Original: Fish Division
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Institute for Fisheries Research
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Report No. 1376

NUMERICAL ABUNDANCE AND EXTENT OF EXPLOITATION BY DIP NETS OF THE WALLEYE RUN IN THE MUSKEGON RIVER, 19

By

Walter R. Crowe

Abstract

In order to ascertain whether dip nets operated during the "Newaygo Transfer" remove, for planting in the various upstream impoundments on the Muskegon River, an appreciable number of the walleyes in the spawning run, a tagging operation was conducted in Muskegon Lake between March 13 and 31, 1953. During this period, 676 walleyes were tagged, before they migrated up the river to spawn. Recoveries, 42 in number, were secured by dip nets at Newaygo during the transfer. From the ratio of tagged to untagged walleyes in the dip net catch, a population estimate computed by the method described by Schaefer (1951) was made. It was concluded that in 1953, something over 100,000 walleyes migrated up the Muskegon River during the spawning season. The number transferred to the impoundments (7,661) amounted to less than 10 percent of the total number of walleyes present.

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Report No. 1376

NUMERICAL ABUNDANCE AND EXTENT OF EXPLOITATION BY DIP NETS OF THE WALLEYE RUN IN THE MUSKEGON RIVER, 1953

By

Walter R. Crowe

For a number of years the "Newaygo Transfer" has been a bone of contention between fishermen interested in fishing above the Newaygo Dam, and those whose fishing interest lies with that part of the Muskegon river system below Newaygo Dam, particularly Muskegon Lake and the Muskegon River immediately above Muskegon Lake. This controversy has been thoroughly reviewed and discussed in earlier reports (I. F. R. Reports No. 1142, 1210, 1222, 1247) and will not be considered here.

Certain questions pertaining to the proper management of the important walleye sport fishery on the Muskegon River have remained more or less unsolved prior to the present investigation. Most of the biological questions concerning the fishery are fairly well understood. Detailed investigations by Eschmeyer (see references) from 1947 to 1949 have indicated that: most walleyes ascending the Muskegon River to spawn originate in Lake Michigan and return to Lake Michigan after spawning; spawning of walleyes does occur in the Muskegon River below the Newaygo Dam, and for a distance of 5 miles downstream; some of the walleyes transferred to the various impoundments on the Muskegon River can and

do return downstream through the various dams; immature walleyes hatched in Hardy Pond or one of the other impoundments show an inclination to leave the impoundments and move downstream, although present information on this question is somewhat limited; and the quality of the fishing in the impoundments is influenced by the numbers of fish transferred.

Other questions, such as the numerical abundance of the run up the river and the extent of exploitation of this run by dip nets at Newaygo have remained unanswered. Investigations conducted this spring were directed towards obtaining at least partial answers to the latter two questions. Extent of exploitation of the run by dip nets at Newaygo has always been a serious question, and to arrive at an answer it was suggested by Eschmeyer (I. F. R. Report No. 1142) that at least 500 walleyes be tagged in Muskegon Lake before their upstream migration. To quote from Eschmeyer's report, "The tagging of a large number of pike-perch (at least 500) in Muskegon Lake or upstream from the lake, in February or early March, would provide good information on this point. The percentage of the total number of tagged fish recovered by dip nets at Newaygo would then indicate directly the approximate percentage of spawners migrating above Muskegon Lake which are taken during the transfer. The approximate total numbers of pike-perch moving upstream, a matter of great biological interest, could then also be estimated."

Two earlier attempts to tag walleyes in Muskegon Lake were made. The first, March 30 to April 1, 1948, by a commercial fisherman using trap nets, resulted in 23 walleyes being tagged. The second attempt, in February 1949, by Institute personnel operating trap nets, was a dismal failure; no walleyes were tagged.

In March of 1952, it was reported to the Institute for Fisheries Research that Mr. Ed Borchers, who seines carp from Muskegon Lake under Conservation Department permit, was catching walleyes in considerable numbers. Two trips

were made to Muskegon by an Institute party. On the second trip Borchers did secure a few walleyes, and eight walleyes were tagged on April 4, 1952. Until 1953, insufficient numbers of walleyes were tagged to provide any usable data.

In 1953, arrangements were made to tag walleyes captured during Borchers' seining operations. It was also decided to supplement Borchers' operation by trap netting in Muskegon Lake. Table I gives the record for the tagging operation at Muskegon Lake from March 13 to 31, 1953. Figure 1 more graphically illustrates the distribution of the tagged fish in Muskegon Lake. Most of the tagged fish were released in three groups: 245 near the mouth of the North Channel, 213 on the south side of the Cobb Plant, and 166 near the entrance of the dredged ship channel from Lake Michigan. The remaining 52 tagged walleyes were released at various other locations as indicated on the map.

