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GROWTH AND SEAWATER ADAPTATION IN ATLANTIC SALMON (SALMO SALAR) RAISED AT DIFFERENT EXPERIMENTAL PHOTOPERIODS.

By

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ABSTRACT

A study was made of the effect of day length and feeding-time on the smolting process and on growth of Atlantic salmon during smolting.

The experiment consisted of five experimental groups with different day lengths.

Highest growth rate and most seawater adapted fishes were found at the longest photoperiod, 24 hours of daylight and lowest growth rate and number of seawater adapted fishes were found at the shortest photoperiod, simulated natural photoperiod for Bergen.

INTRODUCTION

In Norway has been an increasing demand for Atlantic salmon smolts by fish farmers during the last years. The production of smolts for fish farmers was nearly doubled from 1974 to 1975. The production in 1974 was around 600.000 and in 1975 around 1.100.000 smolts. Almost half of these fishes were two year old smolts. In spite of increased production of smolts for fish farming in 1976, the demand this year considerably exceeded the supply (Olav Hansen pers. comm.).

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Another problem for Norwegian fish farmers has been that smolts often have been of poor quality. The rather great mortality, 20 - 60% during the first half year in sea (Møller and Bjerk, 1975) may to some degree be referred to fishes that were not completely smoltified at the transfer from fresh to seawater. Considering that fish farmers paid around 8 Norwegian crowns for each smolt in 1976, it is evidently important that the smolts are of high quality when entering seawater.

To get a better knowledge of the smoltification process in general and at the same time try to get results of practical importance for fish farmers we started laboratory experiments in 1974 (Knutsson and Grav, 1975). These experiments were carried out to study the effect of gradually increasing day length at different temperatures on the smolting process and on growth rate of Atlantic salmon during smolting.

The present paper reports an experiment started in 1975, which is a continuation of the experiment started in 1974. In the 1975 experiment we concentrated our investigation on the importance of the length of the photoperiod and feeding-time for the growth rate and smolting process of Atlantic salmon.

MATERIALS AND METHODS

Experimental fish.

Hatchery-reared yearling salmon from the research station, Fisk og Forsøk, N-5198 Matredal, belonging to the Institute of Marine Research, Bergen, were brought to the Institute on September 17th and the experiment were started on September 20th in 1975. Half the number of fishes were hatched around February 20th, 1975 and descended from fish caught in the river Suldalslågen on the west-coast of Norway inside Haugesund. The other half were hatched in the middle of January 1975 and descended from fish caught in the river Vosso north-east of Bergen.

In their natural environment fish from these populations start to migrate to sea in the beginning of May and migration continues till about the middle of June. The migration starts at a water temperature of 4-5°C and the migrators are usually 13-15 cm long and about 3 years old.

Experiment.

Fish-holding conditions and statistical methods were the same as in the previous experiment (Knutsson and Grav, 1975).

Fig. 1 shows the photoperiod for Bergen from June 1975 to June 1976 and the five experimental photoperiods $L_1 - L_5$, which were all started on September 20th, 1976.

Each experimental group consisted of two parallels. In the present paper the parallels are put together and treated as one group. The water temperature in the growth tanks was held at $11 \pm 0.5^{\circ}C$ for all groups.

The photoperiod L_1, 24 hours of light a day, was chosen because the automatic feeders were working as long as the light was on and therefore this group was supposed to give the greatest possible growth.

Too much light might have a restrictive effect on production of hormones essential for the smoltification and might also stress the fish in some other way. Stress may result in reduced growth and increased mortality caused by disease or aggression. A period with darkness, that will give the fish a chance to rest, might therefore have a positive effect on growth. Therefore a constant photoperiod with 5 hours of darkness and 19 hours of light (L_2) was chosen.

The fishes at the photoperiods L_3 and L_4 had received the same total amount of light at the last seawater tolerance test. The difference between the two photoperiods was that L_3 was constant while L_4 was gradually increased. A comparison between these two photoperiods may give an answer to the question whether a gradually increasing photoperiod enhance growth more than a constant one. Photoperiod L_5 follows the natural photoperiod for Bergen and serves as a reference.

The three seawater tolerance tests were called T_1, T_2 and T_3 and in Fig. 1 the starting dates of the tests, January 26th, March 29th and May 24th, 1976 are indicated by the corresponding letters.

At the tests 100 fishes from each group were tested. The fishes were starved for 24 hours before being put into the test tanks. The water volume in each test tank was about 250 l, the flow rate about 5 l/min. and the temperature was the same as in the growth tanks, $11 \pm 0.5^{\circ}C$.

