A COMPARISON OF THE LOSSES OF JAW, CHEEK, DART, AND SPAGHETTI TAGS; AND THEIR EFFECTS ON THE SURVIVAL AND GROWTH OF TROUT UNDER HATCHERY CONDITIONS

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ABSTRACT

This paper describes an experiment designed to compare lower jaw, spaghetti, cheek, and dart tags as to their effects on the survival and growth of trout and their rates of loss. Four lots of rainbow (and a few brown) trout containing 23 of each with the above marks and 23 adipose fin clipped fish as a control were held in separate hatchery batteries for a period of four months. At the end of the experiment the surviving tagged fish were planted in Parvin Lake, Colorado.

According to the ease and speed of correct application the tags were ranked; 1) jaw, 2) cheek, 3) dart, and 4) spaghetti. Application of the last three tags produced a puncture wound which healed satisfactorily in most cases.

Ninety-six percent of the fish survived to the end of the experiment. There were no significant differences in survival as among the five marks or the four batteries.

There was a significant loss of the jaw tags (11%), cheek tags (28%) and dart tags (73%) as compared to the losses of the spaghetti tags (1%) and the adipose fin clips (2%). The larger fish retained the cheek tag better. From these results and from some reported in the literature it was concluded that the spaghetti and jaw tags are least subject to loss. The great losses of the cheek and dart tags make them of little use for the species and sizes of fish used in this experiment. The results of other studies indicate that they may be of use for other species and larger fish.

The total lengths of the trout used in this experiment ranged from 6.2 to 13.5 inches at the beginning and from 8.0 to 17.0 inches at the end. Two distinct size groups of fish were used, of which the smaller (mean length of 7.9 inches) showed an overall mean increase in total length of 3.7 inches and the larger (mean length of 11.8 inches) of 2.6 inches. The mean increases in length of the smaller fish with the jaw and cheek tags were significantly less than those of the smaller fish with the adipose fin clip and the spaghetti tag. There were no significant differences in the mean increases in length of the larger fish with these marks. The effects of the dart tags on growth could not be determined since so few fish retained their tags. Other studies have found a reduction in the growth rates of jaw, cheek, and spaghetti tagged fish.

The rates of recovery of the different kinds of tagged fish by fishermen were not significantly different in this study or in most of the other studies reported on. Cheek and Petersen tagged fish are reported to be more vulnerable to gill nets than are jaw or spaghetti tagged fish.

INTRODUCTION

In recent years some new types of fish tags have come into use. The cheek tag was developed by Cable (1950) for use in marking shad. The spaghetti tag (Wilson, 1953) and the dart tag (modified from a Woods Hole tag by Yamashita and Waldron, 1958) have been developed in California for use in marking ocean fishes. The results of using some of these tags in fisheries work in Colorado suggested that more needed to be known about their reliability and effects on the fish. Accordingly, this experiment was set up in order to evaluate the following factors: 1) the immediate effects and the ease of application of the tags, 2) the rates of loss of the tags, 3) the effects of the tags on the survival of the fish, and 4) the effects of the tags on the growth of the fish. Cheek, spaghetti, and dart tags were compared to the old standby, the lower jaw tag. Adipose finclipped fish were used as a control. Rainbow and brown trout were marked with these tags and held under hatchery conditions for a period of four months. Following this, the surviving, tagged fish were planted in a lake and their relative rates of recovery by fishermen were determined.

METHODS AND MATERIALS

This experiment was carried out at the Bellvue Hatchery of the Colorado Department of Game and Fish between February 20 and June 18, 1959. Four, two-part batteries were utilized to hold the fish. The batteries are arranged side by side (lengthwise) so that the water flows through them in a serpentine fashion from the upper battery (#1) to the lower battery (#4). Each two-part battery had a total length of from 55 to 68 feet and a width of six feet. The water depth varied between 12 and 14 inches. The water supply was from a spring and well combined. The average flow was 160 gallons per minute and the temperature ranged from 52 to 56° F.