So that estimates to be made later would be more or less unbiased it was necessary that the sample of tagged walleyes should be representative of the whole population (or at least that part of it which ascend the Muskegon River to spawn). All fish tagged were measured (total length) and the sex of each individual was determined. In Table II tagged walleyes are compared with samples of "transferred" walleyes by length and by sex ratio.

An examination of Table II reveals certain similarities and differences between the tagged fish and the large sample of the transferred fish. Of the 7,661 walleyes transferred, 2,242 were measured and "sexed"; thus the sample amounted to about 29 percent of all the fish transferred. The measured sample of the transferred fish covered the whole transfer operation in time, and also included the fish from each of the dip nets on a fairly uniform basis. Every effort was made to sample the transferred fish (fish in the run) evenly, and there can be little doubt that the sample was representative of the fish captured by the dip nets. It is possible that the fish caught in the dip nets

Table I

Tagging record, Muskegon Lake, March 13 to 31, 1953, showing method of capture and point of release of 676 walleyes

Date	Number Tagged	Method of Capture	Point of Release
March 13	33[1]	Seine	Middle Channel, Muskegon River, at Equipment Station.
16	5	Trap net	Muskegon Lake, off mouth of North Channel of Muskegon River.
17	129	Seine	Muskegon Lake, just S.E. of mouth of North Channel, Muskegon River.
18	70	Seine	Muskegon Lake, just S.E. mouth, North Channel, Muskegon River.
19	4	Trap net	Muskegon Lake, S. of Cobb Plant, between mouths of Middle & South Channels, Muskegon River.
20	2	Trap net	Muskegon Lake, S. of Cobb Plant, between mouths of Middle & South Channels, Muskegon River.
20	1	Trap net	Muskegon Lake, West shore, just North of Ship Canal.
21	1	Trap net	Muskegon Lake, off mouth of North Channel, Muskegon River.
21	4	Trap net	Muskegon Lake, West shore, just North of Ship Canal.
21	30	Seine	Muskegon Lake, just S.E. of mouth of North Channel, Muskegon River.
22	6	Trap net	Muskegon Lake, between Cobb Plant & Middle Branch.
23	11	Trap net	Muskegon Lake, West shore, just North of Ship Canal.
24	26	Trap net	Muskegon Lake, West shore, just North of Ship Canal.
25	1	Trap net	Muskegon Lake, just East of Bear Lake Channel.
25	10	Trap net	Muskegon Lake, West shore, just North of Ship Canal.
26	7	Trap net	Muskegon Lake, West shore, just North of Ship Canal.
27	26	Trap net	Muskegon Lake, West shore, just North of Ship Canal.
28	28	Trap net	Muskegon Lake, West shore, just North of Ship Canal.
29	30	Trap net	Muskegon Lake, West shore, just North of Ship Canal.
30	16	Seine	Muskegon Lake, S.E. of mouth of North Channel, Muskegon Lake.
30	213	Seine	Muskegon Lake, off Middle Channel, Muskegon River.
31	23	Trap net	Muskegon Lake, West shore, North of Ship Canal.

[1] These fish captured by Seine, just S.E. of mouth of North Channel, Muskegon River, on March 12, transported to Middle Channel, at Conservation Equipment Station, and held in live-box over night, pending tagging on March 13.

Fig. 1. Map of Muskegon Lake, showing method of capture and points of release for 676 walleyes tagged between March 13 and March 31, 1953. Muskegon River channels at east end of lake are drawn in a somewhat diagrammatic manner. Numbers within symbols are numbers of walleyes tagged.