Fish that were going to be tested for seawater tolerance were taken from their growth tanks and put directly into the test tanks. Dead fishes were removed from the test tanks during the test period.

All fishes in the test groups were weighed to the nearest 0.1 g and measured to the nearest mm (fork length). The fishes were weighed and measured immediately after death, or in the case of the surviving fishes when test was ended. Surviving fishes were marked with different symbols of cold branding before transferred to a seawater pond. The growth rate of the fishes in the seawater pond will be watched for six months and the growth rate will be published in a later paper.

RESULTS

Results of the three seawater tolerance tests, started on January 26th, March 29th and May 24th (Tests T_1, T_2 and T_3), are shown in Figs. 2-3. From the figures we see that growth rate during the experiment and survival during the tests were closely related to the length of the photoperiod. The longer the photoperiod, the better the growth and the higher the percentage of survivors at the tests. However, an exception was growth for fishes at photoperiod L_2 from March 29th to May 24th and survival for these fishes at test T_3. Survival for all groups increased from test T_1 to T_3 with an exception for L_5 where very few fishes survived the tests.

When testing the differences in survival at tests T_1-T_3 by a common χ^2 homogenity test we found significant differences ($p < 0.05$) between all the groups at T_1 with exception of the difference between L_4 and L_5. At test T_2 all differences were significant ($p \leq 0.01$). At test T_3 the difference between L_2 and L_3 was not significant. The differences between L_2- L_4 and L_3- L_4 were significant ($0.05 > p > 0.01$) and between the other groups at T_3 all differences were highly significant ($p < 0.001$).

Length distributions for the groups subjected to tests T_1, T_2 and T_3 are shown in Fig. 4. The figure shows that growth and survival were closely related to the length of the photoperiod and that proportion of survival increased from test T_1 to T_3. In addition Fig. 4 shows bimodality and the second peak of the curves becomes proportionally larger at longer photoperiods and from T_1 to T_3. For all groups the second peak to a larger part denote the surviving fishes.

When testing the differences in mean size between the fishes from the photoperiods at test T_3 with a t-test we found no significant difference between L_2 and L_3 but between the other photoperiods the differences were significant ($p < 0.005$).

DISCUSSION

The results with underyearling salmon described in this paper are in agreement with what was found in the earlier experiment by Knutsson and Grav (1975, 1976). In that experiment was clearly shown that young salmon's ability to survive abrupt transfer from fresh- to seawater and thus to osmoregulate is highly dependent on fish size.

Best growth rate was found at the photoperiod L_1 with 24 hours of daylight a day. This group also had the most survivors at all seawater tolerance tests. It seems as if young salmon do not need a period of darkness to rest, but grow better the longer the photoperiod and feeding-time is.

Growth rate at photoperiod L_2, with 19 hours of daylight a day, was slower than expected in the period between the tests T_2 and T_3. Survival for this group at test T_3 was also less than expected. At the moment no good explanation for this drop in growth rate and survival can be given.

When comparing L_3 with L_4 we see from Fig. 1 that L_3 had a longer photoperiod and feeding-time from the start of the experiment up to the first seawater tolerance test T_1. From test T_1 to T_3 group L_4 had a longer photoperiod and feeding-time and at the start of test T_3 the total amount of light and therefore the total duration of feeding-time were the same for the two groups L_3 and L_4. In spite of this we found that the fishes in group L_3 were bigger than the fishes in L_4 at this moment. Accordingly the survival for L_3 was also better than for L_4. This indicate that a long photoperiod and feeding-time is more important at the beginning than at the end of a growing period in order to get the biggest fishes.

When we compare L_1, 24 hours of daylight, with L_5, simulated natural photoperiod, (Figs. 2 and 3) we really see how important a long feeding-time is for growth and for survival during transfer from fresh to sea-water. At seawater tolerance test T_3 mean length for the fishes at photoperiod L_1 was more than 15 cm and for the fishes at photoperiod L_5 about 9 cm. Survival for the same groups at test T_3 were 90 respectively 7%.

However, before drawing any conclusion about the optimal photoperiod for raising smolt it is necessary to follow the growth rate of the fishes in the seawater phase. Without going deeper into the problem in this paper we may just mention that the proportions of really smolt-looking fishes were lower for photoperiod L_1 and L_2 than for L_3 and L_4. Many fishes at L_1 and L_2, in spite of a big size, still had clearly visible parr-markings.