Since the numbers of fish available at the time were limited, the marking procedure was somewhat complicated, as detailed below. On February 20, there were 75 trout marked and placed in battery #1. Then 75 more trout were marked and placed in battery #2. For each battery there were 15 fish each with the following marks: adipose fin clip, jaw tag, cheek tag, dart tag, and spaghetti tag. Following this, it became apparent that there would not be enough of these smaller fish to give the desired 25 fish of each mark in each battery. Therefore, some larger fish that were available were used. Five each of these were marked as above, bringing the total to 20 fish with each mark in each battery. On February 21, this procedure was repeated for batteries #3 and #4. At this time there were still some of the larger fish left, so an additional three were marked to bring the total to 23 with each mark in each battery, or a total of 115 fish per battery. Most of the fish used were rainbow trout (435) but there were a few brown trout (25) mixed in with these. The marks were applied alternately - for each battery - as recommended by Rousefell and Kask (1949).

All of the fish were anaesthetized in urethane before marking and measuring.

The fish were kept in the same batteries throughout the experiment. They received the regular hatchery feed. The hatchery personnel picked up all of the lost tags from the bottom of the batteries and removed all of the dead fish each day during the course of the experiment.

At the end of the experiment, all of the fish were measured and examined for a mark. On June 26, 1959, the surviving, tagged fish were planted in Parvin Lake, Colorado. Their relative rates of recovery by fishermen during the summer were determined from a partial creel census being made there by fishery students from Colorado State University.

The jaw tags were round, numbered, monel bands (size #8). They were clamped around the lower jaw of the fish (see Figure 1) with special curved pliers. The cheek tags consisted of a 5/16 inch stainless steel rivet with a 5/16 inch, numbered, yellow, plastic disk. They were attached to the operculum (see Figure 2) by means of the special pliers (Cable, 1950) developed for this. The dart tag used was the FT-2 of the Floy Tag and Manufacturing Company of Seattle, Washington. It consists of a single nylon barb inserted into a three-inch length of yellow vinyl tubing. Numbers are printed on the tubing. This tag was inserted just posterior to the dorsal fin by means of a hollow, steel needle and pushed forward in an attempt to engage the interneurals with the barb (see Figure 3). The spaghetti tags consisted of a length of yellow, vinyl tubing (Resinite EP-2, #20) threaded through the back of the fish just posterior to the dorsal fin (see Figure 4) by means of a modified aluminum knitting needle. The ends were secured by crimping a numbered monel band (size #4) around them.

Figure 1. Lower jaw tag.

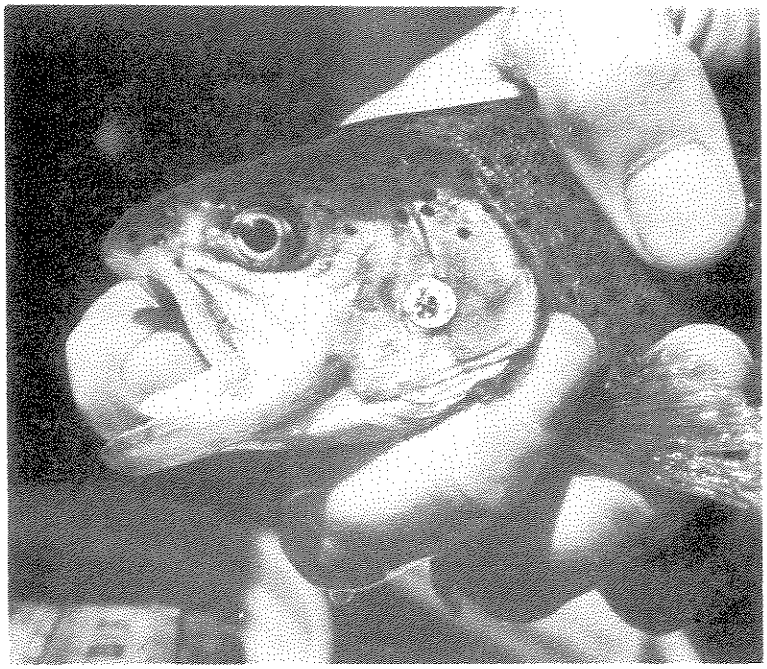

Figure 2. Cheek tag.