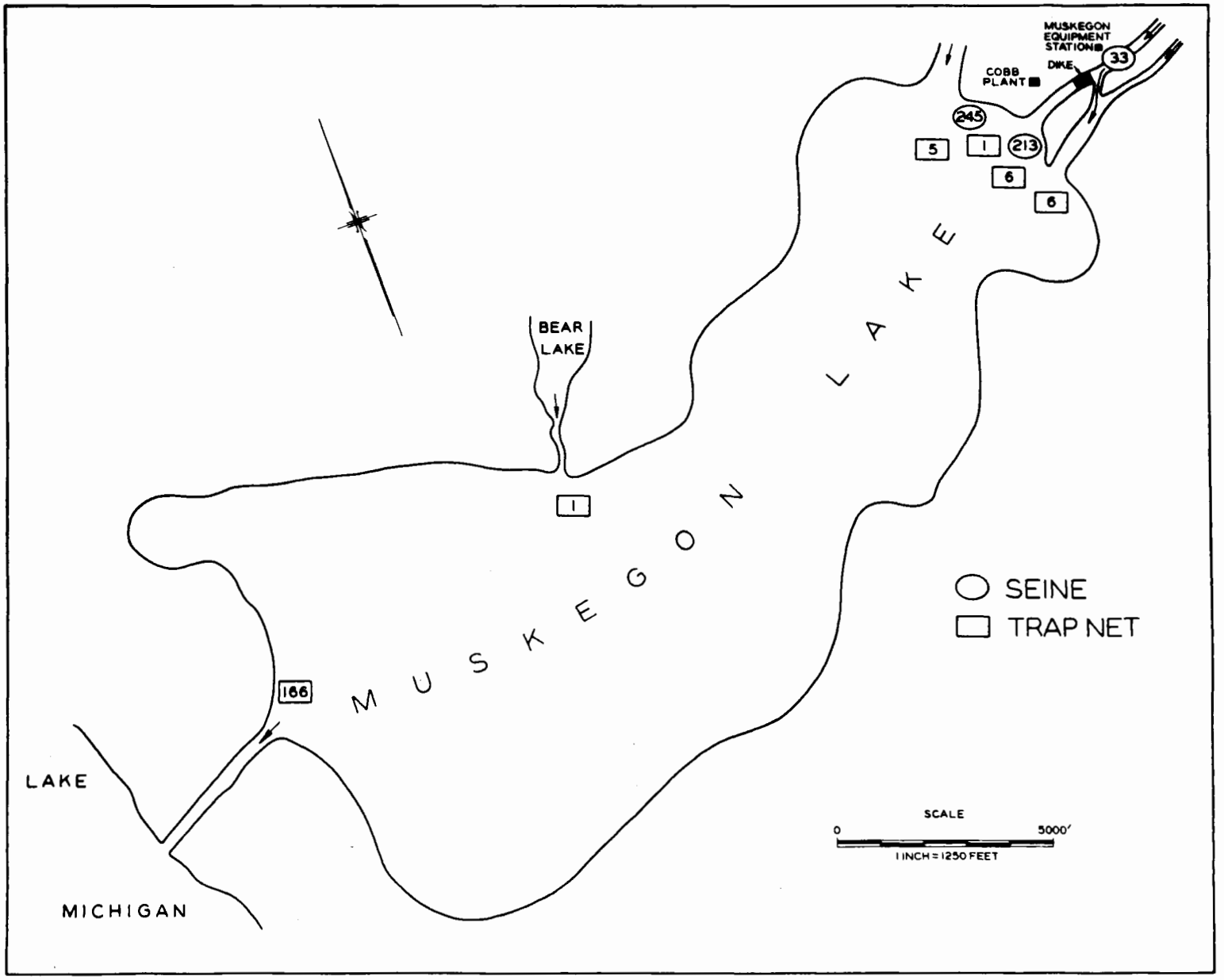
MUSKEGON EQUIPMENT STATION
33
COBB PLANT
DIKE
245
5
1
213
6
6
BEAR LAKE
1
MUSKEGON LAKE
166
LAKE
MICHIGAN
SEINE
TRAP NET
SCALE
0
5000'
1 INCH = 1250 FEET

Figure 1

Table II

Comparison of tagged walleyes with samples of "transferred" walleyes by sex ratio, length range, and mean length (standard error of mean included). All lengths expressed in inches.

	Number	Percent	Length range	Mean length
Tagged				
♂	184	27.2	13.5-25.5	18.3 ± 0.16
♀	336	49.8	16.5-30.5	20.3 ± 0.13
?	155	23.0	11.5-25.5	17.5 ± 0.18
♂ + ?	339	50.2	11.5-25.5	17.9 ± 0.12
all	675[1]	100.0	11.5-30.5	19.1 ± 0.10
Transferred				
♂	1125	50.2	13.5-25.5	17.3 ± 0.05
♀	1110	49.5	14.5-29.5	20.4 ± 0.06
?	7	0.3	11.5-20.5	14.6 ± 1.24
all	2242	100.0	11.5-29.5	18.8 ± 0.05

[1] One tagged walleye was not measured; thus lengths, etc. were determined from 675 walleyes instead of 676 actually tagged.

were not typical of the fish in the spawning run, but we have no reason to believe that it is so. Perhaps the most striking feature in the comparison of the two groups of walleyes, tagged versus transferred, was the large number of fish of undetermined sex among the tagged specimens. Also note (Table II) that the tagged males were somewhat larger than the transferred males. While the transfer was in progress it was not difficult to see that among the fish being transferred there was a preponderance of smaller males. Also the percentage of recognizable males in the transferred sample was much greater than it was in the sample of the tagged fish. Females appear to have been very nearly identical in both lots, both in size and abundance. Nearly all of the walleyes whose sex was not positively determined are thought to have been males. In the

field, sexes were differentiated by whether or not eggs or milt could be forced out by gentle pressure on the abdomen. If so, no problem existed. Many fish were "green", particularly those captured by trap nets near the mouth of the ship channel. These probably represented walleyes which had recently entered Muskegon Lake from Lake Michigan. The sex of "green"fish was determined by relative size and plumpness. Those fish which were obviously plump, i.e. gravid, and of large or moderate size were called females. Other fish, of generally smaller size and less plumpness, were recorded as of questionable sex. The average length of the fish of unknown sex (17.5 inches) supports the contention that they were probably males. The abundance of females recognized as such, in the two lots (49.8 percent and 49.5 percent) also suggests that the 155 walleyes whose sex was not determined were males. If the walleyes of questionable sex are combined with the males, and considered as males, the percentage of males in the tagged lot becomes 50.2, identical with the "transfer" lot.

