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PROGRESS REPORT ON THE CONTROL EXPERIMENTS INVOLVING MARKED AND UNMARKED

LAKE TROUT FINGERLINGS AT THE STATE FISH HATCHERY,

MARQUETTE, MICHIGAN

by

David S. Shetter

When the extensive marking program on lake trout fingerlings for release in Lake Michigan was initiated in September, 1944, an integral part of that operation was the establishment of control experiments on each fin combination used to determine the comparative mortality and growth of marked and unmarked fish under identical conditions. A group of marked fish also was held separately each year to determine the extent of fin regeneration among the marks chosen. This report will discuss the data available from the control experiments since their inception in September, 1944, and includes information on the 1944 mark (dorsal and adipose fins clipped), and the 1945 mark (right pectoral fin clipped). It is too early at this date to present any information on the 1946 mark (left pectoral fin clipped) since less than 4 months have elapsed since the experiment on that mark has begun.

GENERAL PROCEDURE

Each year when the lake trout fingerlings were clipped at the U. S. Fish and Wildlife Station at Charlevoix, marked and unmarked lake trout fingerlings were drawn from each trough at random. One group of marked and unmarked fish were set aside to check on comparative growth and mortality. In 1944, 2,007 marked and 2,000 unmarked fish were used in this phase of the work, while 1,003 marked fish were held separately for the investigation on regeneration. Average lengths and weights were determined on both marked and unmarked fish by measuring and weighing 25 percent of the mortality controls and 20 percent of the regeneration controls. In 1945 and 1946, all fish were measured, and total weights and average weights obtained by weighing the control fish in groups of 10 on a Chatillon balance in water.

At the conclusion of the marking operations each year at Charlevoix, the control experiments have been transferred by tank truck to the State Fish Hatchery at Marquette, Michigan. The experimental lake trout have been held at this location because of the availability of pond space and also because of good water supply for growing lake trout. The 1944 experiment was transferred to outdoor ponds on arrival at Marquette, and remained outside until March 6, 1945, when they were brought inside the station and held in troughs until May, 1945. A severe epidemic of "pop-eye" prompted this move, and was easier to treat inside than in the ice-covered ponds.

Since that time, the experimental fish have been held in the hatchery troughs over the winter immediately following their marking.

The control experiments have been checked twice each year since they were established, in March and again in October. At that time all ponds were drawn down, and the experimental fish were sorted, counted, weighed, and measured. A random series of scale samples also has been collected on two occasions. Daily records of the mortality occurring in any of the experimental ponds are kept by the Marquette Hatchery staff.

COMPARATIVE MORTALITY BETWEEN MARKED AND UNMARKED

LAKE TROUT FINGERLINGS

1944 marking -

The 1944 marking involved the clipping of the dorsal and adipose fins. The experiment was begun with 2,000 normal fish and 2,007 clipped lake trout fingerlings in September, 1944. On examination in March, 1945, and the total mortality on the clipped fish amounted to 27.9 percent on the normal fish to 30.6 percent (Table 1). Mortality among the fish held for regeneration check in a separate pond had amounted to 34.9 percent.

Because of the obvious overcrowding that would occur as these fish grew larger, the 1944 experiments were reduced at this time (after the counting) to 1,005 marked and 1,005 unmarked fish for the comparative mortality and growth investigation, and to 500 fish for regeneration examinations.

On examination in October, 1945, it was found that there had been a mortality of 66.6 percent among the dorsal-adipose-clipped fish, and a mortality of 59.5 percent among the normal fish. Mortality among the regeneration controls amounted to 49.0 percent. These percentages, and all future percentages on the 1944 experiments, are based on the numbers of fish to which the 1944 control experiments were reduced in March, 1945.

Table 1.--Comparative mortality data on the 1944 mark (dorsal and adipose fins) used on fingerling lake trout, showing numbers present on various dates of examination.

