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Effects of Carlin tagging on the mortality and growth of sea trout *Salmo trutta* L.

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In the Vardnes river in northern Norway 8375 brown trout *Salmo trutta* L. smolts and 4352 larger sea trout were captured and tagged when descending and 2248 were tagged when ascending. All migrating fish were tagged individually when they were caught in the traps for the first time. The tagging process reduced the survival rate of the smolts with 17%, while the tagging process had no measurable negative effect on the mortality of the larger-sized trout. Growth of untagged and tagged fish were similar and no effect of tagging on growth-rate was thus recorded.

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INTRODUCTION

Our knowledge of the biology of migratory fishes has, to a large extent, been gained from tagging experiments using external tags. In spite of the rather voluminous literature describing the effects of tags on fish (e.g. Hourston 1958, Youngs 1958, Eschmeyer 1959, Mills 1959, Power & Shooner 1966, Isaksson & Bergman 1978, Kennedy *et al.* 1982), few have been able to quantify these effects (Jensen 1981).

Tagging experiments involve two main risks (Wetherall 1982): Firstly, the attachment of a tag to a fish is likely to cause stress and injury, that may lead to an increase in mortality over and above that resulting from capture alone. Secondly, the mortality of the tagged fish may be greater than that of untagged fish due to several external factors, e.g. they may be more easily detected by predators, and they may be liable to increase fishing mortality in the netfishery. Tags may also reduce the growth-rate of the fish (Power & Shooner 1966, Saunders & Allen 1967).

From the results of a tagging experiment performed in the Vardnes river, northern Norway, an estimation of the effects of the tagging process i.e. the attachment of the tag could be worked out for sea run migrant brown trout, sea trout *Salmo trutta* L. The ability to quantify the differences in the mortality due to tagging is useful, although the total effect of tagging on mortality cannot be estimated in the present paper. Furthermore, possible negative effects of tagging were also investigated by comparing length and weight of untagged and tagged fish in the traps, and by comparing daily growth rates of newly tagged fish with that of fish with old tags.

MATERIAL AND METHODS

Traps for catching fish descending to or ascending from the sea were operated in the Vardnes river on the island of Senja in Troms province, northern Norway (69° 10'N, 17° 30'E). The traps separated between descending and ascending fish and they were situated about 250 m above the estuary. They were operated during 1956—1963 and 1967—1970. A description of the river system and the traps has been given by Berg (1977). The catchment area of the river is about 16,5 km². The mean water flow is 1 m³/s, increasing to 16 m³/s at times of flood, but dropping to a mere 0.2 m³/s during dry periods in summer. From the Vardnes lake to the sea, the river is about 1,2 km long and at normal flow it is about 7,5 m wide. The river generally freezes up in October and the ice-cover has usually broken up by the end of May. The sea trout

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stay in freshwater during winter and in the sea during summer (Berg & Berg 1987). All the trapped fish were examined and those untagged were anaesthetized with MS-222 (tricaine methane sulphonate about 50 mg/l), and tagged close to the base of the dorsal fin, with a numbered Carlin tag (Carlin 1955). Total length (cm) and weight (to the nearest 10 g) of each fish were recorded.

A total of 8375 smolts and 4352 larger sea run migrant brown trout were tagged when descending while 2248 were tagged when ascending. 4481 sea trout were later recaptured in the traps and of these 1796 were recaptured more than once.

The recaptured trout were divided into two groups: Fish recaptured for the first time after tagging (new tags) and those recaptured repeatedly (old tags). The fraction of sea trout being recaptured after tagging (new tags) can thus be compared with the fraction of repeatedly recaptured fish (old tags). The relationship between these two groups can be used to estimate the effects of the tagging process.

