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RETURNS ON HATCHERY TROUT IN MICHIGAN[1]

by

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Brief history

The trout stocking program is a well-regarded activity of a public agency dating back to 1873. The early reports of the old Michigan Fish Commission list many accomplishments in fish culture. The present trout stocking activities, considerably expanded and diversified from the early days, have been carried on since 1921 by the Fish Division of the Michigan Department of Conservation.

Prior to 1880, the only salmonid present in many Michigan streams was the grayling. And it was the early fish culturists who first introduced, and permanently established trout in many of Michigan's present-day trout waters; the early introductions were accomplished by spring and summer plantings of sac fry and small fingerlings.

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[1] Contribution from Dingell-Johnson Project F-27-R-2.

In cold-water streams of northern Michigan the brook trout, particularly, provided excellent fishing following the initial introductions of fry. This went on until about 1900. Between 1900 and about 1938, the size of trout planted was gradually shifted from fry (3/4 inch-1 1/4 inch) to fingerling (1-4 inches), and most of the planting was done in the fall months.

Reference to the planting records of the 1920-1935 period indicates that total trout plantings (brook, brown, rainbow, and lake trout) were in the tens of millions annually. For example, in 1927, 35 million trout were released, two-thirds of them brook trout fry. In the next 10 years the bulk of the fish released were fingerlings.

Increases in the numbers of trout fishermen during the early 1930's, and the suspicion of both anglers and fisheries administrators that few fry and fingerlings were surviving to the creel in waters where a species was already established, led to initiation of research on survival of planted fingerlings, followed by investigations on the survival to the creel of hatchery-reared trout of larger sizes.

As the result of research findings in Michigan and elsewhere, there have been major changes in the size and type of trout produced in hatcheries. Whereas in 1938-1942 about 8 million trout per year were reared and released, with only about 200,000 of them larger than 7 inches, by 1958-1962 the total trout plantings were down to about 2.6 million trout per year, but about 1.5 million of these exceeded 7 inches in length. In other words the planting program changed from fingerlings

to trout of legal size. Also, production of rainbow trout was increased, and that of brown trout decreased, in view of better returns of rainbow trout to anglers.

Numerically, Michigan now plants less than 5 percent of the annual stocking of the 1900-1920 period. But numbers are misleading, for in earlier years the planted fish were fry and fingerlings, whereas now most of them are of legal size. These advancements in production of legal-size trout, stimulated by demand, stem from research in fish-handling techniques, diets, and increased knowledge and understanding of the fish-rearing capacities of the various State-owned cultural facilities.

Next let us consider for a moment who seeks to capture trout, how many follow the sport, and some of the present situations in which they operate.

Some sociological aspects of trout fishing in Michigan

Who are Michigan trout fishermen, and how many use our trout waters? From various types of creel census records we know that they come from every county in the state, with a majority coming from the counties of high population density--Wayne, Genesee, Oakland and Kent--and to a minor extent they come from the neighboring states of Ohio, Indiana, Illinois and Wisconsin. Among trout fishermen, almost

all professions and trades are represented--from day labor to industrial magnate.

As to the "how many," Departmental records provide the numbers of trout stamps sold in the period 1948-1962 (Table 1), and indicate that between 169,000 (1948) and 234,000 (1956) trout stamps were purchased annually. We should then add 20 percent to the indicated sales for the number of wives and minors under 17 who fish for trout but are not required to purchase fishing licenses or trout stamps. This brings the annual estimates of trout fishermen up to 203,000 to 281,000 since 1948; for 1962 the estimated number was 211,000.

The peak years for fishing license sales were from 1951 through 1954, but trout stamp sales were highest during 1955 through 1957. The cost of the fishing license and that of the trout stamp were increased for the 1958 season (from $2.50 to $4.00 for the two licenses); this cost increase may have contributed to the decline in trout stamp sales. Other reasons advanced for the declining sales of both fishing licenses and trout stamps include the upsurge in interest shown in other outdoor sports such as sailing, water-skiing, power-boating, golf and family camping.

It is said that we have in Michigan some 15,000 miles of trout streams. A reasonable estimate for their average width might be 20 feet, which would mean that there are slightly more than 38,000 acres of trout streams. To this one might add 125,000 acres of trout lakes, for a total of 163,000 acres. This would mean something less than an acre for each of the 200,000 trout fishermen.