Figure 3. Dart tag.

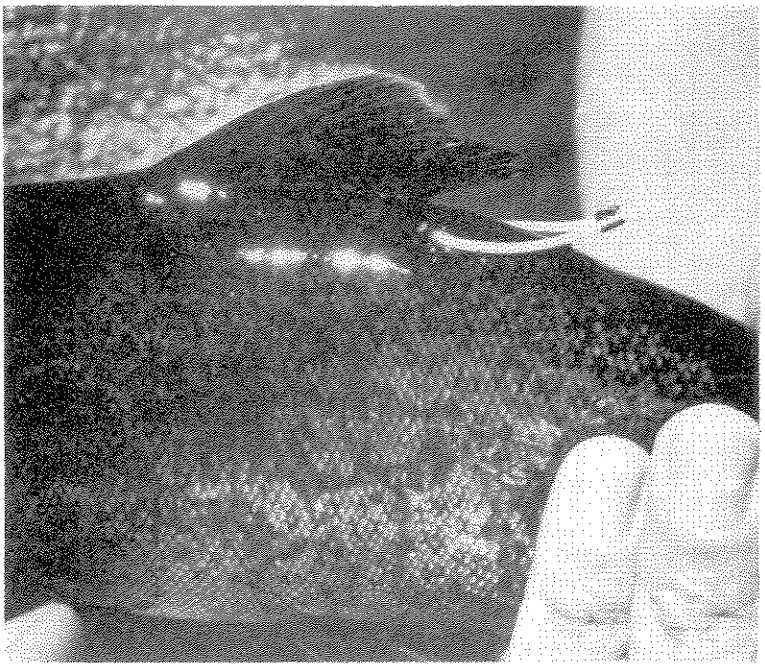

Figure 4. Spaghetti tag.

RESULTS

Immediate Effects and Ease of Application of the Tags

The jaw tags were the easiest and fastest tag to apply correctly. Furthermore, they caused the least injury to the fish. No particular irritation of the jaw was noted, but where the fish were large and growth was considerable, the tag became deeply imbedded in the flesh. Corson (1959) found that jaw tags became embedded in the mandible of large, male, rainbow trout and in some cases the jaw was fractured or torn.

The cheek tag took somewhat longer to apply than the jaw tag since more care was necessary in lifting the operculum and inserting the jaws of the pliers so as not to damage the gills. Furthermore, the pliers did not always work correctly and the whole process then had to be repeated. If this tag was not attached far enough forward on the operculum, it would tear out rather easily. The rivet made a small puncture wound, of course, but in most cases it healed satisfactorily.

Application of the dart tag was a little slower than that of the cheek tag. Some difficulty was experienced both in pushing the tag through the skin of the fish (due to the rather soft needles used) and in getting the barb to engage in bone or flesh. Quite often the tag came out as the needle was withdrawn and had to be re-applied. The immediate effect of the wound made by the application of this tag was a discoloration in the skin around the area, due to hemorrhage. In fish which had lost these tags the wound healed so well that little or no evidence of it could be seen. In a few of the fish which retained these tags, the wound did not heal well (see Figure 3). This tag tended to accumulate algal growths.

Application of the spaghetti tag was the most time consuming since it involved several separate motions. A steel needle would be better than the soft aluminum needle that was used. The monel band crimped over the ends of the tubing is believed to be superior to the usual method of tying a knot. It has an ineradicable number on it and is much easier to apply. We have found it very difficult to tie a knot in the small piece of tubing with wet and cold hands. The wound made by the application of this tag is perhaps more serious than that for any of the others. However, in most cases it healed satisfactorily. In a few cases the wound remained raw, probably due to the wearing action of the tag. This tag also tended to accumulate algal growths.