The length-frequency distribution (Fig. 1) of the descending and ascending sea trout exhibits three major groups representing the first and second time migrants and older fish. The following length groups and notations have therefore been employed in the subsequent treatment of the data:

Descending sea trout (seaward migration)

On first descent (smolt)	< 24 cm	termed D-1 group
On second descent	24-32 cm	termed D-2 group
On third, or later descent	> 32 cm	termed D-3 + group

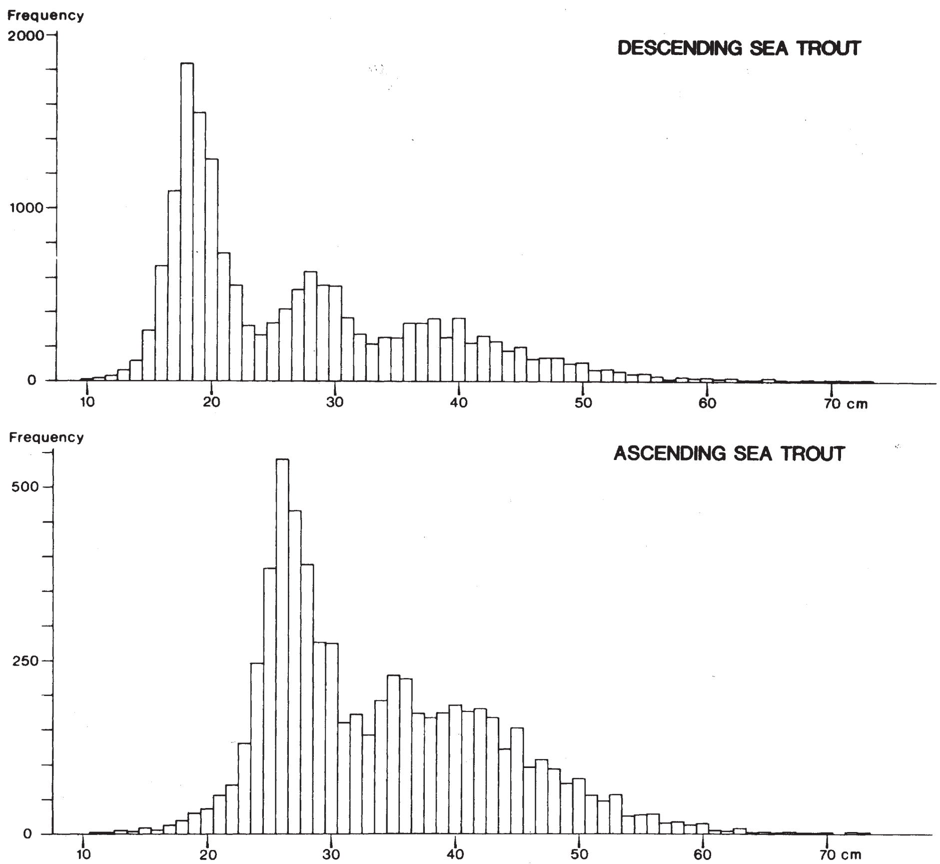

Fig. 1. Length-frequency distributions of the descending and ascending sea trout caught in the Vardnes river traps.

Ascending sea trout (upstream migration)

On first ascent	< 31 cm	termed A-1 group
On second ascent	31-37 cm	termed A-2 group
On third, or later ascent	> 37 cm	termed A-3 + group

The validity of the chosen length groups of first and second time migrants (D-1 to A-2) can be checked from the trap records, as these will indicate the proportion of misplaced fish. Out of a total of 8547 descending sea trout < 24 cm in length, 172 had been tagged previously as downstream or upstream migrating first time migrants. Seven sea trout out of a total of 3856 measuring 24—32 cm had been recaptured on more than two previous occasions. Out of a total of 2962 ascending sea trout < 31 cm in length, 33 had been recaptured more than once previously and 31 out of a total of 1116 measuring 31—37 cm had been recaptured on more than three previous occasions. In spite of the fact that trap efficiency has been below 100%, the above mentioned results show that the chosen values for length in the groups D-1 to A-2 fit well. The rates of recapture in the traps of fishes with old tags were compared with that of fishes with new tags to estimate the effects of the Carlin tagging on fish of similar length.