If the lengths of males in the two lots (tagged and transferred) are compared statistically (t test), the difference in mean length of the two groups is significant at the 95 percent level. The same is true, though to a lesser degree, if the walleyes of unknown sex are included with the males in the tagged group. Females in the two groups, when subjected to the same test, showed no significant difference. Statistical comparison of the two groups, regardless of sex, again shows a significant difference. All of this means that the average difference in the two groups, though small, was genuine and probably did not come about by chance alone. The difference in the two lots of fish, is not of sufficient magnitude to invalidate the representativeness of the tagged sample, especially since it will be shown that tagged fish did become more or less mixed with the walleyes captured by dip nets for the "Newaygo Transfer."

The extent of exploitation, by dip nets, of the spawning run of walleyes is one of the most important questions concerning the management of the walleye sport fishery on the Muskegon River system. If the dip nets capture a large percentage of the fish reaching Newaygo, there might well be some justification for discontinuing the transfer, or at least greatly reducing its scope. Again, if only a very small part of the run is transferred, upstream interests might have legitimate excuse for demanding that greater numbers of fish be transferred. Numbers of fish captured by dip nets and numbers of tagged fish recaptured are presented in Table III.

Table III

Daily summary of walleye catch, and tag recoveries during "Newaygo Transfer", April 4 to April 18, 1953

Date	Dip net catch	Number of tags recovered
April 4	569	1
5	627	2
6	704	2
7	597	4
8	797	0
9	585	4
10	715	6
11	401	3
12	885	6
13	597	4
14	357	2
15	279	6
16	297	0
17	145	2
18	106	0
Total	7,661	42

During the period of the transfer 7,661 walleyes were captured by the dip nets, and 42 of these were walleyes which had been tagged at an earlier date in

Muskegon Lake. From the ratio of tagged to untagged walleyes in the total catch by the dip nets it is possible to estimate the number of walleyes in the spawning run.

Before turning to estimates of the walleye run in the Muskegon River in 1953, a few observations on the distribution and recovery of the tagged walleyes are in order. Certain questions naturally arise: (1) do the walleyes congregating in Muskegon Lake and moving up the river ascend as far as the Newaygo Dam and thus become available to the dip nets? (2) did the tagged fish (and fish in Muskegon Lake or the Muskegon River at the time of the tagging operation) make the trip to Newaygo Dam quickly enough to become available to the dip nets during the period of the transfer? (3) were tagged fish mixed with the untagged fish both in time and space? (4) were tagged fish from the entire tagging operation equally represented throughout the period of recovery? Tables IV, V, VI and VII are presented to clarify some of these questions. Table IV indicates that tagged fish from throughout the tagging period did reach Newaygo during the period of the transfer, except that no individual tagged on March 31 (the last tagging day) had been recovered at Newaygo by April 18 (the last day of the transfer). Also note (Table III) that one or more tagged walleyes were captured on each day of the transfer operation, except on April 8, 16, and 18. Information summarized in Table IV does indicate that walleyes which were congregated in Muskegon Lake before the spawning season do move up the river to Newaygo, and thus become available to the dip nets. Table VII, which shows the lapse of time in days between tagging in Muskegon Lake and recovery by dip nets at Newaygo, gives at least a partial answer to the second question. It appears that fish may make the trip from Muskegon Lake to Newaygo Dam, a distance of about 39 miles, relatively quickly, possibly in as short a time as 11 days. The average number of days required for a walleye to make

Table IV

Summary of recoveries of tagged walleyes, showing numbers of recoveries from each tagging day.

Date of tagging	Number tagged	Number recovered[1]	Percent recovered
March 13	33	2	6.1
16	5	1	20.0
17	129	11	8.5
18	70	10	14.3
19	4	0	0.0
20	3	0	0.0
21	35	5	14.3
22	6	1	16.7
23	11	1	9.1
24	26	0	0.0
25	11	1	9.1
26	7	0	0.0
27	26	1	3.8
28	28	0	0.0
29	30	0	0.0
30	229	9	3.9
31	23	0	0.0
Total	676	42	6.2

[1] All recoveries made by dip nets at Newaygo, April 4 to April 18. All tagging done at Muskegon Lake, March 13 to 31.