Table 1.--Fishing license sales, trout stamp sales, and estimated trout fishermen in Michigan, 1948-1962

Year	Fishing licenses (resident, temporary and non-resident)	Trout stamp sales	Estimated* trout fishermen	Percentage of total licensees estimated to be trout anglers
1948	1,089,901	169,498	203,396	18.7
1949	1,101,872	182,058	218,470	19.8
1950	1,056,060	170,773	204,928	19.4
1951	1,124,338	186,138	223,366	19.9
1952	1,146,386	193,744	232,493	20.3
1953	1,159,925	208,497	250,196	21.6
1954	1,188,134	216,774	260,123	21.9
1955	1,007,049	226,824	272,189	27.0
1956	1,119,657	234,009	280,811	25.1
1957	1,109,433	233,417	280,100	25.2
1958	1,056,462	202,572	243,086	23.0
1959	964,473	192,580	231,096	24.0
1960	952,852	190,246	228,295	24.0
1961	927,627	187,509	225,011	24.3
1962	903,190	175,880	211,056	23.0

* Trout stamp sales + 20 percent (minimum estimate of numbers of wives and minors who fish for trout, as determined from creel census data at Department research areas).

Why do people fish for trout? In the days of early settlers, a creel of trout probably was sought to augment the usual diet of meat and potatoes, and in many instances to ease the strain on the family food budget. Today probably the incentive of obtaining food is relatively of less importance, whereas we judge that many anglers now fish in response to the challenge of outwitting a creature in his own habitat, or the challenge of competition with fellow fishermen. Our modern corps of trout fishermen mostly divide up into natural bait fishermen, fly fishermen, or spin fishermen--each to his preferred method. However some fishermen, to whom the method is unimportant, take up trout fishing just because the sport is ordinarily pursued in pleasant outdoor surroundings. Lastly, a few people fish for trout simply because it is the current "in" fad of their associates.

Trout fishing in Michigan today takes numerous forms. With little or no guide service, and with a little searching and hiking, anglers so inclined can fish in the contemplative solitude of Walton on a headwater beaver dam or cedar swamp tributary. Or if elbow-to-elbow crowds, often numbering in the hundreds, do not detract from his aesthetic views of the sport, the angler can try to capture spawning-run steelhead in any one of several streams where this species migrates. Between these two extremes, we can observe all gradations of piscatorial practices and competition.

The angler's mental approach and actual practice of the sport appear to be determined (a) by reading angling literature, both classic and current, (b) learning through word-of-mouth from friends and older

members of the family, and (c) by actual experience. The economic status of the individuals involved also undoubtedly influences the attitudes adopted concerning various angling traditions, commonly accepted ethics and practices associated with trout fishing.

Thus what trout fishing signifies, and what 200,000 Michigan trout anglers want out of trout fishing, can be--and probably is--extremely varied. Here results of periodic angler-opinion surveys to sample all segments of the trout fishing public in a statistically sound manner could be of definite assistance to the fisheries administrator, manager and biologist in their attempts to give better service to the license holders.

Fishing pressure on trout waters is noticeably influenced by industrial work patterns, by the length of the school year, and by the quality of our highway system; also, to a minor extent the fall trout season conflicts with the small game and deer seasons.

The Monday-Friday work week, plus the fact that it is only a 3- to 5-hour drive to the trout country of one's choice, bring on extremely high weekend angling pressures on readily accessible trout waters, also on waters known or rumored to yield above-average catches. In contrast, the fortunate angler who fishes at some time between 3 PM on Sunday and 3 PM the next Friday even today can have his favorite site almost entirely to himself during many weeks of the trout season.

On the opening weekend of the trout season, one can hardly expect to have good fishing on a productive lake or stream without much angler competition. Most good, accessible trout waters are fished

heavily on the opening weekend. In certain of the best lakes and streams extreme fishing pressure is generated in a Coney Island atmosphere. And there is intense competition for both fishing sites and fish. If weather and water conditions are favorable, particularly in trout lakes, 50 to 70 percent of the total season's catch may be removed on the opening weekend.