In 1975 an additional experiment was conducted as both capture and handling of fish easily leads to the loss of scales. 200 descending sea trout between 28 and 58 cm in length were trapped and tagged. From 100 of these fishes, scale samples were taken from the region between the dorsal and the adipose fin. The recapture rates of these two groups were compared to investigate whether any differences existed.

RESULTS

There is, as normally found, a numerical increase in survival rate with increase in size of smolts (Table 1). This is in accordance with the results of others, e.g. Kennedy et al. (1982). Among the D-1, 14.5% of those with old tags (sea trout less than 24 cm, previously tagged as migrating fish) returned compared to 10.2% of those with new tags. Since only one of the recaptured sea trout with an old tag was less than 19 cm in length, the data for those less than 19 cm ought to be excluded from the calculations of the effects of tagging. The calculated return rate for newly-tagged sea trout between 19 and 23 cm in length was thus 12.8% compared to 15.4% for the corresponding group of sea trout with old tags ($p<0.05$; Wilcoxon paired sample test). The return rate of the smolts thus decreased by about 17% as a consequence of the tagging.

The percentage of returns for the D-2 group with new tags was higher (20.0%) than that for those with old tags (17.4%). The

Table 1. Rates of return of the different length groups of tagged and of recaptured sea trout in the sea.

Length groups	N descending Tagged	N descending Recaptured	N ascending Recaptured (new tags)	N ascending Recaptured (old tags)	% return (new tags)	% return (old tags)
< 14 cm	128	-	-	-	-	-
14 cm	115	1	3		3	-
15 cm	290	1	20		7	-
16 cm	658	2	35		5	-
17 cm	1090	5	90	1	8	20
18 cm	1819	7	160		9	-
19 cm	1531	15	181	1	12	7
20 cm	1256	25	163	3	13	12
21 cm	708	30	102	5	14	17
22 cm	515	35	71	8	14	23
23 cm	265	51	30	7	11	14
D-1	8375	172	855	25	10,2	14,5
D-2	2446	1410	489	245	20,0	17,4
D-3 +	1906	2524	598	782	31,4	31,0

Table 2. Rates of return of tagged and of recaptured sea trout after residence in freshwater

Length groups	N descending Tagged	N descending Recaptured (old tags)	N ascending Recaptured (new tags)	N ascending Recaptured (old tags)	% return (new tags)	% return (old tags)
A-1	1668	827	672	348	40	42
A-2	304	718	103	266	34	37
A-3 +	276	1403	142	645	51	46

length distribution of the two groups was almost identical.

No effect on mortality due to the tagging was noted for the largest-sized sea trout (D-3+) as 31.4% of those with new tags returned in comparison to 31.0% of those with old tags.

There was no significant difference in length frequency distribution between the 100 sea trout sampled for scales and those which were not. The descending sea trout varied in length between 28 and 58 cm (mean 42 cm). 18 of the sea trout from which scale samples were taken were recaptured, compared to 15 of the other group, i.e. no increase in mortality due to the scale sampling was noticeable.

There was no significant difference in recapture rate of newly tagged fish compared to fish with old tags when ascending into freshwater (Table 2), i.e. in freshwater, the tagging process does not seem to result in any increased mortality.

The mean lengths and weights of sea trout recaptured for the first time after tagging were compared with those of untagged sea trout caught in the traps (Table 3), either after their residence in the sea, or in freshwater. No significant differences were found. The daily increases in length and weight of newly tagged fish, compared to those of sea trout with old tags, were also calculated and no significant differences were found either after the sea sojourn (Table 4) or after the freshwater residence. Thus, the tagging has apparently not led to any reduction in growth.

DISCUSSION

Comparison of rates of returning after either being trapped and tagged (new tags) or trapped and measured (old tags) has been used as an estimate of the decrease in the total return rate as a consequence of the tagging process alone. This estimate, however, does not tell us the total effect of tagging, viz. the difference in return rates between tagged and untagged, unhandled fish.