Item	Mortality experiment		Regeneration experiment
	Unclipped	Clipped	
Start - Sept. 17, 1944	2,000	2,007	1,003
Observed mortality 9/44 - 3/45	235	450	189
Totals counted 3/6/45	1,398	1,447	653
Unobserved mortality 9/44 - 3/45	367	110	161
Total percentage of mortality 9/44 - 3/45 (Observed - Unobserved)	30.6 (11.8-18.8)	27.9 (22.4-5.5)	34.9 (18.8-16.1)
Experiment reduced 3/6/45	1,005	1,005	500
Observed mortality 3/45 - 10/45	102	151	107
Totals counted 10/5/45	407	336	255
Unobserved mortality 3/45 - 10/45	496	518	138
Total percentage of mortality 3/45 - 10/45 (Observed - Unobserved)	59.5 (10.1-49.4)	66.6 (15.1-51.5)	49.0 (21.4-27.6)
Observed mortality 10/45 - 3/46	3	3	1
Totals counted 3/13/46	364	296	251
Unobserved mortality 10/45 - 3/46	40	37	3
Total percentage of mortality 3/45 - 3/46 (Observed - Unobserved)	63.8 (10.4-53.4)	70.5 (15.3-55.2)	49.8 (21.6-28.2)
Observed mortality 3/46 - 10/46	19	4	...
Totals counted 10/4/46	325	273	...
Unobserved mortality 3/46 - 10/46	20	19	...
Total percentage of mortality 3/45 - 10/46 (Observed - Unobserved)	67.7 (12.3-55.4)	72.8 (15.7-57.1)	...

In March, 1946, the mortality in the various categories was as follows: Between March, 1945, and March, 1946, 63.8 percent of the normal fish had died or disappeared and 70.5 percent of the clipped fish were missing from the comparative mortality and growth experiment; and 49.8 percent of the clipped fish retained for regeneration examination had vanished. The regeneration experiment was concluded shortly after this date, as it had served its purpose, as will be described later in this report.

When examined last in October, 1946, the 1944 control fish had suffered the following mortalities between March, 1945 and October, 1946: Clipped fish, 72.8 percent, normal fish, 67.7 percent, a 5.1 difference in rate of mortality in favor of normal unmarked fish.

Some mention must be made concerning the great variations between the percentage of observed mortality and the percentage of unobserved mortality. The 1944 experiments were in open ponds from October 1944, until ice covered the ponds in early December, and undoubtedly some mortalities were caused by bird predation, particularly herring gulls and blue herons. These fish were transferred outside in May, 1945, but the pond was not screened over the top until June 19, and birds again could have removed an unknown number of fish. The chicken wire screens over these fish were removed with the first heavy snow in November, 1945, and replaced on March 29, 1946, and was left until November, 1946.

Other factors which may have produced the unobserved mortality are: (1) cannibalism among the experimental fish because of a range in

total lengths varying from 53 to 113 millimeters at the various dates of examination; (2) escapement of fish through or under retaining screens. From the standpoint of logic, all the factors discussed or mentioned would operate on both the marked and unmarked fish equally so that the observed plus the unobserved mortality provides a proper measure for comparison. This is born out by the data in Table 1, where it will be noted in the last three examinations that the unobserved mortality on both marked and unmarked fish was almost equal.

1945 marking -- The lake trout fingerlings planted in 1945 were marked by clipping the right pectoral fin. For the comparative mortality and growth study, 1,000 unclipped and 1,001 clipped fish were retained, and 499 clipped fish were held for observations on regeneration of this mark (Table 2). When examined in March, 1946, the total percentage of mortality of the normal (unclipped) fish was observed to be 5.1 percent, of the clipped fish, 2.3 percent. Mortality among the regeneration controls (held by themselves in a separate trough) amounted to only 1.4 percent.