The angling congestion can be alleviated somewhat by getting a more widespread distribution of plantings of hatchery trout in both time and space--spread the fish more throughout the season, and among more planting sites. Cooper (1953) found that this practice resulted in better returns to the anglers in experiments with rainbow trout in the Pigeon River. The same thing can be expected from trout lakes if, instead of a single planting at the beginning of the season, the annual stocking quota is divided up into a number of plantings spread out during the season. The extent to which this tactic might be developed is dependent to a large degree on how much the angler is willing to pay for his fishing and how good he wants it.

The advances of "civilization" in Michigan have all but eliminated what our earlier anglers would call "wilderness trout fishing." Anyone who is not convinced should examine the county road maps with their great network of back-country roads. Because of this network of roads, each angler must share his "secret" pools and stream stretches with other "explorers." As in other fields of human endeavor where many persons are entitled to share in what is common property, the application of common sense, good manners and the Golden Rule contribute much to a pleasant fishing experience.

Since about 1937, the Michigan Department of Conservation has attempted to spread the angling public on the available waters by the purchase and maintenance of several hundred Public Fishing Sites, many of them on trout streams and trout lakes.

Perhaps in some Utopian society there would be a way to divide each year's catch of wild and stocked trout equally among the 200,000 licensed trout fishermen. Since they all pay the same price--and especially if they were to put in the same effort in fishing--they might expect to receive the same benefits. Until we as fisheries managers learn how to get a better distribution of hatchery fish, and until the novice and intermediate anglers learn better how to catch trout, the expert and persistent trout fishermen will continue to creel the lion's share of the yearly trout catch. In general, 10 percent of the anglers catch 50 or more percent of the trout (McFadden, 1961; and unpublished creel census reports from Michigan).

The contribution of the trout stocking program to Michigan angling

In this section we attempt to estimate the contribution of stocked hatchery trout to the Michigan anglers' creel.

Since about 1930, fisheries administrators and anglers alike have been increasingly concerned about the eventual fate of artificially reared trout stocked for the pleasure of the license buyer in public waters. This interest in hatchery fish has not been limited to Michigan but is shared in other trout areas of the continent.

Widespread differences in recaptures of hatchery trout can be expected because of differences in geography, trout stream ecology, angling pressure, and the genetics and care of the trout stock in the hatcheries. In attempting to assess the contribution of the stocked trout, we have gone to the fisheries literature and to Departmental files for information relating to numbers of trout stocked and numbers later recovered by angling. Such records are available from studies involving known numbers of hatchery-reared trout released after marking (by tagging or fin-clipping) whose subsequent presence in anglers' creels was later tallied by some type of creel census. Since there are noticeable differences in survival to the creel (a) between plantings in lakes and streams, (b) between species, (c) between various sizes of trout, and (d) between seasons of stocking, the data in Table 2 have been summarized accordingly. Average percentages of recovery are given for Michigan experiments, along with results of similar experiments conducted elsewhere, for comparison. The observed recovery percentages, slightly modified where it is felt that they may not be entirely representative, are then applied to the 1960 Michigan trout stocking records for brook, brown and rainbow trout to estimate the catch of stocked trout by Michigan anglers in that year.

To derive true estimates of numbers of stocked trout later recovered from known numbers planted, and to obtain accurate figures for planting costs and estimates of value in the creel, would require detailed analysis of planting records and recovery estimates for at least a two-year period, and preferably three years. At present, lake stocking

Table 2.--Percentage return to anglers of hatchery trout, for Michigan and elsewhere, analyzed by species, size and habitat, and based on numerous planting experiments