The estimate of the effects of tagging on smolts is based on the fraction of recaptures of fish between 19 and 23 cm in length, where the largest smolts are found. In addition, the

Table 3. Number (N), mean length (1) in cm and mean weight (w) in g of the recaptured and of the untagged sea trout caught in the traps on the ascending and descending runs, respectively

Mean length and weight after residence in the sea

Length groups	Tagged N	Tagged 1	Tagged w	Untagged N	Untagged 1	Untagged w
A-1	865	26,1	181,6	2060	26,1	182,0
A-2	668	34,2	419,5	462	33,9	407,7
A-3 +	1381	45,0	945,0	379	44,5	901,0

Mean length and weight after residence in freshwater

Length groups	Tagged N	Tagged 1	Tagged w	Untagged N	Untagged 1	Untagged w
D-2	921	28,2	187,6	2508	28,1	182,1
D-3 +	1190	42,3	593,8	1948	40,9	562,8

Table 4. Number (N), mean daily increase in length (Δ1) (in cm) and in weight (Δw) (in g), of newly tagged compared with those with old tags after the sea sojourn.

Length groups	New tags N	New tags Δ 1	New tags w	Old tags N	Old tags Δ 1	Old tags W
A-1	855	0.11	1.9	25	0.11	2.5
A-2	411	0.10	4.0	223	0.10	3.9
A-3 +	508	0.07	6.3	707	0.06	6.3

percent of recaptures of the largest smolts with new tags have been compared with second time migrants within the same size group.

The average length of the recaptured D-1 sea trout with old tags was somewhat larger than that of the tagged sea trout with new tags. The natural mortality of the group of sea trout with old tags is therefore likely to be somewhat lower than the mortality rate of the newly tagged sea trout (Table 1). The estimated differences in mortality, due to tagging, should eventually tend to be overestimated.

Anon. (1984) reported a tag loss of 71% on sea trout from Ireland. The reported losses were to some extent dependent on the degree of experience of the tagging team. On Atlantic salmon *Salmo salar* L., Anon. (1983) reported tag losses of between 10% and 25%. Lister *et al.* (1981) reported a tag loss of about 10% on chinook (*Oncorhynchus tshawytscha* Walb.) and coho (*O. kisutch* Walb.), while Eames & Hino (1983) estimated tag losses on chinook to be about 2—5%. Arnason & Mills (1981) found annual tag loss rates between 1% and 70% on lake whitefish (*Coregonus clupeaformis* Mitch.). Tag loss cannot be estimated from the present data. Since relatively few of the sea trout caught in the Vardnes river were observed to bear a scar due to loss of a tag, the tag loss here is presumed to be fairly low.

There appeared to be a higher fraction of newly tagged returning D-2 in comparison to those with old tags in the sea. Also in freshwater the largest, A-3 + , newly tagged sea trout showed a higher rate of returning in comparison to the corresponding ones with old tags. Fast growing, and therefore relatively young fish, for their size, are likely to have been more recently caught for the first time in the traps and tagged than slower-growing and older fish. If the latter group also suffered a greater mortality due to natural causes like spawning, or had a higher rate of tag loss, such a result would be anticipated.

Many differences exist between the feeding migration into the sea and the freshwater residence. In freshwater the tagging process does not seem to result in any increased mortality. This may be due to the fact that the fish ascend into freshwater during the autumn, a time with falling water temperatures and thus less danger of serious infections occurring. Healing of tagging lesions among Atlantic salmon is known to be better at lower water temperatures, as is also the case in sea water (Roberts *et al.* 1973 a, b; Morgan & Roberts 1976).

Thus, the tagging process in itself does not seem to infer any detectable increase in mortality of larger sea trout, while a certain, but small, effect is visible among smolts. No significant differences in mean length and weight between untagged and tagged sea trout were detected. Neither were any significant differences detected in daily increases in length and weight of newly tagged sea trout compared to those with old tags. Thus, the tagging process has apparently not led to any reduction in growth of the sea trout. This finding agrees with the results obtained for brown trout by Alm (1950), Mills (1959) and Pickering *et al.* (1982). Data from tagged sea trout can therefore apparently be used in an analytical study of fish growth.

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