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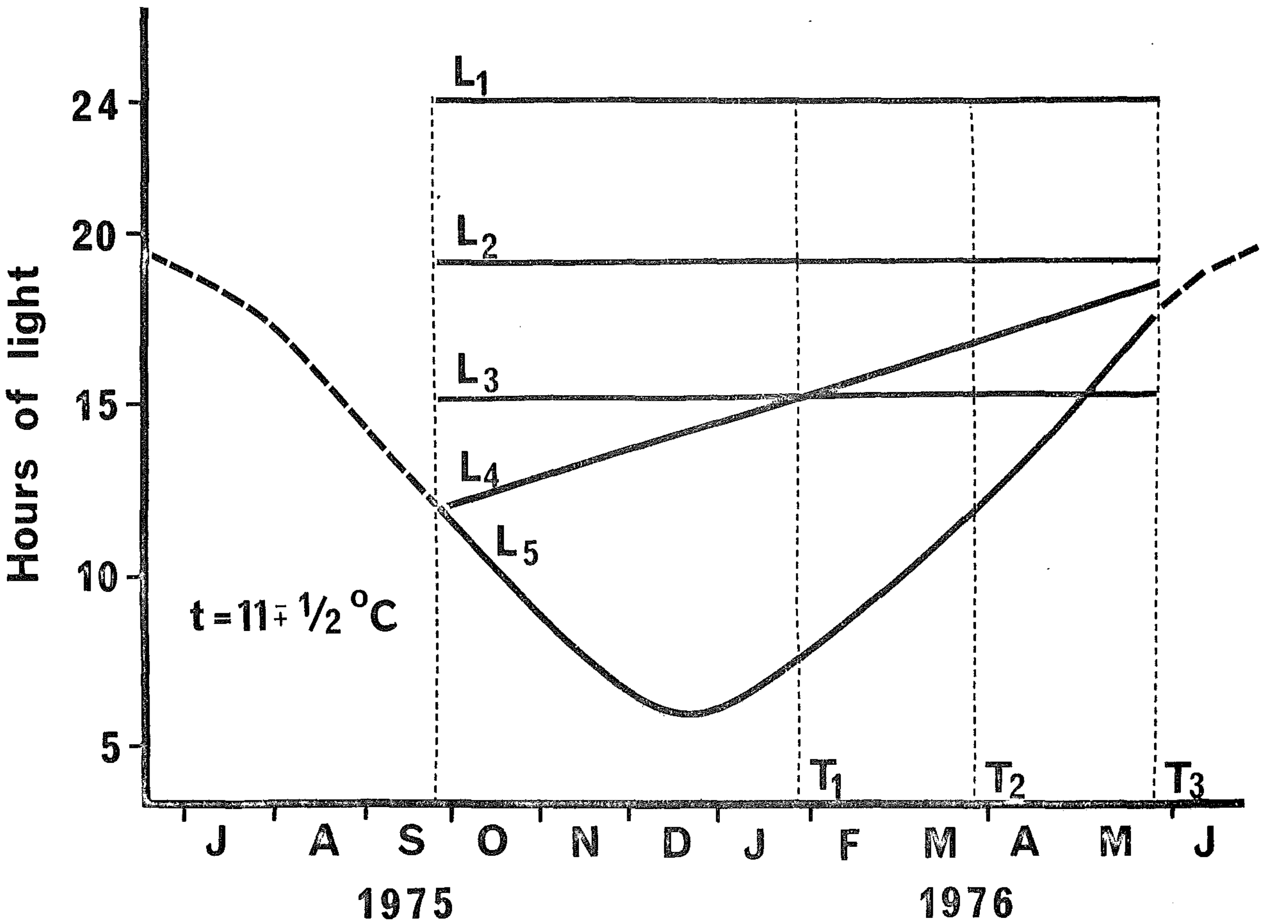

Fig. 1. Annual photoperiod cycle at Bergen and the five experimental photoperiods (L_1 - L_5). T_1, T_2 and T_3 denote the starting dates of seawater tests.

