International Counsil for the Exploration of the Sea

C.M.1988/F:18
Mariculture Committee

# THE EFFECT OF SHADING IN PEN REARING OF ATLANTIC SALMON (SALMO SALAR)

by

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## ABSTRACT

A full scale pen rearing experiment with covers to reduce illumination was carried out. No significant effects were observed on growth, mortality, ectoparasite infection, maturation or net pen fouling.

## INTRODUCTION

Pen rearing of salmonids has developed into an important industry in many countries around the world (Rosenthal, 1985, Ackefors, 1986). The method is cost effective and farms can easily be expanded in protected coastal areas. While a substantial effort has been put into enhancing the method in terms of operational functionality, little is done to improve the conditions for the fish. One aspect of the environment, which can be controlled in aquaculture, is the level of light the fish are exposed to.

It is well known among river anglers that salmon tend to occupy shady areas in the river (Jones, 1972). Fish farmers also observe that salmon is less willing to surface feed in bright sunlight than in owercast weather. Pickering & al. (1987) showed that overhead cover significantly increased the growth rate of juvenile Atlantic salmon. Sun burns in shallow water fish and in fish kept near the surface in net pens are reported by Bullock & al. (1979).

The parasitic copepod Lepeophtheirus salmonis, also called salmon louse, represents a major problem in pen rearing of Atlantic salmon. The pelagic larvae of this parasite are positively phototrophic (Johannessen, 1975). A preliminary study indicated reduced Lepeophtheirus infection in a group of salmon kept in a pen covered by a light proof roof compared to a control group in an uncovered pen.

Fouling of net pens by algae and invertebrates also represents an important problem in net pen operations both due to decreased water exchange and to obligatory antifouling procedures. Shading of net panels could be expected to reduce algal growth through reduced photosynthesis.

In the present study possible effects of shading pen reared Atlantic salmon from direct sunlight are investigated with special reference to net fouling, ectoparasites, growth and mortality.

## MATERIALS AND METHODS

The experiments were carried out at the pen rearing facilities of Institute of Marine Research, Austevoll Marine Aquaculture Station. Five net pens of 12x12m with a depth of 6m were used. Three of the pens were covered with a fine mesh black polyethylene netting. The experiment was divided into two subexperiments, U1 and U2. In addition to an uncovered control pen, U2 had two covered pens. The two covers were specified by the manufacturer to absorb 70% and 40% of the direct sunlight respectively. Measurements carried out with a luxmeter at noon on November 26 gave absorption values of 76.1% and 43.9%. U1 had one pen covered with the 70% netting in addition to an uncovered control pen.

The net pens were all exchanged to be cleaned at the same time when this was considered necessary by the sea cage personell. All pens were treated for ectoparasites at the same time when this was considered necessary with regard to the most infected group. The general arrangement is shown in Fig.1. The experimental blocks were not randomized as one wanted to keep the shaded pens together for practical reasons.

The pens in U2 were stocked with 3222,3225, and 3230 smolts respectively. The fish were produced by a commercial hatchery and were put to sea one year old medio May 1986 at a mean weight of 100g. The pens in U1 were stocked with 5540 and 5528 smolts. The fish were produced at Matre Aquaculture Station and were put to sea primo June at a mean weight of 35g. The experimental groups were set up on October 8, and the fish were measured for the first time one week later.

All groups were measured for length and weigth every third month. Parasite infection was also recorded. A subsample was obtained by dividing each pen into four compartments in one operation. All fish in one compartment were measured. Before each parasite treatment 150 fish from each group were sampled, and the degree of parasite infection was registered and cathegorized as follows:

| | | | |
|---|---|---|---|
| Cathegory | 1: | 0 | parasites |
| " | 2: | 1-5 | " |
| " | 3: | 6-10 | " |
| " | 4: | 11-20 | " |
| " | 5: | > 20 | " |

No sampling was carried out in advance of a parasite treatment July 9, 1987 since a main measurement had been undertaken one week before.