Table V

Summary of recoveries of tagged walleyes, separated by type of gear used to capture them for tagging.

Tagging date	Method of capture, Muskegon Lake		Recoveries at Newaygo[2]	
	Seine	Trap net	Seine	Trap Net
March 13	33	...	2	
16	...	5		1
17	129	...	11	
18	70	...	10	
19	...	4		
20	...	3		
21	30	5	5	
22	...	6		1
23	...	11		1
24	...	26		
25	...	11		1
26	...	7		
27	...	26		1
28	...	28		
29	...	30		
30	229	...	9	
31	...	23		
Total	491	185	37	5

[2] All recoveries at Newaygo by means of dip nets, April 4 to April 18.

Table VI

Summary of walleye recoveries at Newaygo, separated by date of tagging at Muskegon Lake

Tagging date	Number tagged	Number recovered[1]	Percent recovered
March 13-23	296	31	10.5
24-31	380	11	2.9
Total	676	42	6.2

[1] All recoveries at Newaygo by means of dip net, April 4 to April 18.

Table VII

Summary of recoveries of walleyes showing time lapse in days between tagging at Muskegon, and capture by dip nets at Newaygo

Time lapse, days	Number
11	1
12	...
13	2
14	1
15	1
16	6
17	1
18	1
19	3
20	2
21	5
22	3
23	3
24	4
25	3
26	2
27	1
28	...
29	...
30	1
31	1
32	...
33	...
34	...
35	1

the trip upriver and be captured by a dip net at Newaygo was computed to be 20.9 days, (standard deviation 5.09, standard error of the mean 0.79). Thus we may say that the walleyes make the trip from Muskegon Lake to Newaygo in something less than three weeks, for most "transfer" fish are not captured immediately upon arrival at the dip netting site. The wide variation in the number of days of lapsed time between tagging and recapture must have been due in part to the fact that it took 15 days to recapture 6.2 percent of the tagged fish. On any particular day the rate of recapture varied from 0.0 percent to 0.9 percent. Apparently the dip nets catch only a very small percentage of the fish present on any given day, and therefore it is evident that there is, on the average, a lapse of several days between arrival at the dipping area and capture by dip nets. In other words, several days must be subtracted from the "time out" period in order to give the best possible estimate of the minimum length of time to make the trip. Further insight into the problem may be had by an examination of Figure 2. From the figure it is apparent that fish in the earlier part of the run made the trip more slowly than fish in the later part of the run; this is shown by the average, and minimum, number of days out for consecutive tagging dates. In fact, minimum number of lapsed days between tagging and recapture may be the best estimate for the average length of time required to complete the trip from Muskegon to Newaygo. This average can be computed as 19.3 days; or if records are used only for those tagging dates from which there were 5 or more recaptures the number of days required for the trip becomes 16.1. From these data it is concluded that spawning walleyes make the trip from Muskegon Lake to Newaygo (39 miles) in something between 16.1 and 20.9 days, on the average.

That tagged fish were mixed with the untagged fish, more or less evenly, is apparent from Table III. Tagged fish were captured along with untagged on

Fig. 2. Recoveries of tagged walleyes, by dip nets at Newaygo, plotted according to date of tagging and number of days at liberty.