Species	Size at planting (inches)	Michigan				Other localities			
		Spring or open season		Fall		Spring or open season		Fall	
		Number of experiments	Percent recovery	Number of experiments	Percent recovery	Number of experiments	Percent recovery range	Number of experiments	Percent recovery range
Streams									
Brook	1.0-3.9	...	...	8	1.8	1	0.7	1	0.7
	4.0-6.9	6	1.9	3	1.0	...	...	2	1.3- 8.7
	7.0 +	18	41.7	5	2.5	11	19.6-83.0	4	2.4-47.0
Brown	1.0-3.9	2	2.0	11	3.1	2	0.6- 2.6	...	...
	4.0-6.9	...	...	...	...	...	...	...	...
	7.0 +	10	29.9	...	...	5	8.6-79.0	5	1.4-54.5
Rainbow	1.0-3.9	...	...	1	9.6	2	0.7- 3.2	3	0.7- 6.0
	4.0-6.9	6	10.2	1	0.5	...	...	3	0.7- 8.3
	7.0 +	23	56.1	...	...	19	28.2-83.0	4	2.2-48.4
Lakes									
Brook	1.0-2.9	7	4.5	...	...	2	1.7-25.3	6	0.3-13.0
	3.0-4.9	...	...	21	15.2	...	...	3	4.3-19.8
	5.0-6.9	2	18.1	25	41.8	1	25.6	2	1.8-36.2
	7.0 +	11	59.5	11	43.0	7	12.0-60.0	8	0.9-86.8
Brown	1.0-2.9	...	...	...	...	...	...	...	...
	3.0-4.9	...	...	...	...	...	...	...	...
	5.0-6.9	1	14.0	...	...	1	32.0	...	...
	7.0 +	2	11.8	8	33.0	9	0.5-92.0	...	...
Rainbow	1.0-2.9	...	...	...	...	4	0.3- 3.8	1	3.1
	3.0-4.9	...	...	1	0.8	...	...	3	5.8-18.3
	5.0-6.9	1	4.7	...	...	2	71.6-72.3	...	...
	7.0 +	13	26.5	12	43.7	15	27.4-85.0	...	...

is done mainly in the fall, and anglers recapture these fish during the following two seasons. If stocked in the fall of 1959, they were paid for from fees collected in that year; but these fish were harvested by anglers who bought their licenses in 1960 and 1961. The analysis is further complicated by the fact that license fees and trout stamps are sold on a calendar year basis, whereas Departmental budgets are established on a fiscal year basis. Thus trout stamps sold before July 1 are credited to receipts of one fiscal year, and those sold after July 1 are credited to another.

In the analysis presented on the following pages, the Departmental cost records for the fiscal year 1959-1960 were regarded as the costs for 1960, and the estimated percentages of recovery from the 1960 plantings were regarded as occurring in 1960, even though some were probably captured later. The total percentage of recovery is correct even though the timing is not.

Our estimates of total returns to anglers from hatchery fish planted in Michigan during 1960 are derived by applying to hatchery plantings the percentage returns from Michigan experiments given in Table 2. With some 200 planting experiments involved, with fairly consistent results within Michigan, and with quite similar results in other states, the present statewide estimate is believed to be good. Admittedly there is considerable variation in returns from individual waters, both in the experimental data of Table 2 and in waters throughout the state.

Application of the percentages of recovery in experimental plantings to the 1960 stocking records yields the estimates listed in Table 3. From the summary, an estimated 812,000 trout were caught by anglers from the 2,071,000 trout stocked, or about 39 percent of the total 1960 stocking. The present policy calls for releases in streams in the open season and early spring to obtain best returns, and for lake stocking almost entirely in the fall or early winter for economy of hatchery operations and for better growth of the fish. Therefore, the angler returns from spring and fall plantings were computed from the corresponding seasonal recovery percentages. These percentages (adjusted from Table 2) are as follows:

	Fingerling	Sublegal	Legal
Brook trout			
Streams	2	2	42
Lakes	12	15	45
Brown trout			
Streams	2	5	30
Lakes	12	15	40
Rainbow trout			
Streams	..	..	56
Lakes	10	15	50

Fraction of 1960 creel made up of stocked trout

We have estimated the number of hatchery fish caught in 1960, but we cannot estimate what percentage of the total trout catch this was,

Table 3.--Estimated angler recovery of 1960 planted brook, brown and rainbow trout, inland waters of Michigan

[Note: Fingerlings = 1.0-3.9 inches, Sublegals = 4.0-6.9 inches, Legals = 7.0 inches and larger]

Locality	Size planted	Species and numbers of trout planted				Estimated catch - 1960 [based on (a) x (b)]			
		Brook	Brown	Rainbow	Total	Brook	Brown	Rainbow	Total
Streams	Fingerling	54,000	...	...	54,000	1,080	...	...	1,080
	Sublegal	1,480	17,650	...	19,130	30	883	...	913
	Legal	419,820	145,024	480,985	1,045,829	176,324	43,507	269,352	489,183
	Totals	475,300	162,674	480,985	1,118,959	177,434	44,390	269,352	491,176
Lakes	Fingerling	109,600	46,000	83,300	238,900	13,152	5,520	8,330	27,002
	Sublegal	38,655	27,800	89,500	155,955	5,798	4,170	13,425	23,393
	Legal	87,640	43,030	426,995	557,665	39,438	17,212	213,497	270,147
	Totals	235,895	116,830	599,795	952,520	58,388	26,902	235,252	320,542
Grand totals		711,195	279,504	1,080,780	2,071,479	235,822	71,292	504,604	811,718