Survival and Tag Loss

Of the 460 fish at the beginning of the experiment, 442 (96%) were recovered four months later. Of these survivors, 342 (78%) had retained their mark. The total known mortality was 13 fish (3%). Five fish (1%) disappeared.

The results are summarized in Table 1 according to mark and battery. There were two fish and seven lost tags found in batteries other than those they were originally put in, but these have been included in the results for the original battery in Table 1. The lost tags are those actually found in the batteries. Likewise, the mortalities are the dead fish that were found. The unaccounted for fish are those for which no lost tag was found, or which disappeared. The unmarked fish are the surivivors which had lost their mark. The disappeared fish are those which escaped, were taken by predators, or were missed in the final census.

Since the fish with each kind of tag were not also marked with a distinctive fin clip, it was not possible to completely separate tag loss and mortality. The numbers of observed mortalities were too few for any tests to be made. However, it is apparent that there was little difference as

Table 1. Survival and tag loss according to mark and battery over a 4 month period (see text for further details).

Battery	1	2	3	4	Totals
Adipose fin clipped	22	21	23	23	89
Mortalities	1	0	0	0	1
Unaccounted for	0	2	0	0	2
Spaghetti tagged	23	22	23	21	89
Lost tags	0	0	0	0	0
Mortalities	0	1	0	1	2
Unaccounted for	0	0	0	1	1
Jaw tagged	22	19	21	18	80
Lost tags	1	2	1	0	4
Mortalities	0	1	0	1	2
Unaccounted for	0	1	1	4	6
Cheek tagged	14	15	17	16	62
Lost tags	4	4	3	6	17
Mortalities	1	0	2	1	4
Unaccounted for	4	4	1	0	9
Dart tagged	7	4	10	1	22
Lost tags	15	15	11	19	60
Mortalities	0	1	1	1	3
Unaccounted for	1	3	1	2	7
Unmarked	24	28	17	31	100
Mortalities	0	1	0	0	1
Total survivors	112	109	111	110	442
Total mortalities	2	4	3	4	13
Disappeared	1	2	1	1	5

between marks (1 to 4 mortalities) or batteries (2 to 4 mortalities). Three of the known mortalities occurred within three days after marking and may have been due to the effects of the handling and marking. Of the other ten mortalities, four were in March, four were in April, and one each were in May and June. Those in March and April may have been due to some delayed effects of the marking. A comparison of the numbers of survivors and of the other fish (mortalities plus disappeared) as between the batteries showed that they were homogeneous ($X^2 = 1.14$, 3 df., $P = 0.77$).

From these results it was concluded that none of the tags used had a significant effect on the survival of the fish. It is possible that the loss of many of the cheek and dart tags may have obscured any effects of these on survival. Stroud (1953) found that cheek tags had no effect on the survival of trout held in a hatchery for 2-1/2 years. It is difficult to evaluate the effects of tags on survival under field conditions due to the effects on growth, tag loss, and varying vulnerability to the type of gear used. However, some information on this score is presented in the final section on tag recovery under field conditions.

The numbers of fish (for all batteries) that survived and retained their jaw tag (see Table 1) and of those that did not (lost tags plus unaccounted for) were found to be significantly less than those of the spaghetti tagged and adipose fin clipped fish ($X^2 = 11.48$, 2 df., $P < 0.01$).

The numbers of fish that survived and retained their cheek tag (see Table 1) were obviously significantly less than for the above three marks. The numbers of these cheek tagged fish were not significantly different as between the batteries ($X^2 = 1.95$, 3 df., $P = 0.59$). Since there were two rather distinct size groups of fish used, it is of interest to compare the losses of the cheek tag accordingly. There were 36 out of 59 (surviving plus

disappeared fish) of the smaller fish and 25 out of 29 of the larger fish which retained their cheek tags. Thus there was a significantly greater loss of the cheek tags from the smaller fish ($X^2 = 6.03$, 1 df., $P = 0.01$).

