
	1953	1954	1955	1953	1954	1955	1953	1954	1955
Michigan (Upper Peninsula)									
Alger	...	...	1	...	...	...	1	...	...
Chippewa	1	...	...	...	...	...	...	...	...
Delta	21	18	14	11	2	12	28	6	34
Dickinson	...	...	...	1	...	...	...	...	...
Houghton	...	...	3	2	...	...	...	...	...
Iron	...	...	3	...	...	...	...	...	...
Luce	1	...	...	...	...	...	...	...	...
Marquette	261	318	320	179	118	152	244	130	267
Menominee	...	2	...	...	...	...	3	2	3
Michigan (Lower Peninsula)									
Calhoun	1	...	2	2	1	...	...	...	...
Grand Traverse	1	...	...	...	...	...	...	...	...
Ionia	...	1	...	...	...	...	...	...	...
Kalamazoo	1	...	...	...	...	...	...	...	...
Kent	2	5	5	...	...	...	...	...	...
Montcalm	...	1	...	...	...	...	...	...	...
Muskegon	...	1	...	...	...	...	...	...	...
Oakland	...	...	2	...	...	...	1	...	...
Ottawa	...	1	...	...	...	...	...	...	...
Washtenaw	2	...	1	...	1	...	...	...	...
Wayne	2	...	1	2	...	...	...	...	3
California	...	...	...	...	...	...	...	1	...
Illinois	3	2	4	1	...	...	3	1	1
Indiana	...	2	...	...	...	...	...	...	...
Minnesota	...	2	...	...	...	...	...	...	...
Mississippi	...	...	...	...	...	...	...	4	...
Ohio	...	...	2	...	...	...	...	...	...
Pennsylvania	...	...	2	...	...	...	...	...	...
Washington	...	...	...	...	...	...	1	...	...
Wisconsin	5	3	6	2	...	3	2	...	4
Unknown	3	...	...	...	...	...	...	...	...
Males	277	328	338	185	119	154	271	142	286
Females	27	28	28	15	3	13	12	2	26
Total	304	356	366	200	122	167	283	144	312

Peninsula and more than 85 percent were residents of Marquette County. About 90 percent of the anglers were men.

Acknowledgments

INSTITUTE FOR FISHERIES RESEARCH

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Appendix

Methods of analyzing creel census data

The objective of the creel census was to determine, separately for each lake, (1) total hours of angling, (2) average catch per hour of angling, and (3) total catch, as the product of the first two estimates. The full time of one creel census clerk was used, along with added help during the early days of the season. The clerk worked four days per week, with effort concentrated on Saturdays, Sundays and holidays, and with two weekdays each week rotated on a sampling schedule to include equal numbers of Mondays, Tuesdays, etc. The clerk interviewed anglers at only one lake each day, and a lake was never sampled on consecutive days (See Table 10). The data were treated as a stratified random sample.

To estimate total angling hours for each lake, the season was broken into non-overlapping strata (periods of time) which together included all time from the first hours of opening day through the last of closing day, except for night hours, and midday hours on weekdays. These periods were omitted from the study under the presumption that fishing then was unimportant. For each stratum, an estimate was made of the hours of fishing separately for shore and for boat anglers. The sum of these separate estimates was the seasonal total.

The stratification of the season in time (division of the season into computational subunits) was carried out prior to any detailed inspection of the data, and was based upon general information on fishing intensity and success. The season was divided into four consecutive periods; week-end days and holidays were examined separately from weekdays; and each day was divided into three time periods. The sampling unit was the time period which was a sample from a number of similar time periods throughout the season. The actual measurement used was the average within the time period, of hourly counts of anglers.

Table 10.--The creel census schedule for Swanzy (S),

Airport (A), and Moccasin (M) lakes during 1955[1]

Week of	Sat.	Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.
April 30	Census all three lakes		S	M	A	S	M
May 7	(three clerks)		..	..	M	A	S
May 14	S	M	..	..	A	S	..
May 21	M	A	..	S	M	..	..
May 28	A	S	M	A	..	..	..
June 4	S	M	A	..	..	..	S
June 11	M	A	..	..	..	S	M
June 18	A	S	..	..	M	A	..
June 25	S	M	..	A	S	..	..
July 2	M	A	S	M	..	..	..
July 9	A	S	M	..	..	..	A
July 16	S	M	..	..	..	A	S
July 23	M	A	..	..	S	M	..
July 30	A	S	..	M	A	..	..
August 6	S	M	A	S	..	..	..
August 13	M	A	S	..	..	..	M
August 20	A	S	..	..	..	M	A
August 27	S	M	..	..	A	S	..
September 3	M	A	S	M	..	..	..
September 10	A	S	..	..	..	..	..

[1]This schedule was the same for 1953 and 1954 except that the dates were changed.