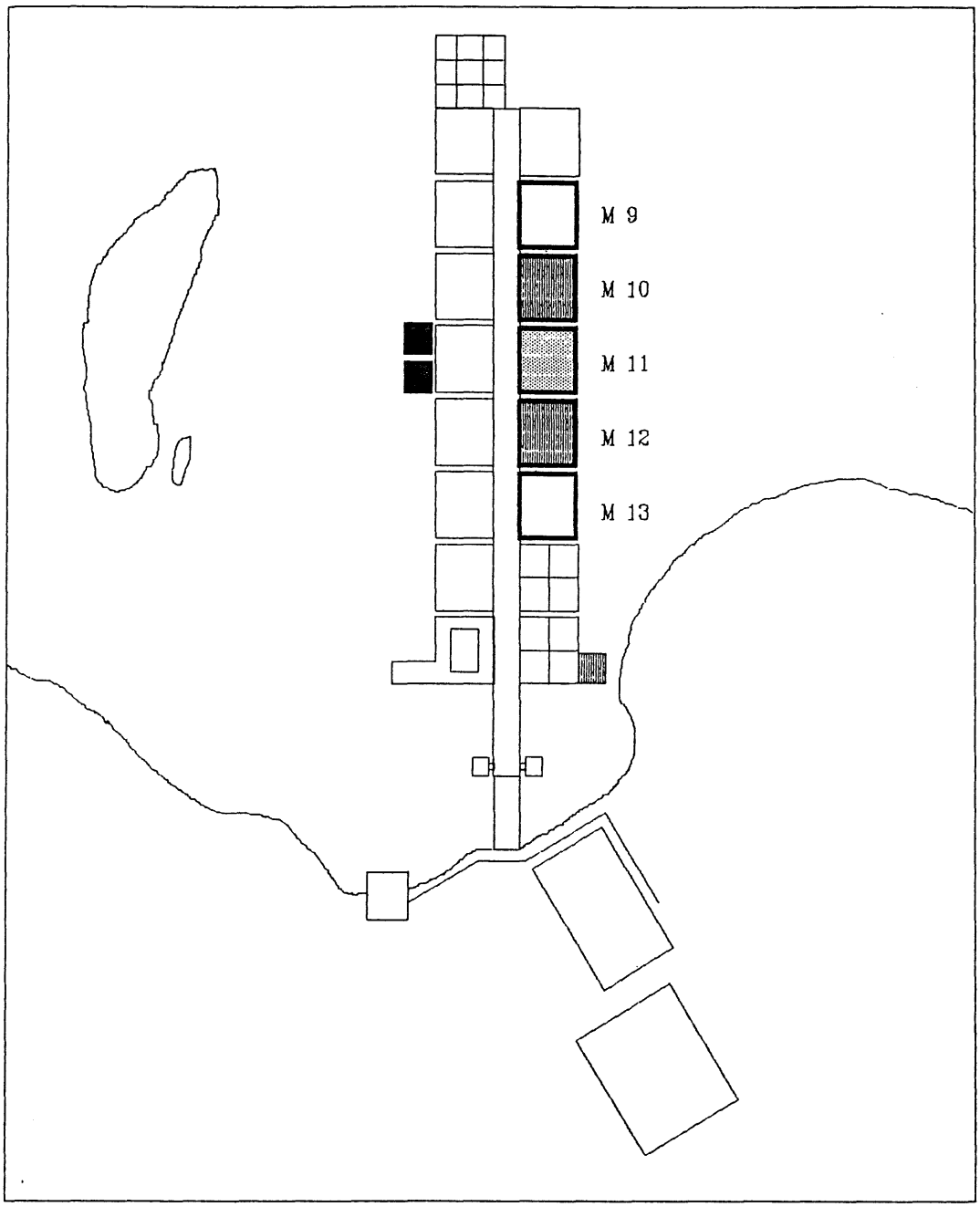


Figure 1. General arrangement of experimental units.

During measurements and parasite controls the fish were anesthesized with saturated ethanol solution of benzocaine. The time of the different fish measurements and parasite controls are given in Table 1.