On the last examination in October, 1946, the mortality on the various groups of fish was as follows: In the comparative mortality and growth experiment, normal fish, 10.0 percent; clipped fish 14.1 percent, or a 4.1 difference in mortality in favor of the normal fish. It must be pointed out that if the unobserved mortality on marked and unmarked fish had been anywhere near comparable, the total mortalities very likely would have been at least equal for the two groups. Why there is so much difference in the last unobserved mortality is hard to

Table 2.--Comparative mortality data on the 1945 mark (right pectoral clipped) used on fingerling lake trout, showing numbers present on various dates of examination.

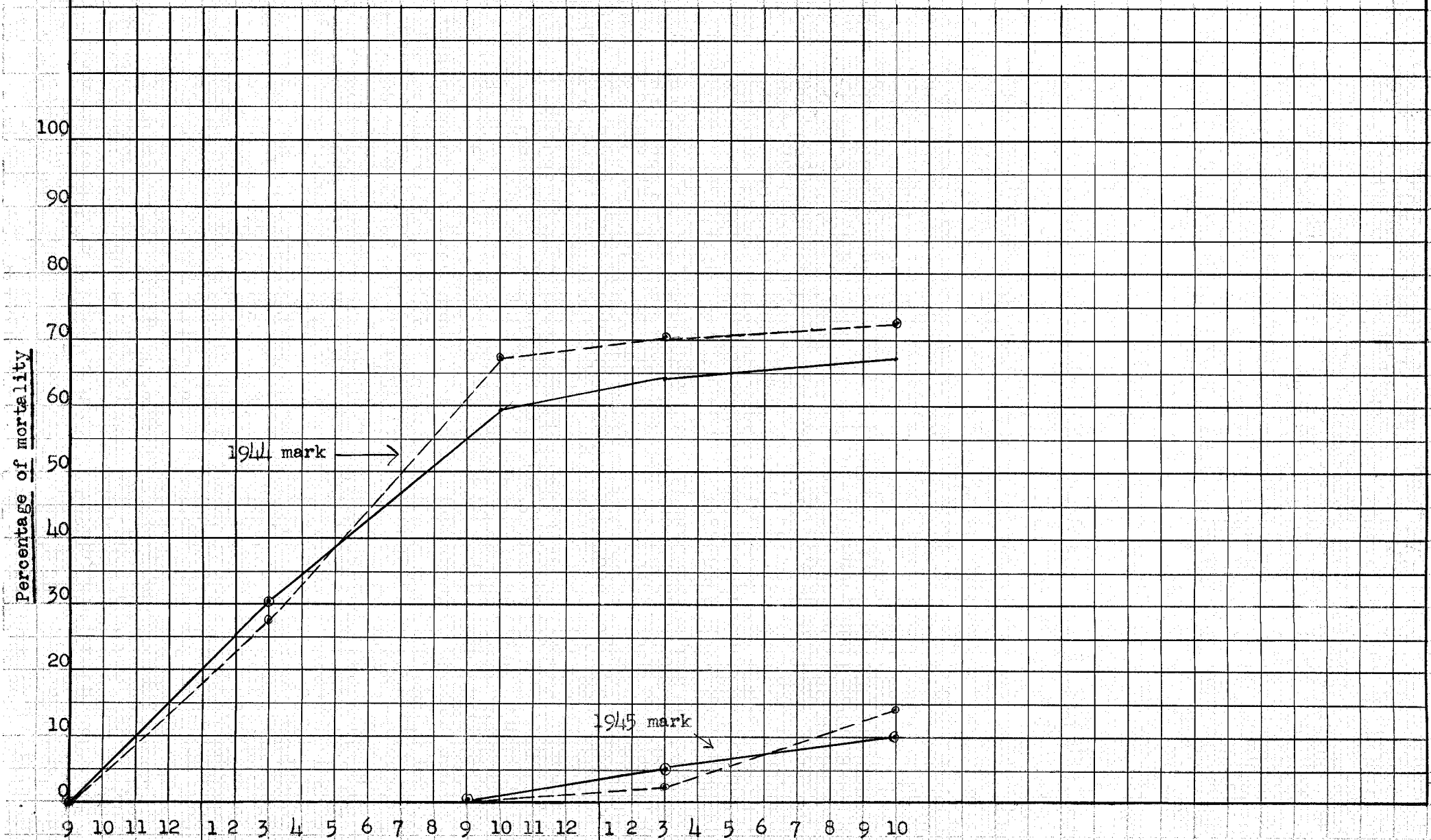
Item	Mortality experiment		Regeneration experiment
	Unclipped	Clipped	
Start - Sept. 12, 1945	1,000	1,001	499
Observed mortality 9/45 - 3/46	12	2	2
Totals counted 3/13/46	949	978	492
Unobserved mortality 9/45 - 3/46	39	21	5
Total percentage of mortality 9/45 - 3/46 (Observed - Unobserved)	5.1 (1.2 - 3.9)	2.3 (0.2 - 2.1)	1.4 (0.4 - 1.0)
Observed mortality 3/46 - 10/46	38	17	14
Totals counted 10/4/46	900	860	328
Unobserved mortality 3/46 - 10/46	11	101	150
Total percentage of mortality 3/46 - 10/46 (Observed - Unobserved)	10.0 (5.0 - 5.0)	14.1 (1.9 - 12.2)	34.2 (3.2 - 32.2)