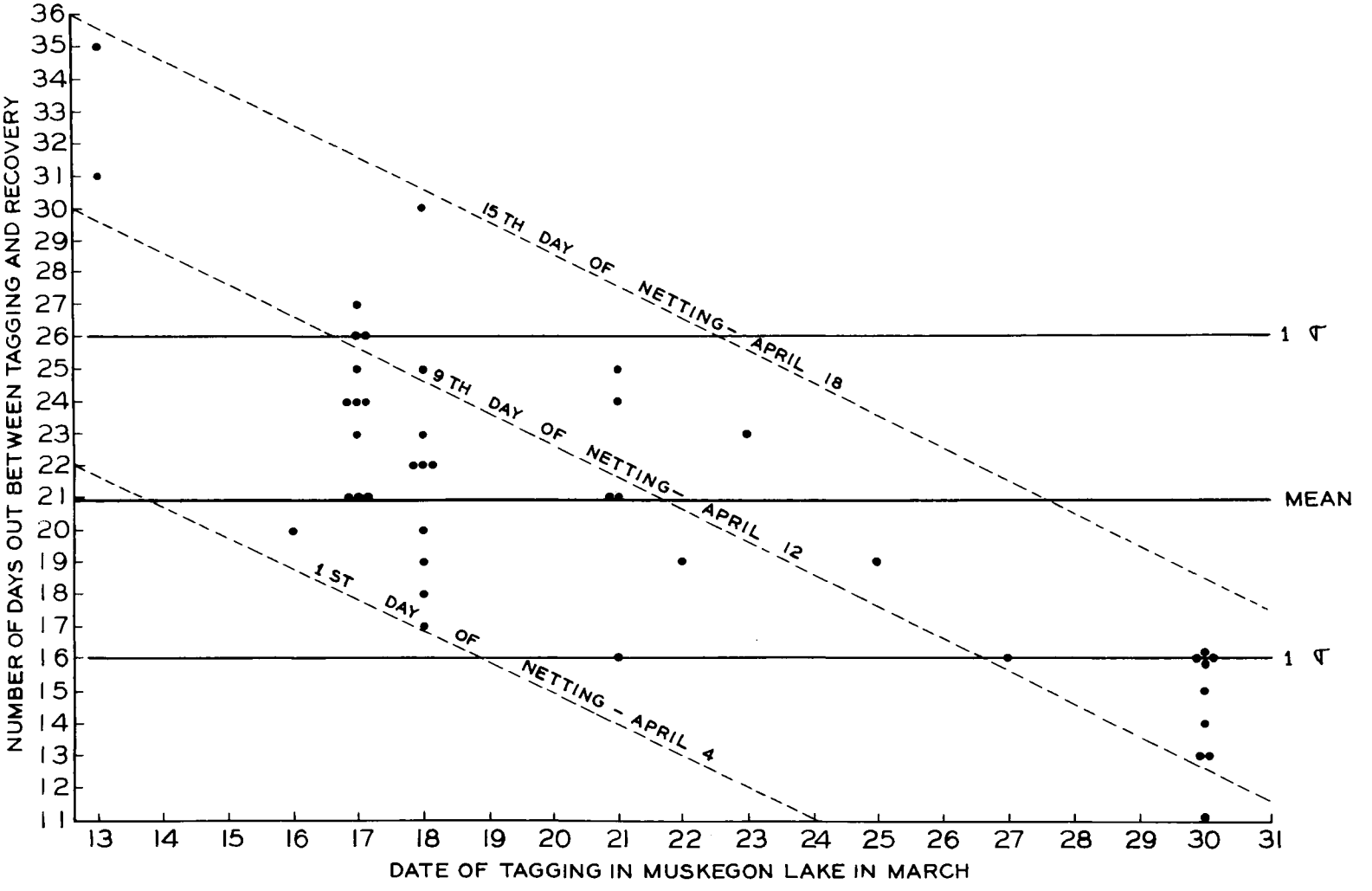
NUMBER OF DAYS OUT BETWEEN TAGGING AND RECOVERY
DATE OF TAGGING IN MUSKEGON LAKE IN MARCH
15TH DAY OF NETTING - APRIL 18
9TH DAY OF NETTING - APRIL 12
1ST DAY OF NETTING - APRIL 4
MEAN
1 σ
1 σ

Figure 2

most days. However, Table V and VI show that this mixing was not random in space and time. Seine-caught fish, all of which came from the area where the Muskegon River enters Muskegon Lake (Fig. 1), were recovered at a rate of 7.5 per hundred, while trap-net-caught fish, most of which came from near the entrance of the ship channel at the west end of the lake, were recovered at a rate of only 2.7 per hundred. Fish captured by seine (72.6 percent of the total) furnished 88.1 percent of the recoveries; walleyes captured in trap nets (27.4 percent of the total) furnished only 11.9 percent of the recaptures. In time, the difference in rate of recovery is more striking; fish tagged between March 13 and March 23 (43.8 percent of the total number tagged) gave 73.8 percent of the recoveries, while those tagged between March 24 and 31 (56.2 percent of the total) furnished only 26.2 percent of the recoveries. As indicated in Table VI fish tagged during the early part of the tagging period were recovered at a rate of 10.5 per hundred, while those from the later period were recaptured at a rate of 2.9 per hundred. If these variable rates of recapture, influenced by time and space, are subjected to statistical test (chi-square), there is a better than 99 percent probability that the difference in rate of recapture, as influenced by time (Table VI), did not occur by chance, and a better than 95 percent probability that the difference in rate of recapture, as influenced by space (Table V), did not occur by chance.

Most methods of estimating populations, based on a ratio between marked and unmarked individuals in samples drawn from the population, make certain basic assumptions. The population must be a closed unit; that is, it is not being augmented or decimated during the period of the estimate. Marked individuals must be randomly distributed through the whole population, or sampling must be unbiased. In this investigation the first assumption (of a closed population) is more or less satisfied. The spawning run of walleyes moving up

the Muskegon River between Muskegon Lake and the Newaygo Dam may be considered as a unit. The second assumption (even distribution of marked fish, and unbiased sampling) was not completely satisfied as has been pointed out (page 16). It will be shown that this bias did not have too profound an effect on the final estimate.