Table 1. Fish measurements. M) Main measurement.
P) Parasite control.

| Measurement No. | Type | Time |
|---|---|---|
| 1 | M | Oct.13-17 1986 |
| 2 | P | Dec. 1-5 1986 |
| 3 | M | Jan. 5-10 1987 |
| 4 | M | Apr. 1-4 1987 |
| 5 | M | Jul. 1-3 1987 |
| 6 | P | Aug. 3-7 1987 |
| 7 | P | Sep. 8-9 1987 |
| 8 | M | Oct. 1-3 1987 |

Weekly mortality per pen was noted. In early July 1987 maturing fish were sorted out from U2, reducing the number per pen with ca.16% .

The fish were fed a commercial high energy dry pellet (Ewos Vextra), distributed with automatic feeders set at equal feeding intensity in each pen of U1 and U2. In addition the fish were hand fed to satiation twice daily. The fish were starved one day before measurement, net change and parasite treatment.

The covers over the pens were taken off when this was required due to handling procedures. Also from December to March the covers were taken off in periods with snowfall. Before every net pen change the fouling of each net panel was observed and compared with the other pens . Samples of fouling organisms were also collected.

RESULTS

The growth data from the experiment are given in Table 2.

Table 2. Fish measurement data

| Sampling No. | | ( U1 | | )( U2 | | ) |
|---|---|---|---|---|---|---|
| | | PEN 09 no cover | PEN 10 70% | PEN 11 40% | PEN 12 70% | PEN 13 no cover |
| 1 | N | 936 | 829 | 628 | 646 | 584 |
| | W(mean) | 260 | 262 | 476 | 467 | 462 |
| | SD | 75 | 71 | 116 | 115 | 112 |
| | C.fact. | 1.12 | 1.12 | 1.10 | 1.08 | 1.08 |
| | SD | 0.08 | 0.12 | 0.08 | 0.08 | 0.09 |
| 2 | N | 800 | 800 | 711 | 703 | 702 |
| | W(mean) | 526 | 517 | 996 | 970 | 980 |
| | SD | 153 | 145 | 258 | 251 | 256 |
| | C.fact. | 1.36 | 1.21 | 1.26 | 1.28 | 1.28 |
| | SD | 0.16 | 0.08 | 0.09 | 0.08 | 0.08 |
| 3 | N | 750 | 782 | 762 | 756 | 767 |
| | W(mean) | 725 | 771 | 1459 | 1453 | 1548 |
| | SD | 243 | 246 | 378 | 403 | 423 |
| | C.fact. | 1.16 | 1.18 | 1.27 | 1.29 | 1.31 |
| | SD | 0.09 | 0.09 | 0.09 | 0.10 | 0.11 |
| 4 | N | 874 | 1131 | 870 | 632 | 725 |
| | W(mean) | 1056 | 911 | 2135 | 2168 | 2267 |
| | SD | 364 | 407 | 674 | 647 | 652 |
| | C.fact. | 0.91 | 0.82 | 1.07 | 1.10 | 1.15 |
| | SD | 0.13 | 0.16 | 0.14 | 0.13 | 0.14 |
| 5 | N | 1297 | 973 | 610 | 530 | 742 |
| | W(mean) | 1565 | 1671 | 2868 | 2959 | 2955 |
| | SD | 495 | 513 | 720 | 730 | 810 |
| | C.fact. | 1.00 | 1.00 | 1.07 | 1.09 | 1.08 |
| | SD | 0.12 | 0.11 | 0.09 | 0.13 | 0.10 |

The fish in U1 were substantially smaller than the fish in U2 from the start, but the overall growth rates in both subexperiments were similar, as indicated in Figure 2. Condition factor developments indicate that the fish were fed suboptimally during the last six months of the experiment.

Data for infection of the ectoparasite Lepeoptheirus salmonis are given in Table 3.