because there is no estimate of the state-wide total catch of trout. Estimates for individual localities of percentage of catch contributed by hatchery trout, given in the literature (Shetter and Hazzard, 1941; Cooper, 1953), range from 12 percent to 70 percent, depending on the species involved, the number planted, the stream, and angling pressure.

To correct this lack of information on the relative contribution of hatchery trout, we might well initiate some type of state-wide sampling which would produce estimates of the total trout catch and the numbers of hatchery-reared fish included. Such figures would provide a more precise evaluation of the trout stocking program.

The cost of stocked trout, 1960

Total trout planted in 1960 amounted to 2,120,232 fish weighing slightly less than 360,000 pounds. In the absence of any other available cost figures, it is assumed that the cost of raising and planting these fish was the listed operational costs of the 9 hatcheries raising trout plus some $31,000 in capital outlay at certain of these hatcheries, or a total of $670,000, as listed in the 1959-1960 Biennial Report of the Department of Conservation. From this it is estimated that it cost $1.86 to produce a pound of trout in 1960.

The poundage of hatchery trout of different sizes was estimated from planting records and from known length-weight relationships of trout, as follows:

Fingerlings: 292,900 fish, 3,873 lbs (Av. 2.9 inches, 0.0132+ lb)

Sublegals: 184,085 fish, 11,046 lbs (Av. 5.6 inches, 0.06 lb)

Legals: 1,643,247 fish, 345,081 lbs (Av. 8.0 inches, 0.21 lb)

Then it was estimated for brook, brown and rainbow trout that the 1960 production of:

Fingerlings cost $7,208 to raise, or $0.0246 per fish.

Sublegals cost $19,647 to raise, or $0.1122 per fish.

Legals cost $626,696 to raise, or $0.3908 per fish.

We next summarized the stocking records for 1960 and calculated the cost of making the various plantings in lakes and streams, by species and sizes (Table 4). Then, with figures on percentage return of planted fish to anglers, in different types of water, we calculated the cost (per fish) of hatchery trout recovered in the creel (Table 4).

Except for rainbow trout, stream-stocked trout cost more in the creel than do those stocked in lakes. This comes about because recovery percentages of lake-stocked fish are noticeably higher than for stream-stocked fish. Also masked in the purely numerical analysis is the fact that lake-stocked trout generally show a considerable gain in weight (particularly those planted as fingerlings or sublegals), whereas trout released in streams under present stocking procedures are caught out before they have a chance to make much growth.

Our estimated costs (given above) of producing fish for stocking, and the cost of the fish in the creel, may be too high, and thus somewhat in error, for the following reasons:

Table 4.--Estimated costs of stocking various sizes of trout in Michigan lakes and streams, and the estimated cost of these fish in the anglers' creel

[Estimated cost per fish of hatchery fish planted: fingerlings $0.0246, sublegals $0.1122, legals $0.3908]

Costs	Locality	Size at planting	Species			Total
			Brook	Brown	Rainbow	
Total costs of hatchery plantings in 1960	Streams	Fingerling	$ 1,328	$ ...	$ ...	$ 1,328
		Sublegals	166	1,980	...	2,146
		Legals	164,066	56,675	187,969	408,710
	Lakes	Fingerling	2,696	1,132	2,049	5,877
		Sublegals	4,337	3,119	10,042	17,498
		Legals	34,250	16,816	166,870	219,936
Costs per fish in anglers' creel	Streams	Fingerling	$ 1.23	$ ...	$ ...	$ 1.23
		Sublegals	5.53	2.24	...	2.35
		Legals	0.93	1.30	0.70	0.84
	Lakes	Fingerling	0.20	0.20	0.25	0.22
		Sublegals	0.75	0.75	0.75	0.75
		Legals	0.87	0.98	0.78	0.81

Example: 54,000 brook trout fingerlings were stocked in streams; they cost 54,000 x $0.0246 or $1,328, in round figures. A total of 1,080 estimated to be recovered; $1,328 ÷ 1,080, or $1.23 per fish in creel.