The losses of the dart tags were much greater than for any of the other tags (see Table 1). The numbers of fish that survived and retained their dart tag (and of those that did not) were significantly different as among the batteries ($X^2 = 10.70$, 3 df., $P = 0.02$). There were 11 out of 58 of the smaller fish and 11 out of 31 of the larger fish which retained their dart tags. Thus there was not a significantly greater loss of the dart tags from the smaller fish ($X^2 = 2.35$, 1 df., $P = 0.13$). Three dart tags were lost during the first day of the experiment. After that the losses rose to a maximum (8) in the eighth week. The losses thereafter were less (from 1 to 4 per week). These losses were significantly different as between two week periods ($X^2 = 16.78$, 7 df., $P = 0.02$).

It is difficult to account for the differences in dart tag losses as between the four batteries. Possibly slight differences in the techniques of applying the tag may have been responsible. The fish in battery #4 were tagged last and the loss of the tags was greatest there. Also, this battery is at the end of the row so that visitors can easily walk around it to view the fish. The hatchery superintendent stated that these tagged fish were a source of attraction to visitors, who stood around the batteries and caused the fish to become agitated. This may have caused the loss of some of the tags. Occasionally, fish were observed to make passes at the dart tags on other fish. Some of the tags may have been pulled out this way, but this should not have been a differential factor between the four batteries. The overall pattern of loss of the dart tags is also difficult to explain. One would expect

that poorly applied tags would come out quite soon. Perhaps the period of eight weeks represents the time required for the wound to heal and seal the dart tags in more effectively.

The maximum possible numbers of lost marks were calculated by adding the numbers of known lost tags and the numbers of unaccounted for fish (survivors for which no lost tag was found and fish which disappeared cannot be separated). For the adipose fin clipped fish a maximum of two (2%) lost their mark (regenerated the fin or else were not clipped in the first place). For the spaghetti tagged fish only one (1%) of the fish may have lost its mark. For the jaw tagged fish a maximum of 10 (11%) lost their mark. For the cheek tagged fish a maximum of 26 (28%) lost their mark. For the dart tag a maximum of 67 (73%) lost their mark.

These results show that--on the basis of tag loss over a four month period--the spaghetti tag was the most reliable. Collyer (1954) says that the staying powers of this type of tag were excellent. Kimsey (1956) found no loss of this type of tag from largemouth bass held in aquaria, except for one tag which caught on brush and was pulled out. Milne and Ball (1958) got better recoveries of Petersen tagged salmon than of spaghetti tagged salmon on hook and line. They thought it was due to loss of the spaghetti tags because the knots came untied. Spaghetti tags have been used in marking trout for making population estimates in Upper Camp Lake, Colorado, over a period of four years (Nelson, 1960 a). During this time a total of 199 of these fish have been recovered. Fourteen (7%) of these had lost the tag as shown by the distinctive scar on the back.

On the basis of these results, the jaw tag was usable but less reliable than the spaghetti tag. Eschmeyer (1959) found that 91% of lake trout marked with a strap tag on the lower jaw survived and retained their tag over a period

of one year in a hatchery. In Parvin Lake, Colorado, the loss of jaw tags from 8 to 10 inch, planted rainbow trout, which had also been marked with a fin clip, was determined (Boyd, 1954). Of the 334 fish caught by fishermen in the same year the fish were planted, 15 (4%) had lost their tags. In the second year, 3 (5%) out of 61 had lost their tags. In the third year, 7 (43%) out of 16 had lost their tags.