One method, and perhaps the simplest, of estimating the number of walleyes in the spawning run is from the proportion of tagged to untagged during the transfer. This computation would be 42/676 = 6.21302; therefore 7,661 = 6.2+ percent of the total run, and the total run (estimated) = 7,661/6.21302 X 100 = 123,306.

Similar estimates might be computed from the daily catch records from Table III. For example, from Table III it can be seen that for April 4, 5, and 6 the total catch was 1,900 walleyes. During the same period there had been 5 recoveries. The estimate for April 6 could be computed as follows: estimated population = $\frac{\text{total catch X number of marked fish}}{\text{number of recoveries}}$ = 1,900 X 676/5

= 256,880

Such estimates, computed by direct proportion, were made for each 3-day period of the transfer. They were: April 4-6, 256,880; April 7-9, 167,225; April 10-12, 90,178; April 13-15, 69,459; and April 16-18, 185,224. The simple average of these periodic estimates is 153,793.

Other methods, somewhat more refined, for computing population estimates for fishes have been described by Schnabel (1938) and by Schumacher and Eschmeyer (1943). By the Schnabel method an estimate of 119,724 was obtained, and by Schumacher and Eschmeyer's method the estimate was 120,807 $\pm$ 19,402.

All of the estimation techniques described above have one weakness: they assume either unbiased sampling or random mixture of marked with unmarked individuals. No correction for bias is included in any of the methods mentioned to this point.

Schaefer (1951) has described an estimation technique which appears to be particularly applicable to the problem of determining the approximate numerical abundance of walleyes in the Muskegon River during the spawning run. In the abstract of his paper Schaefer says, "For some migratory fishes, which are marked at a point on their migration path and sampled at some other point, there exists, when the migration extends over a considerable space of time, a correlation between time of tagging and time of recovery at the point of subsequent sampling. In such cases, the total number of fish marked or drawn in subsequent samples cannot in general be regarded as random samples of the whole population. Where numbered tags are used to mark the individuals, so that they may be identified individually both when tagged and when recovered in the samples, a method of estimating N is suggested." As has been pointed out (page 16), time and place of tagging did have a definite effect on recovery rate. Schaefer's method makes allowance for such bias. For formulae and computation details the reader is referred to Schaefer's paper. By this method an estimate of 113,882 was obtained. This is considered to be the "best" estimate. Note that it agrees rather closely with estimates obtained by other methods, except for the average of the periodic estimates which are the least precise.

Conclusions

The 1953 tagging operation, conducted primarily to determine the approximate numerical abundance of the walleye run up the Muskegon River, and the extent of its exploitation by dip nets at Newaygo, has provided certain information which should prove useful in establishing policies for the management of the walleye sport fishery on the Muskegon River System:

1. In 1953 the number of walleyes available to the dip nets at the dipping site below Newaygo Dam was something over 100,000. Less than 10 percent of these fish were transferred to the various impoundments.

2. Most of the walleyes, congregated in Muskegon Lake prior to spawning, ascend the river as far as Newaygo Dam. Small numbers may remain in Muskegon Lake or return to Lake Michigan without ascending the river. One walleye, tagged in Muskegon Lake near the entrance to the ship channel on March 27, was recovered in Lake Michigan a few miles south of Muskegon on April 1.

3. Most of the walleyes make the trip from Muskegon Lake to the dipping area (about 39 miles) in from 16 to 21 days. Doubtless there is a wide variation among individual fish in length of time required to make the trip. As concerns exploitation by the dip nets it is obvious that late arrivals and individuals which do not ascend the river as far as the dipping site do not become available to the dip nets; but such fish are included in the population estimate, and properly so, because they are a part of the spawning run.

4. In 1953, the sex ratio of the walleyes in the spawning run was one male to one female (50.2 percent males, 49.5 percent females, and 0.3 percent walleyes of undetermined sex). Average weight according to sex was determined for three lots of fish. Three planting-unit loads of walleyes were weighed on a platform scales (in a coal yard) before being planted in the impoundments. The three loads contained widely varying and known numbers of males and females. The average weights of males and females were determined by simultaneous solution of three algebraic equations. For the fish in the 1953 transfer, males had an average weight of 1.3 pounds, and females had an average weight of 3.8 pounds.

Appendix

Certain observations and recommendations pertaining to the "Newaygo Transfer" are in order. Many of the following recommendations have already been submitted by Mr. Sharkey in his report "Newaygo Transfer - 1953," and will be mentioned only briefly here.

1. The graduated scale of payment for game fish captured by the dip netters should be discontinued. As recommended by Messers. Andersen and Sharkey, the rate should be changed to 25 cents per game fish. This would result in a possible maximum cost to Consumers Power Company of $2,500. During the period of the transfer there exists a definite correlation between netting effort (and catch) and the price paid per fish.