1. An unknown fraction of the operational costs of certain of the hatcheries is assignable to warm-water fish production.
2. A certain unknown fraction of operating costs of certain other hatcheries is properly chargeable to aiding the lake trout program in the Great Lakes waters.
3. Some of the operating cost is expended in various activities not related to trout production, such as grounds maintenance and equipment construction.
4. Hatcheries receive many public visitors during the year. Most of these people are not trout fishermen paying for this operation but add considerably to maintenance of grounds.

On the other hand, the estimated costs given above do not include depreciation charges on capital investment, establishment of reserves for replacement, or administrative costs properly chargeable to the program at other than the hatchery level. The two sources of error here compensate to some extent.

Some cost estimates for the rearing of trout are available in the fisheries literature, although many are somewhat indefinite and confusing on close inspection; a number of the more pertinent estimates are listed in Table 5. Here it will be noted that the present Michigan cost estimate is somewhat near the mean of other values, suggesting that our estimate may be quite good. The most detailed cost analysis was that made by Kingsbury (1951) for a typical New York state trout hatchery which produced brook trout, brown trout, and lake trout of all sizes, at a cost of $0.8774 per pound, exclusive of transportation and administrative overhead.

Table 5.--Some estimates of the cost of producing artificially reared trout for stocking

State	Size of trout	Cost		Author and date, comments	
		Per pound	Per fish		
Minnesota	18 mo. 7" +	$2.19		1955	Hale and Smith no administrative costs
Wisconsin	12 mo. browns and rainbows approx. 6"	1.36		1957	Snow and Brynildson
Massachusetts	7" +	1.00		1959	Mullan and Tompkins no supporting evidence
California	7 1/2-9"	1.80	$0.225	1959	Anonymous
New York	All	0.88		1951	Kingsbury best documented for rearing cost
Federal hatcheries in the West	3"	2.14 (approx.)	0.03	1940	Fish
Michigan, state of		1.86			
Fingerling	2.9"		0.025)	estimates from data available	
Sublegal	5.6"		0.112)	for 1960, as developed on	
Legal	8.0"		0.391)	previous pages of this report	
Michigan commercial hatchery trout prices	2-3"		0.07)	1957	Cedarbrook Trout Farms, Harrisville, Michigan. Plus $15 minimum transportation charge
	5-6"		0.20)		
	7-8"		0.45)		
	8-9"		0.55)		

If accurate cost figures for the rearing and planting of trout are desired, some feasible cost accounting system must be set up for the Michigan hatchery managers and administrators. This should be done by a qualified cost accountant, who must familiarize himself with the variations in operations at the various hatcheries. One difficulty in the proper assignment of cost figures to a given lot of fish comes from a splitting of lots, with some fish planted as fingerlings, some as sublegals, and others as legal trout, in widely separated localities. The hatchery crew may spend different amounts of time working on different lots of fish, depending on the needs of the fish, the planting schedule, and the time of year. Also, in the past, many hatchery crews have performed needed services not directly related to fish-rearing or planting, the cost for which is not separated from trout-rearing costs.

Some suggestions for future trout stocking

As rapidly as possible, fisheries personnel should classify all trout streams in their respective districts which would provide a state-wide classification for orderly management procedures. Streams might well be classified into three categories: (a) streams with good trout populations derived from natural reproduction, (b) streams with low trout populations and low natural reproduction, and (c) marginal trout streams with few or no native trout and in which mid-summer temperatures are too warm for trout. With streams classified as above, stocking policies as set by administrative decision could no doubt be put into effect readily.

At the time this report is being prepared, a change in philosophy on trout planting is being considered by fish administrators, which will greatly curtail the planting of legal-size hatchery trout in the better trout streams and put more emphasis on stocking legal trout in second-class trout streams or on a put-and-take basis in sub-marginal streams. An important question is whether anglers will get as good returns (recovery percentage) from legal trout planted in sub-marginal waters as they have been getting from plantings made in the better trout streams. We have very little information on this latter question, because most test plantings have been made in the better trout streams.

Where legal trout are stocked on a put-and-take basis in marginal streams, stocking rates should be related to extent of part use, public access, and distance from centers of angling pressure. Such streams might properly be stocked for the opening weekend, Decoration Day weekend, and possibly Labor Day weekend.