The results of this experiment indicate that the cheek tag was not reliable for the size of trout used. It may be usable for larger fish or for those with a stronger operculum. Stroud (1953) found from 1 to 3% loss of cheek tags from trout held in a hatchery for a month.

Likewise, the results of this experiment indicate that the dart tag used was not reliable. It may not have been applied correctly or in the best place. However, a tag which is difficult to apply correctly is of little use. Yamashita and Waldron (1958) state that this type of tag remained firmly anchored in the yellowfin tuna to which it was applied. Blunt and Messersmith (1960) got good recoveries of skipjack marked with this tag.

Effects on Growth

Since the two rather distinct size groups of fish were used, it was necessary to analyze the results accordingly. At the beginning of the experiment the smaller-sized lot of fish (300) ranged in total length from 6.2 to 10.7 inches with a mean of 7.9 inches. The larger-sized lot of fish (160) ranged in total length from 10.1 to 13.5 inches with a mean of 11.8 inches. Since the length-frequency distributions for each lot of fish were approximately normal, the analysis of variance test was applied to each lot to see if the fish for each mark and battery had been chosen randomly according to length. The results (Table 2) show that this was the case except for the larger

fish in battery #2, which had a significantly smaller mean length than the others.

Table 2. Analysis of variance tests of the mean total lengths of the fish at the beginning of the experiment according to size group, mark, and battery (* significant at the 5% level).

Source	Smaller Fish		Larger Fish	
	F	df.	F	df.
Batteries	1.63	3, 280	2.93*	3, 140
Marks	1.48	4, 280	0.80	4, 140
Interaction	0.59	12, 280	0.88	12, 140

At the end of the experiment the overall range in total length was from 8.0 to 17.0 inches. The mean increases in total length of the fish surviving and retaining the adipose fin clip, the spaghetti tag, and jaw tag, and the cheek tag (see Table 3) were compared as among the batteries and separately for the two size groups by analysis of variance. Each increase is the mean of from 7 to 15 of the smaller fish and from 5 to 8 of the larger fish. While the individual adipose fin clipped survivors could not be recognized, it is thought that the error in assigning them to the size groups was negligible. There were too few dart tagged survivors for them to be included in the tests.

For the smaller fish there was no significant difference as between the batteries ($F = 1.31$; 3, 9 df.) but there was as between the marks ($F = 6.69$; 3, 9 df.). It is obvious that there is no significant difference between the mean increases in length for the adipose fin clipped fish and the spaghetti tagged fish, but that these are significantly greater than the mean increases for the jaw and cheek tagged fish. For the larger fish there was no significant difference as between batteries ($F = 2.64$; 3, 9 df.) or marks ($F = 2.17$; 3, 9 df.).

The surviving fish which lost their marks (large and small) showed a mean increase in length of from 3.3 to 3.6 inches as among the batteries. This was slightly less than that for the adipose fin clipped fish.

Table 3. The mean increases in total length (inches) according to size group, mark, and battery.

Battery	1	2	3	4	Total
Smaller size group					
Adipose	3.9	4.0	4.0	3.7	3.9
Spaghetti	3.9	3.8	3.8	3.7	3.8
Jaw	3.8	3.6	3.7	3.4	3.6
Cheek	3.6	3.6	3.5	3.7	3.6
Dart	3.5	3.0	3.8	3.3	3.6
Total	3.8	3.8	3.8	3.6	3.7
Larger size group					
Adipose	2.6	3.4	2.6	2.7	2.8
Spaghetti	2.6	3.0	2.4	2.6	2.6
Jaw	2.5	2.1	2.3	2.6	2.4
Cheek	2.6	3.0	1.9	2.1	2.4
Dart	3.0	2.8	2.8	-	2.8
Total	2.6	2.9	2.4	2.5	2.6

The above results indicate that the spaghetti tag did not have a significant effect on the growth of the fish. Tebo (1957) found no effect of spaghetti tags on the growth of largemouth bass held in a pond for one year. Nelson (1960 b) found that spaghetti (and Petersen) tagged rainbow trout planted in a pond showed no significant growth over a period of three months, whereas finclipped rainbow trout did.