explain, since the pond holding the 1945 comparison experiment was screened over as soon as the experiment was transferred outside in April, 1946, and the marked and unmarked fish were very close to the same average size.

The excessive unobserved mortality in the regeneration experiment can be explained as follows: To save pond space, the 1944 mortality-growth comparison experiment was confined to the lower portion of the first pond used, and was separated from ^{the} 1945 regeneration experiment by a screen and bulkhead. Unfortunately, in August, 1946, this bulkhead suffered a washout because it had not been sheet-piled deeply enough. This permitted mixture of dorsal-adipose-clipped, right pectoral-clipped, and normal unmarked 1944 lake trout. The foot screen of the pond was of 1/2-inch mesh. As soon as this situation was discovered, repairs were made to the separating bulkhead and the fish were sorted into their proper retaining ponds. However, it is suspected that some of the smaller right-pectoral-marked fish escaped into the open stream after passing through the 1/2-inch mesh while mixed with the larger fish of the 1944 experiment (which 1/2-inch mesh was sufficiently small to retain).

The progressive comparative mortality between marked and unmarked lake trout fingerlings of the 1944 and 1945 markings is illustrated graphically in Figure 1. The data on which it is drawn up is taken from ^{be} Tables 1 and 2. It will be noted that there was considerably less mortality on the 1945 right pectoral mark, and also on the 1945 normal fish than for the 1944 fish. Reasons which might account for the variation in the mortality between the two markings are:

Figure 1.--Comparative rates of mortality for marked (-----) and unmarked (——) fish from the 1944 (dorsal and adipose clipped) mark and the 1945 (right pectoral clipped) mark used on lake trout fingerling planted in Lake Michigan. Data taken from tables 1 and 2.



1. The 1945 fingerlings have received more protection from the elements and from aerial predation than the 1944 fingerlings.

2. The numbers of fish in the 1945 experiment were only half that used in 1944, which may have resulted in higher survival in covered troughs.

3. The 1945 fingerlings were of a larger average size at the time of clipping than the 1944 fingerlings.

4. Only one fin was clipped in 1945, whereas two fins were removed in 1944. The extra handling and additional cut may have contributed to the higher mortality in 1944.

COMPARATIVE GROWTH BETWEEN MARKED AND UNMARKED LAKE TROUT FINGERLINGS
HELD UNDER IDENTICAL CONDITIONS

1944 marking -- In September, 1944, at the start of the control experiments on this mark, 2,000 normal fish were of an average total length of 74.6 millimeters and their average weight was 3.4 grams. The average size of 2,007 clipped fish was 73.5 millimeters total length and 3.1 grams in weight. Regeneration controls (1,003) were of an average total length of 73.5 millimeters and their average weight was 3.2 grams (Table 3). These averages were obtained by measuring and weighing 500 marked and 500 unmarked fish from the comparison group and 200 marked fish from the regeneration experiment. In March, 1945, when the 1944 experiment was reduced, 1,000 each of the marked and unmarked fish of the comparison experiment were measured and weighed, and 500 marked fish from the regeneration experiment. After that date all fish present in all experiments were measured individually and weighed in large groups.