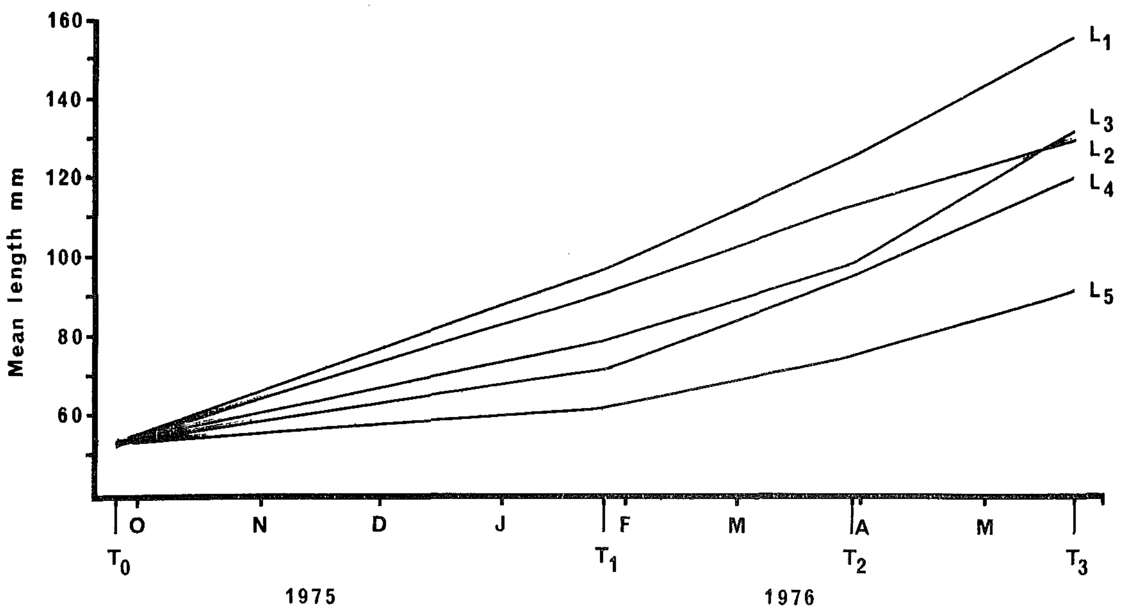

Fig. 2. Mean fish length (fork length) of each experimental group in seawater tests $T_1 - T_3$.