The jaw tags had a slight but significant effect on the growth of the smaller fish in this experiment. Eschmeyer (1959) found that lower jaw tags retarded the growth of lake trout held in a hatchery for one year by about 25% as compared to adipose fin clipped fish. Corson (1959) found that jaw tags affected the growth of male rainbow trout, but not of female rainbow trout, held in a hatchery for a period of three years. Schuck (1942) found a significant difference in the weights, but not the lengths, of jaw tagged and untagged brown trout recovered from a stream. Ricker (1942), Ball (1947), Smith et. al. (1952), and Tebo (1957) have all found a lower growth rate for jaw tagged fish under field conditions. However, it should be pointed out that it is difficult to separate the effects of mortality, tag loss, gear vunerability, and growth in such studies.

The cheek tag had a significant effect on the growth of the smaller fish in this experiment. Stroud (1953) found no effect of this tag on growth when used on various species of fish in Massachusetts. Eschmeyer (1959) found that the cheek tag retarded the growth of lake trout held in a hatchery for one year by about 25% as compared to adipose fin clipped trout.

The dart tag may have affected the growth of the smaller fish, although the results are not reliable due to the small number of fish which retained the tag. Everhart and Rupp (1960) say that dart tagged brook trout showed acceptable growth over a period of six months in a hatchery, but did not compare them to untagged fish.

Relative Recoveries of the Tags under Field Conditions

The numbers of the different kinds of tagged fish planted in and recovered from Parvin Lake, Colorado, are given in Table 4. All of these fish were caught by fishermen between June 26 and July 31, 1959. Since the creel

census was only partial, the numbers of recoveries are also only partial but are comparable as between tags. The numbers of the different tagged fish recovered (and not recovered) were homogeneous (X^2 = 3.37, 3 df., P = 0.34), i.e., the rates of recovery were not significantly different for the different tags.

Table 4. Relative recoveries of tagged fish after planting in Parvin Lake, Colorado.

Tag	Number Planted	Number Recovered
Spaghetti	88	21
Jaw	79	12
Cheek	60	11
Dart	21	2
Total	248	46

Little can be concluded from these results regarding survival and tag loss under field conditions. It does appear that all of the fish with the different kinds of tags were equally catchable. Ricker (1942) found that jaw tags reduced the catchability of sunfish by hook and line. Nelson (1960 b) found that the numbers of unmarked, both pelvic fin clipped, Petersen tagged, and spaghetti tagged rainbow trout caught by fishermen from Mosquito Lake, Colorado, were not significantly different from those expected on the basis of the numbers of each originally planted in the lake. Nelson (1959 and 1960 a) found that there were no significant differences in the vulnerabilities of fin clipped, jaw tagged, cheek tagged, or spaghetti tagged trout to the flyrod (on the basis of marked fish recaptured in making population estimates in the Rawah lakes, Colorado).

Some information on the recoveries of tagged fish by other types of gear is also available. Eschmeyer (1959) found that the returns of jaw and cheek tagged lake trout from Lake Superior were less than half those of Petersen tagged fish. He says that this was primarily due to the greater vulnerability of the Petersen tagged fish to the gill nets used by the commercial fishermen. Both Davis (1959) and Nelson (1960 b) have found that Petersen tagged fish are more vulnerable to the gill net than are spaghetti tagged fish. Nelson (1959 and 1960 a) found that cheek tagged trout were more vulnerable to the gill net than were jaw or spaghetti tagged trout. Blunt and Messersmith (1960) got better returns of dart tagged than of spaghetti tagged skipjack. They thought this was due to the lower tagging mortality associated with the dart tagging. Yamashita and Waldron (1958) got higher returns from dart tags than from other types of tags (including spaghetti) used previously on tuna.