Table 3.--Comparative growth data between marked and unmarked lake trout fingerlings from the 1944 (dorsal and adipose fins) and 1945 (right pectoral fin) markings. (Range in total length is given in parentheses under each date).

Date	Mortality Experiment						Regeneration Experiment		
	Unclipped fish			Clipped fish			Clipped fish		
	Number	Average length (millimeters)	Average weight (grams)	Number	Average length	Average weight	Number	Average length	Average weight
Dorsal-adipose - 1944 clipping									
Sept. 17, 1944 (45 - 103)	2,000	74.6	3.4	2,007	73.5	3.1	1,003	73.5	3.2
March 6, 1945 (68 - 121)	1,005	93.4	5.0-	1,005	93.6	5.1	500	93.7	4.8
Oct. 5, 1945 (105-210)	407	164.9	38.0-	336	162.4	35.8	255	167.4	39.6
March 13, 1946 (130-243)	364	185.4	48.5	296	184.3	52.2	251	188.5	53.1
Oct. 4, 1946 (190-347)	325	261.0	139.3	273	256.2	136.1	...	...	...
Right pectoral - 1945 clipping									
Sept. 12, 1945 (54 - 109)	1,000	81.9	4.8	1,001	81.5	4.6	499	82.5	4.7
March 13, 1946 (70 - 136)	949	106.4	...	978	105.6	...	492	107.5	9.1
Oct. 4, 1946 (105 - 218)	900	169.4	38.1	860	169.2	37.6	328	175.2	39.0

The growth of the marked and unmarked fish in the 1944 comparison experiment has been almost identical. On the March, 1945, examination, the marked fish had gained an average of 1.3 millimeters more than the unmarked fish. In October, 1945, the increase in length of the normal fish averaged 1.4 millimeters more than the marked fish. At the March, 1946 check, both marked and unmarked fish had an average gain up to that time of 110.8 millimeters. The normal fish were of a slightly larger average size in October, 1946, having gained an average of 3.4 millimeters more than the marked fish since the previous examination. Stated in a different way, under identical conditions, unmarked lake trout fingerlings gained 1.3 percent more length than did dorsal-adipose-clipped lake trout fingerlings in the same period of time.

1945 marking -- The fish for this year were marked by removing the right pectoral fin. One thousand (1,000) unmarked fish were of an average total length of 81.9 millimeters and their average weight was 4.8 grams; confined with them were 1,001 clipped fish whose average total length was 81.5 millimeters and whose average weight was 4.6 grams. The regeneration controls (499) were of an average total length of 82.5 millimeters and their average weight was 4.7 grams.

On the two examinations of the 1945 control experiments since their initiation the differences between the average increases of marked and unmarked fish has been 0.4 of a millimeter or less. In March, 1946, the normal fish had an average gain of 24.5 millimeters over the September, 1945, measurements, while the clipped fish showed an average increase of 24.1 millimeters. In October, 1946, average increase in length for the

marked fish for 13 months amounted to 87.7 millimeters; for the unclipped fish, 87.5 millimeters, or the percentage increase over the original length was 0.8 percent greater for the marked fish.

A study of Table 3 also will show that the average increases in length of the regeneration controls for both the 1944 and 1945 experiments were greater than the average increases already described. Presumably this capability to grow faster resulted from the confinement of fewer fish in a proportionately larger pond space than in the mortality-growth comparison experiments.

The average increases in weight of the marked and unmarked fish, both of the 1944 and 1945 experiments, have not been discussed since the same conclusions are reached that are obtained from a study of the increases in average length.