2. The sale of suckers under the present system should be discontinued. I believe the reasons for this recommendation have been well covered by Mr. Sharkey in his report. Satisfactory means for disposing of the suckers under a modified system could perhaps be worked out. The sale of suckers has been a feature of the operation for some time, and if it is discontinued some people will certainly be disappointed.

3. Mr. Sharkey has also recommended that a more thorough beforehand check be made to try to anticipate the date of the early part of the run. Results of a single test dip net should not be considered conclusive. Test nets, at least three in number, and separated by some distance should be put into operation during the latter part of March (perhaps about March 22 to 25) and operated for a period of an hour or so each night. The transfer should be opened when the test nets begin to catch walleyes with some degree of success.

4. During future transfers it is recommended that the Fish Division employee in charge of the operation collect certain biological data as an aid in

comparing runs from one year to another. About one third of the transferred fish (at least 2,000 walleyes) should be measured and "sexed" each year. The measuring and "sexing" should be spread throughout the period of the run, and fish from all net sites should be included in the sample. Every effort should be made to make this sample representative. It is suggested that the fish in one unit-load be measured and "sexed" each day of the operation. Secondly, the supervisor of the operation should continue to check for lamprey scarring and lymphocystis infection. As indicated in Mr. Sharkey's report, in 1953, 80 of 7,669 game fish transferred bore lamprey scars, and 30 of 7,661 walleyes showed lymphocystis. These jobs can be done quite easily and do not require too much time. Each fish must be examined for tags anyhow.

5. My final recommendation deals with the possibility of dispensing with the use of dip nets. It is realized that one attempt (a weir in 1951) has already been made, and I have heard that seining was attempted years ago. During the tagging operation at Muskegon Lake, Mr. Ed Borchers of Spring Lake expressed an interest in trying to obtain walleyes for transfer by means of a seine. I suggested to Mr. Borchers that there was too much current and too much water, particularly in the early spring when walleyes are present in the river in numbers. Nevertheless we (Borchers, Fukano, Crowe) did make a trip to Newaygo on March 22, 1953, to look for possible seining sites. Two possible sites were selected: one immediately above the spill from the Newaygo Dam powerhouse where a reverse current is present, and the other on the north side of the river, immediately below Newaygo Dam, again where a reverse current is present. At that time (March 22) it was agreed that Mr. Borchers would be notified when the transfer operation commenced and it was his intention to try a couple of seine hauls to test the practicality of seining. Either because Borchers decided, upon further consideration, that there was too much current or because

he had heard, via the "grapevine," that the seining project was none too popular, he apparently decided to forego the attempt, at least this spring (April, 1953). Borchers did spend a part of one evening with me while the transfer was still in progress, and we again looked over possible netting sites. Borchers is definitely interested in trying to learn whether walleyes can be taken readily by seine, and I believe he should be encouraged to do so. It is my intention to write to him, and arrange to meet with him at Newaygo in August or early September during the period of low water. Then it may be possible to select seining sites more judiciously, and Borchers might be willing to clean a site, or sites, for future operations. If it is possible to seine effectively during low water, effective seining might also be possible during the high water in spring. Consumers Power Company might be willing to shut off the dam during the periods of actual seining. Any experimenting that Borchers cares to do will have to be done on his own time, with his own equipment, and with his own employees, but I think we should be willing to authorize him to do some looking around, and some experimental seining, and the Department should be willing to supply some supervision if necessary. I hope that plans can be completed for some test seining during the spring of 1954. In other words, during the 1954 operation we should plan to use the dip nets, and any fish captured by Borchers would supplement the catch of the dip nets. If Borchers can siene effectively, the operation might be conducted without dip nets (and the accompanying complications) in the future. Such a program would certainly cause some dissatisfaction among dip netters, but if the objective of the transfer is to move walleyes to the impoundments on the Muskegon, and if seining could streamline the whole operation, it would be most desirable. The job could then be done on a contractual basis between Borchers and Consumers Power Company, and the Department would have only to supply supervision (1 or 2

men) and furnish planting units to transport the fish.

6. The present Fish Division policy on the Newaygo Transfer (10,000 walleyes, or 15 nights of dipping) appears to be quite conservative insofar as exploitation of the run is concerned. On the other hand, such a number of adult walleyes is possibly quite large enough to furnish reasonably good fishing in the impoundments (the transferred walleyes do return downstream) because they are available to anglers fishing in the impoundments over a more or less extended period of time. In the past, as judged from tagging returns, harvest of fish (walleyes) planted in the impoundments has been somewhat more intensive than it has been for fish tagged and returned to the river. The fate of walleyes reared in the impoundments by natural reproduction needs further investigation. Present information indicates that many of these fish leave the impoundments and migrate downstream when they reach maturity, but more evidence on this point is needed. Continued investigation of this problem, and also on the effect on walleyes passing through the turbines, is planned.

INSTITUTE FOR FISHERIES RESEARCH

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