The greatest returns to the angler, based on past experience, result from the use of rainbow trout. The other species will also provide good recovery percentages if angling pressure is adequate as soon as the fish are released. Small portions of some of Michigan's trout streams have been studied intensively, and we have population data on stream sections which have received average to heavy angling pressure. We know they have yielded fair to good fishing. It is suggested that stocking rates be set up in streams so that the number planted does not greatly exceed the number which would be present under average natural reproduction. For example, we have averaged the spring population estimates for 1961,

1962 and 1963 on the North Branch of the Au Sable River (Table 3, IFR Report 1577, 4th supplement) and arrive at an average figure of 584 trout per mile larger than 7 inches. This population of trout was subjected to an average yearly angling pressure of 1,700 hours per mile of stream (unpublished MS). In estimating requirements for legal trout plantings in streams, the fisheries manager should have some knowledge of the spring population of catchable trout and the usual angling pressures, and adjust the stocking accordingly. Unless angling pressure were extremely heavy, he should not stock over 600 catchable trout per mile per year; this is based on the average spring estimates for the North Branch of the Au Sable River.

Trout lakes and ponds, also, should be classified as to their capabilities to yield trout, as to their angling pressure, and according to the following categories (A to D). Here we are recommending rates and species for stocking, based on returns from numerous test plantings.

A. Reclaimed lakes--those lakes which possess limnological and physical characteristics enabling them to support trout populations at all seasons of the year, and which have been treated with toxicant to remove undesirable trout competitors. Stock with 5- to 6-inch sublegal trout in the fall at the rate of 100 per acre. Excellent returns in both numbers and weight have been obtained in lakes of this type by stocking brook trout at this rate, and it probably will work for browns and rainbows as well.

B. Combination (or "two-story") lakes--those which are capable of supporting both warm-water species as well as trout during all

parts of the year, and which in addition to trout may provide a satisfactory fishery for one or more of the warm-water game fish present.

Results of test plantings in two-story lakes in Michigan, California, Canada and elsewhere, have led to the following general conclusions. Anglers get good returns from plantings of legal-size trout, fair returns from sublegals, and poor returns from fingerlings and fry. Plantings, even of legals, in lakes with many northern pike give very poor returns. A stocking rate of about 25 legal trout per acre per year gives best results in terms of good growth and percentage return to anglers. Fall plantings give nearly as good results as spring plantings, because the over-winter growth of fall-planted fish compensates for the additional mortality among these fish. Thus, at least some of the fish could be planted in the fall, to save on hatchery costs.

C. Stream impoundments, including beaver dams--these provide semi-lake conditions, and usually trout grow better than in the normal stream channel. If there are established populations of large trout present, and angling pressure demands it, stocking is best done in the spring and open season with legal trout of the species already present.

Wherever beaver create ponds which do not entrap significant numbers of native trout, or where a beaver dam blocks adult trout from their spawning grounds, it is possible to create good trout fishing by stocking sublegal (4- to 6-inch) fish. Stocking in April and at the rate of 100 per acre is recommended.

D. Seasonal trout lakes--any lake smaller than 25 acres, with limnological and temperature characteristics that will support trout only up to about May 20, and with favorable conditions to the extent that the lake will not winterkill.

Stock in late fall with 6- to 8-inch trout at the rate of 30 per acre, or in spring with 7- to 9-inch trout at the rate of 20 per acre. The harvesting of these fish before onset of lethal water temperatures should be encouraged. Such lakes would provide a means of spreading the opening day angling pressure which occurs in many areas where the number of angling sites is presently limited.

The economics of Michigan trout stocking

The wise utilization of the various natural resources such as forests, fish and game, or the establishment of State Parks has a noticeable impact on the general economy. Trout stocking appears to be no exception. The dollar effects of trout fishing are perhaps not as dramatic as those readily noted from the activities of 400,000 deer hunters during 16 days of November, because the army of trout fishermen are spread out over a much greater part of each year; the regular trout season is 130 to 142 days, while on some rainbow trout waters the extended season from early April to November 30 amounts to nearly 250 days.