The average total length of the 1944 and 1945 marked and unmarked fish are shown in Figure 2 for the various dates of examination. This graph shows how closely the growth of marked and unmarked fish has paralleled each other since the initiation of both 1944 and 1945 experiments.

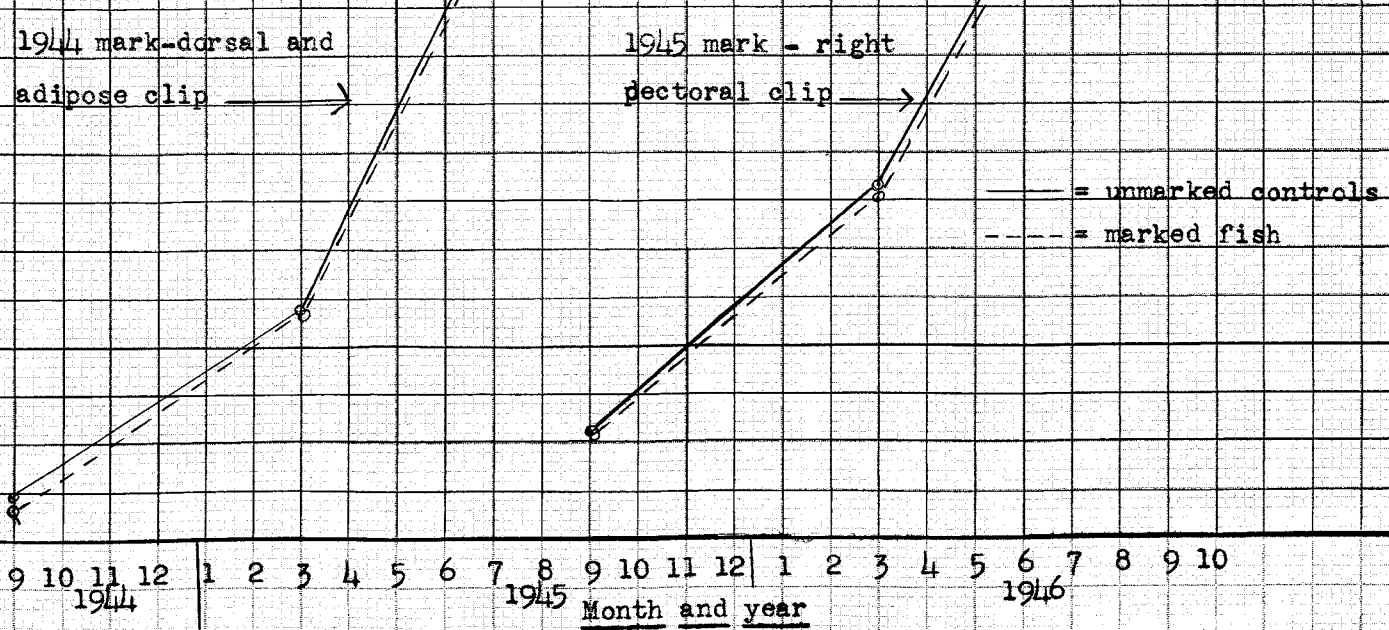
OBSERVATIONS ON FIN REGENERATION AMONG FIN-CLIPPED

LAKE TROUT FINGERLINGS

1944 marking -- Of the dorsal-adipose mark used in 1944, 1,003 clipped fish were first set aside, but this number was later reduced to 500 in March, 1946. In October, 1946, the survivors (255 in number) were examined for regeneration. At that time 254 were measured as they were inspected.

In assaying these marked fish held for determination of regeneration, varying amounts of re-growth of both adipose and dorsal fin were found.

Figure 2.--Average size of 1944 (dorsal-adipose clip) mark and 1945 (right pectoral clip) mark compared with average sizes of unmarked lake trout fingerlings confined in the same ponds over the same period of time. Data taken from Table 3.



It is believed that this regeneration was due to failure to remove the entire fin along its junction with the body in the original clipping operation.