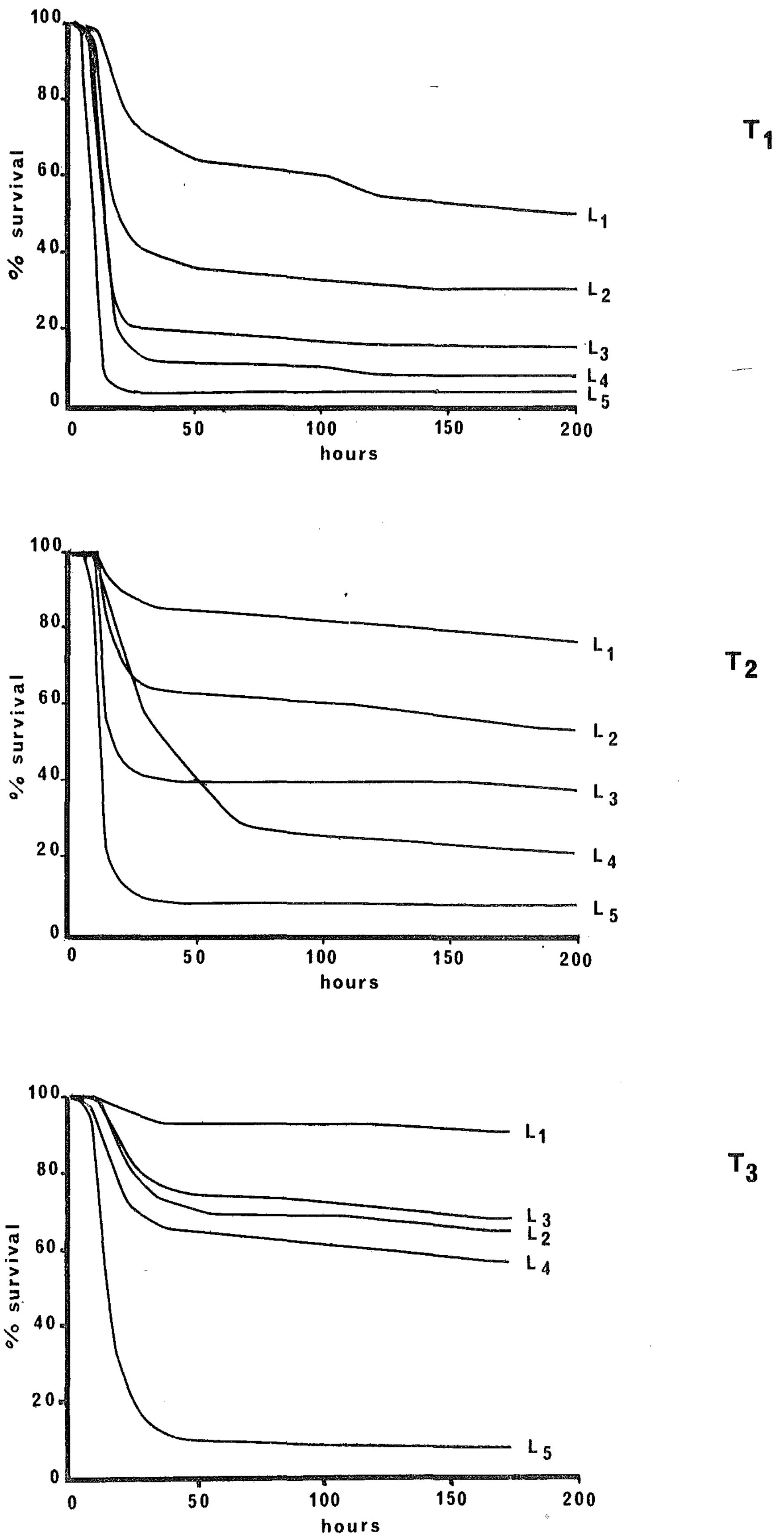

Fig. 3. Mortality rates of young Atlantic salmon exposed to seawater (34.5 $^{o}/oo$) after having been reared in different photoperiod and temperature regimes.

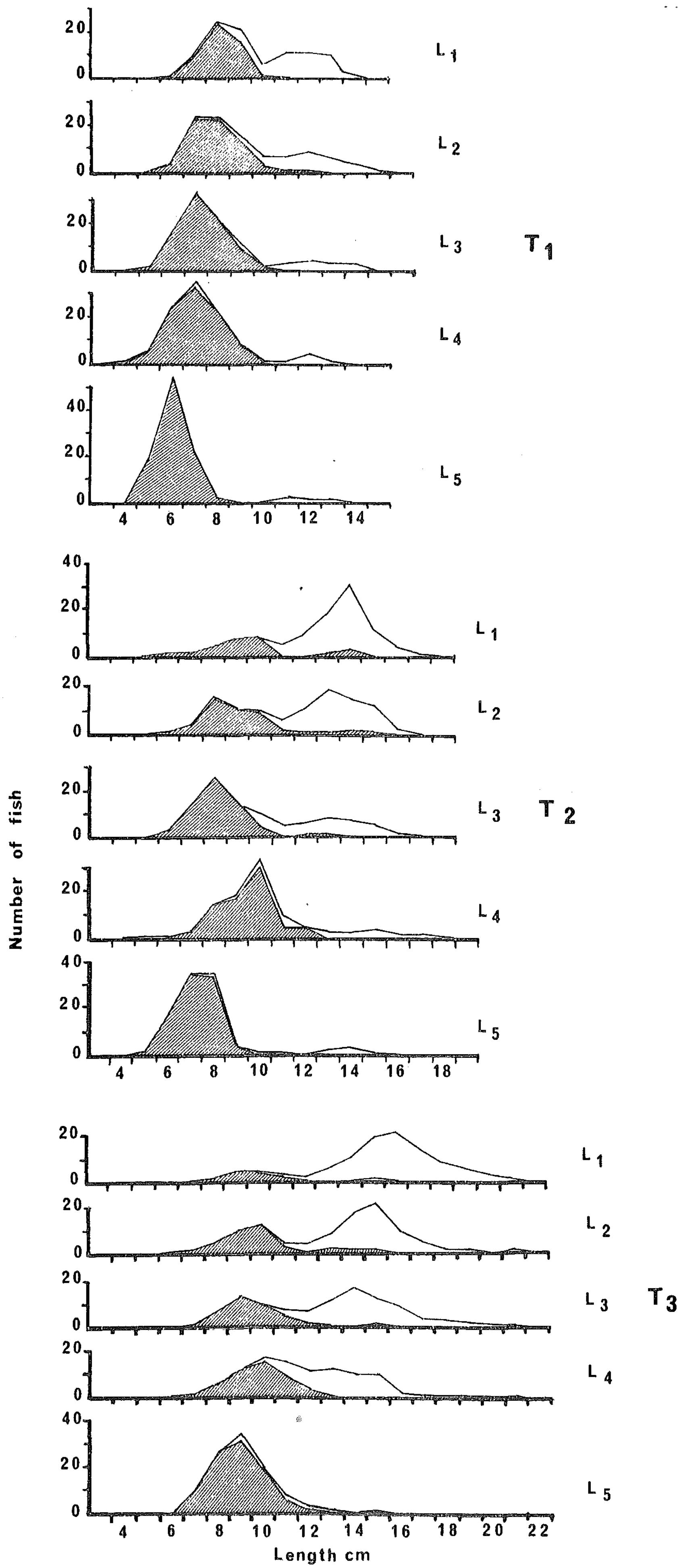

Fig. 4. Length distribution curves for young Atlantic salmon reared in different photoperiod regimes. The shaded areas denote the fish that died within 200 h of having been exposed to seawater (34.5 ^{o}/oo).