In 1960 Michigan sold slightly more than 190,000 trout stamps (Table 1). At $2 for each fishing license and $2 for each trout stamp, the 190,000 trout fishermen contributed $760,000 in fees that year. During

the 1959-1960 fiscal year, the expenditures for trout stocking (here assumed to be the operating costs of Watersmeet, Marquette, Thompson, Oden, Grayling, Harrietta, Paris, Wolf Lake, and Benton Harbor hatcheries plus about $31,000 worth of capital outlay and other expenses) amounted to $670,000 (p. 23, Twentieth Biennial Report 1959-1960, State of Michigan, Department of Conservation).

According to the 1960 National Survey of Fishing and Hunting (Circular 120, U. S. Dept. of the Interior, Bureau of Sport Fisheries and Wildlife), fresh-water anglers made expenditures during their 1960 fishing which averaged $95.25. For Michigan anglers this would amount to about $90, if we exclude the cost of fishing license and trout stamp. Sheftel (1958) estimated that Minnesota fresh-water anglers spent an average of $84 in 1956.

Using the slightly adjusted ($90) national figure, it is estimated that the 190,000 Michigan trout fishermen in 1960 spent $17,100,000--an excellent return on a $670,000 investment. Even if the national estimates on spending by fresh-water anglers are much too high for Michigan trout fishermen, and we have no reason to believe that they are, the trout-license expenditure is small as compared to the value of trout fishing.

Most of our trout fishing in lakes comes from planted fish, for most trout do not reproduce in lakes. Trout fishing in streams is less dependent on stocking; however, heavy stocking does increase fishing pressure considerably.

There remains the question of who should contribute the estimated $670,000 being spent on trout. Is it fair that the trout stamp purchaser should finance the entire cost of a program, the results of which furnish much of the income for various service trades? It would seem that these other interests should contribute, especially if expenditures are to be increased.

Experience and research have eliminated some of the problems related to trout planting, and can eliminate more. For Michigan and many other states there are many examples of successful use of stocked trout to maintain interesting fisheries, both in lakes and streams. And research is being carried on along a number of lines to improve on the use of hatchery fish.

So long as our water quality is maintained, hatchery trout will be a useful tool in providing sport fishing, and can make an important contribution to the economy of Michigan. A pine-bordered lake or stream is a beautiful scene, but the rise of a feeding trout somehow seems the proper embellishment.

Those individuals charged with the management of trout fishing could do a better job of planning if they had the answers to the following questions:

1. What does it cost to rear and plant trout in the various areas of the state?
2. What kind of trout fishing do Michigan anglers want? It is high time that a well-planned "consumer survey" be conducted

among anglers from all parts of Michigan so that we can work toward their desires, if these are biologically and financially within reason.

3. How many trout do Michigan anglers catch during a trout season? What fraction of them are stocked trout? Again, some kind of a Gallup-type sampling of all Michigan trout anglers is indicated.

4. How much does the average Michigan trout angler spend in a season in pursuit of his sport? Reliable answers to this question and to No. 3 would permit a more valid appraisal of the economic value of trout stocking than we can give at present.

5. What is the best stocking policy for rainbow trout in streams tributary to the Great Lakes? We need research to develop information similar to that obtained in some of the Pacific Coast states (Hallock, Van Woert and Shapovalov, 1961).

6. As opportunity presents, we should obtain further data on the survival of brown trout stocked at various sizes in some of our "two-story" trout lakes, and also in lakes managed for single species. We have shied away from this species in the past because of its known difficulty of capture, but this may be an advantage under present and future angling pressure.

7. The use of lake trout to produce sport fishing has been little explored, and has not been touched on here because we have almost no information as to its utilization by sport fishermen in our inland waters.

8. Are the present strains of trout used in the State hatcheries the best that can be obtained? There is a real need for genetically oriented research in selective breeding to improve on the hatchery stock, especially for better survival in natural waters.

9. Will frequent small (numerically) plantings of trout in lakes result in a better percentage return to anglers in a put-and-take fishery?

10. What are the main causes of natural mortality on hatchery trout in lakes? More detailed knowledge might lead to control methods and increased survival of planted trout.

The scope and type of hatchery operations may change with the passing years, depending on the angling desires of the public, on what changes occur in angling regulations, and on how we maintain the basic trout habitat. Nevertheless trout culture probably will be continued indefinitely in one form or another because stocking is, when properly used, one of the best management techniques available to the fisheries manager.

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