Five degrees of regeneration were established arbitrarily; none, $1/4$, $1/2$, $3/4$ and full. As two fins were involved in the 1944 marking, a total of 25 combinations of regenerated fins might have been found. Actually only 17 combinations were encountered (Table 4) on two different dates of examination, but not the same 17. Regeneration was estimated with frequent reference to a specimen with normal fins. The method might be said to be an estimate of the fin area regenerated regardless of whether it was the forward quarter of the fin, the quarter of the fin nearest the body, or some proportion of the rear part of the fin.

Of the 254 dorsal-adipose-clipped fish examined in October, 1945, 121 or 47.6 percent showed no regeneration of either fin. Complete regeneration (or a complete miss in the clipping operation) was noted for five fish, or 1.9 percent of the total examined. Fourteen and nine-tenths percent (38 fish) with the dorsal fin $1/4$ regenerated but with no re-growth of the adipose fin, while 9.4 percent (24 fish) had re-established $1/4$ of both fins. The combination of no dorsal regeneration and $1/4$ regeneration of the adipose fin was observed in 8.2 percent of the total examined. The remaining 12 combinations of fin regeneration were represented by from one to 10 fish each.

The nine most visually recognizable of the fin combinations as they have regenerated are underlined in the first column of Table 4. It is felt that because of the small amount of regeneration noted in

Table 4.--Summary of observations on fin regeneration among dorsal-adipose-clipped and right pectoral-clipped lake trout fingerlings held at Marquette Hatchery.

Regeneration of		October 5, 1945		March 13, 1946		Regeneration of right pectoral	March 13, 1946		October 4, 1946	
		Number of fish with combination	Percentage of total present with combination	Number of fish with combination	Percentage of total present with combination		Number of fish with re-generation	Percentage of total present with re-generation	Number of fish with re-generation	Percentage of total present with re-generation
Dorsal	Adipose									
None	None	121	47.6	129	51.4	None	474	96.4	257	78.4
	1/4	21	8.2	16	6.4	1/4	12	2.4	47	14.3
	1/2	2	0.8	1	0.4	1/2	3	0.6	11	3.4
	3/4	3	1.2	...	0.0	3/4	2	0.4	6	1.8
	Full	2	0.8	3	1.2	Full	1	0.2	7	2.1
1/4	None	38	14.9	40	15.8	...	...	...	...	...
	1/4	24	9.4	18	7.2	...	...	...	...	...
	1/2	4	1.7	1	0.4	...	...	...	...	...
	3/4	2	0.8	...	0.0	...	...	...	...	...
	Full	...	0.0	1	0.4	...	...	...	...	...
1/2	None	5	1.9	12	4.8	...	...	...	...	...
	1/4	10	3.9	7	2.8	...	...	...	...	...
	1/2	6	2.4	3	1.2	...	...	...	...	...
	3/4	...	0.0	2	0.8	...	...	...	...	...
	Full	...	0.0	...	0.0	...	...	...	...	...
3/4	None	3	1.2	3	1.2	...	...	...	...	...
	1/4	3	1.2	3	1.2	...	...	...	...	...
	1/2	1	0.4	...	0.0	...	...	...	...	...
	3/4	...	0.0	...	0.0	...	...	...	...	...
	Full	...	0.0	...	0.0	...	...	...	...	...
Full	None	4	1.7	4	1.6	...	...	...	...	...
	1/4	...	0.0	1	0.4	...	...	...	...	...
	1/2	...	0.0	...	0.0	...	...	...	...	...
	3/4	...	0.0	...	0.0	...	...	...	...	...
	Full	5	1.9	7	2.8	...	...	...	...	...
Totals	...	254	100.0	251	100.0	...	492	100.0	328	100.0

both fins in these combinations that they will be identifiable in the future by all interested anglers, commercial fishermen and investigators. The total of such fish present in these combinations amounts to 231, or 90.9 percent of the total examined.