The specific boundaries established for the strata were as follows:

1. Four seasonal periods:

    a. The 2-day opening week end with high fishing intensity and success;

    b. The next 17 days, a period of moderate fishing intensity and success;

    c. The mid-season period, which was characterized by low fishing pressure and low success except at Swanzy Lake, and,

    d. The last few weeks. This period of increased effort and success was set to include sampling on at least two weekdays and two week-end days for each lake, so that a variance might be computed within the stratum.

2. Week-end days and holidays were considered separately from the remaining days of the week because of the known differences in fishing intensity, and,

3. Because fishing intensity also varies with time of day, each day was divided into three time periods. Over the three-year study these time periods differed slightly but by no more than one hour. In 1953 these periods were:

    (a) 6:30 a.m. to 10:30 a.m.

    (b) 10:30 a.m. to 3:30 p.m. but not sampled on weekdays,

    (c) 3:30 p.m. to 9:30 p.m.

As an example we will consider shore anglers on Moccasin Lake during the second part of the season in 1953, for the week-end hours between 6:30 a.m. and 10:30 a.m. In the 17-day period there were four week-end days, so that this stratum totaled 16 hours. On three of the days, anglers were counted, the tally on Saturday, May 2 being, for example, 14, 10, 4, 4, for an average of 8.0. On May 3 the average count was 9.7 and on May 10 it was 0.5, so that the

stratum mean count, established on 3 samples, was 6.07, a figure which might be termed man-hours per lake hour, or the estimated average number of fishermen present at any time during this period (6:30 a.m. to 10:30 a.m. on week-end days). Since the stratum totaled 16 hours, the corresponding estimated total hours of fishing was 16 x 6.07, or 97.1 hours. On those occasions when no anglers were counted during any of the sample periods, the estimate of total hours of fishing was, of necessity, zero.

Success of anglers was measured in this study as the ratio of mean catch per angler to mean hours of fishing (or as the identical ratio of total catch to total hours for anglers interviewed) rather than catch per hour per angler. As Jessen[1] has pointed out, this latter measure does not yield an unbiased estimate of total catch. It was here necessary to calculate catch per hour for certain combinations of strata, for two reasons. First, it is often impossible to allocate the success of a particular angler to only one part of a day when his fishing time extends over two strata. Second, in some instances the ratio was established on only a few interviews. Cochran[2] suggests the following rule for ratio estimates, that small samples (less than 30) should be pooled unless the empirical data differ strongly. In following this rule, the t test was used (significance level .05) in testing for differences between shore and boat anglers, and between week-end and weekday anglers. In the absence of significant differences, samples of less than 30 interviews were pooled.

The total catch was estimated as the product of estimated catch per hour and estimated total hours for the strata over which the catch per hour was determined.

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[1] In Carlander, Kenneth D., Editor, 1956. Symposium on sampling problems in creel census. Iowa Cooperative Fisheries Research Unit. Page 63.

[2] Cochran, W. G., 1953. Sampling Techniques, John Wiley and Sons, Inc. 1953, pp. 1-330.

Confidence limits (95 percent) as shown in the tables are expressed as percentage of the estimated totals. Standard errors were calculated according to methods outlined in standard references on sampling, of which Cochran (op. cit.) is a good example.

In addition to estimating the total catch, the total return from any one hatchery planting was computed by applying proportional returns in the creels of anglers which were interviewed to the estimated total catch. Since there was a shift during the season in rates of returns from different plantings, a separate ratio and corresponding estimate was computed for each of the various seasonal periods. The estimated catch from a particular plant for the year was the sum of these estimates for the four seasonal periods. A variance of the fraction of separate estimates for a particular plant was also computed for each period, as shown below. The variance of the estimated catch for the year was the sum of these variances.

To obtain the variance of the estimated catch from a particular plant, the following equation was used:

$$\text{Var } E_r = R^2 (\text{var } E) + E^2 (\text{var } R) + (2ER \text{ cov } ER)$$

where: $R = \dfrac{\text{catch of a particular plant}}{\text{catch of all fish}}$

E = estimated total catch of all year classes

var E = the variance of the total estimated catch

var R = variance of the ratio of the year classes

cov = zero; for explanation read last paragraph

The variance of R (ratio) is based upon the binomial theory (variance = pq/n) which assumes a random distribution of the particular plant through the entire catch.

$$\text{Var } R = \frac{c_1}{C} \cdot \frac{C-c_1}{C} \cdot \frac{1}{C} \doteq \frac{c_1 (C-c_1)}{C^3}$$

where C = total number of fish observed, all plants

c_1 = number observed of a particular plant

Since the total catch consists of one species of trout, and assuming that most fishermen are eager to catch any legal-size trout rather than specialize in catching trout from a particular year class, a random distribution of the catch of the various plants seems plausible particularly for only part of the season. The covariance term in the above formula would reflect any relationship between the catch of all fish and the proportion of the catch consisting of one of the year classes which comprise the catch. In this case, no such relationship appears to exist and therefore the covariance term is considered to be zero.