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LITERATURE CITED

Ball, R. C. 1947. A tagging experiment on the fish population of Third Sister Lake, Michigan. Trans. Am. Fish. Soc. 74: 360-369.

Blunt, C. E. Jr. and J. D. Messersmith. 1960. Tuna tagging in the eastern tropical Pacific, 1952-1959. Calif. Fish and Game 46(3): 301-369.

Boyd, J. 1954. Returns to the creel of hatchery reared eight to ten inch rainbow trout from Parvin Lake. Colo. Dept. of Game and Fish, Denver, Colo., 35 pp., mimeo.

Cable, L. E. 1950. A cheek tag for marking fish, with semi-automatic pliers for application of tag. J. du Cons. Int. pour l'Exp. de la Mer 16(2): 185-191.

Collyer, R. D. 1954. Tagging experiments on the yellowtail, Seriola dorsalis. Calif. Fish and Game 40(3): 295-312.

Corson, B. W. 1959. Jaw tags and sexual dimorphism in mature rainbow trout. Prog. Fish Cult. 21(3): 134.

Davis, W. S. 1959. Field tests of Petersen, streamer, and spaghetti tags on striped bass, Roccus saxatilis (Walbaum). Trans. Amer. Fish. Soc. 88(4): 319-329.

Eschmeyer, P. H. 1959. Survival and retention of tags, and growth of tagged lake trout in a rearing pond. Prog. Fish Cult. 21(1): 17-21.

Everhart, W. H. and R. S. Rupp. 1960. Barb-type plastic fish tag. Trans. Amer. Fish. Soc. 89(2): 241-242.

Kimsey, J. B. 1956. Largemouth bass tagging. Calif. Fish and Game 42(4): 337-346.

Milne, D. J. and E. A. R. Ball. 1958. The tagging of spring and coho salmon in the Strait of Georgia in 1956. Fish Res. Bd. Can., Pacific Prog. Reports 111: 14-18.

Nelson, W. C. 1959. Rawah-McIntyre high lakes project. Progress Report for 1957 and 1958. Colo. Dept. of Game and Fish, Denver, Colo. 56 pp., mimeo.

_____. 1960 a. Rawah-McIntyre high lakes project. Progress report for 1959. Colo. Dept. of Game and Fish, Denver, Colo., 30 pp., mimeo.

_____. 1960 b. A study of some population estimation methods as applied to Mosquito Lake, Colorado, 1956-1957. Colo. Dept. of Game and Fish, Denver, Colo., 34 pp., mimeo.

Ricker, W. E. 1942. Creel census, population estimates, and rate of exploitation of game fish in Shoe Lake, Indiana. Inves. Ind. Lakes 2: 215-253.

Rounsefell, G. A. and J. L. Kask. 1945. How to mark fish. Trans. Am. Fish Soc. 73: 320-363.

Schuck, H. A. 1942. The effect of jaw tagging upon the condition of trout. Copeia 1942: 33-39.

Smith, L. L. Jr., L. W. Krefting, and R. L. Butler. 1952. Movements of marked walleyes, Stizostedion vitreum vitreum (Mitchill) in the fishery of the Red Lakes, Minnesota. Trans. Am. Fish. Soc. 81: 179-196.

Stroud, R. H. 1953. Notes on reliability of some fish tags used in Massachusetts, J. Wld. Mgmt. 17(3): 268-275.

Tebo, L. B. Jr., 1957. Preliminary experiments on the use of spaghetti tags. Proc. 10th Ann. Conf. Southeastern Assoc. Game and Fish Comm., Columbia, S. C., pp. 77-80. Taken from Biological Abstracts 1959, #8908.

Wilson, R. C. 1953. Tuna marking, a progress report. Calif. Fish and Game 39(4): 429-442.

Yamashita, D. T. and K. D. Waldron. 1958. An all-plastic dart-type fish tag. Calif. Fish and Game 44(4): 311-317.