Examination of this same group of fish in March, 1946, of which 251 were still present indicated that comparatively little additional regeneration had taken place. In the nine most visually recognizable groups, a total of 227 fish were found, or 90.4 percent of the total examined. As little change was noted since the previous examination, this group of experimental fish was turned over to the Watersmeet Hatchery for planting in inland lakes of Michigan in April, 1946.

1945 marking -- Excision of the right pectoral fin constituted the 1945 mark, and 499 clipped fish were retained for examination of regeneration. Examination of these fish in March, 1946, using the same general criteria as for the 1944 experiment, gave the following results: No regeneration, 96.4 percent (474 fish); 1/4 regeneration, 2.4 percent (12 fish); 1/2 regeneration, 0.6 percent (3 fish); 3/4 regeneration, 0.4 percent (2 fish); and full regeneration, 0.2 percent (1 fish). The first three groups (no regeneration, 1/4 and 1/2 regeneration) contained 99.4 percent of the total present.

These fish were examined again in October, 1946, with the following results: Of 328 experimental fish present, 257, or 78.4 percent showed no regeneration; 47, or 14.3 percent were 1/4 regenerated; 11, or 3.4 percent were 1/2 regenerated, 6, or 1.8 percent were 3/4 regrown; and 7, or 2.1 percent were fully regenerated or missed in the original clipping operation. In the three most easily recognized groups 315 fish were found or 96.1 percent of the total present.

Knowledge of the amount of fin regeneration, as determined by the experiments, make possible corrections of the percentage of mortality as determined by the mortality experiments previously discussed. It will be seen that mortality figures on the fin-clipped fish would be reduced slightly, and would be increased correspondingly for unclipped fish. However, no corrections have been applied to the mortality data presented in this report.

A higher percentage of fish with regenerated fins was found among the 1944 dorsal-adipose-clipped fish than among the 1945 right pectoral-marked lake trout fingerlings. Possible reasons for this difference in amount of regeneration are:

1. Size of the fish at the time of marking (the 1944 fish were smaller at the time of marking)
2. A greater lineal length of fins had to be removed in the 1944 mark than in the 1945 mark.

CONCLUSIONS

After 25 months of operation of the 1944 control experiments, and 13 months of operation on the 1945 control investigations, it seems reasonable to conclude the following:

1. Total mortality among dorsal-adipose clipped lake trout fingerlings over 25 months has been 5.1 percent higher than among unclipped lake trout fingerlings confined at the same time in the same water. Both lots of fish were approximately of the same average total length and average weight at the start of the experiment.
2. Total mortality among right pectoral-clipped lake trout fingerlings over 13 months has been 4.1 percent higher than among normal lake

trout fingerlings of the same approximate average size held under identical conditions.

3. Mortality on all 1945 experimental fish was considerably less than on the 1944 controls. The possible factors which may have caused this difference are: More protection from severe weather and from bird predation for the 1945 experiments; a difference in the average size of the experimental fish in the two years; and possibly the fact that only one fin was clipped in 1945, while two fins were removed in 1944.

4. As determined from average lengths at several dates of examination, the 1944 dorsal-adipose-marked fish grew almost at the same rate as normal fish held under identical conditions, as the percentage increase over their original average length was only 1.3 percent less than that noted for normal fish.

5. The 1945 right pectoral-marked lake trout fingerlings grew very slightly faster than did the normal fish confined with them, as the marked fish showed a percentage increase over their original average length which was 0.8 percent higher than found for the unclipped fish.

6. In both of the regeneration experiments varying amounts of fin regeneration were found. In the dorsal-adipose mark of 1944, it was estimated that at least 90.4 percent of the marked fish would be recognizable as such. As this percentage had not changed very much between October, 1945, and March, 1946, this portion of the 1944 experiments was concluded.

The 1945 experiment involving the right pectoral mark has fewer regenerations among the individuals held. Thirteen months after the start, less than 4 percent would be difficult or impossible to recognize as right pectoral clipped fish.

The possible corrections to the mortality data which the results of the regeneration experiments imply have not been applied.

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