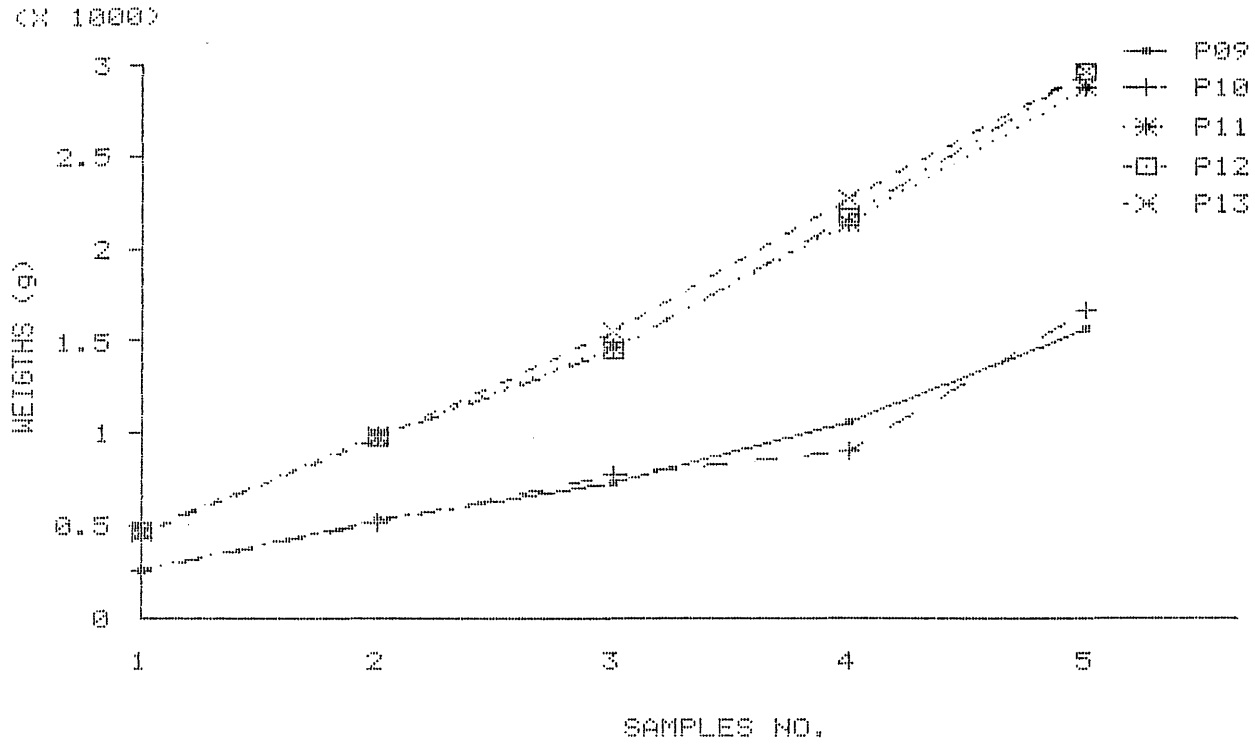


Figure 2. Growth in the different pens (P09-P13) during the experimental periode.

Table 3. Ectoparasite infection (cathegories)

| Sampling No. | | ( U1 | | ) ( U2 | | ) |
|---|---|---|---|---|---|---|
| | | PEN 09 no cover | PEN 10 70% | PEN 11 40% | PEN 12 70% | PEN 13 no cover |
| 1 | N | 936 | 829 | 628 | 646 | 584 |
| | Mean inf | 3.2 | 3.5 | 2.9 | 3.0 | 3.1 |
| | Max. | 5 | 5 | 5 | 4 | 5 |
| | Min. | 2 | 2 | 2 | 1 | 2 |
| | SD | .53 | .62 | .68 | .57 | .64 |
| 2 | N | 150 | 150 | 150 | 150 | 150 |
| | Mean inf. | 3.5 | 3.2 | 4.1 | 4.1 | 4.0 |
| | Max. | 5 | 4 | 5 | 5 | 5 |
| | Min. | 2 | 2 | 2 | 2 | 2 |
| | SD | .67 | .67 | .55 | .64 | .67 |
| 3 | N | 799 | 799 | 710 | 702 | 702 |
| | Mean inf. | 2.1 | 1.8 | 2.1 | 1.7 | 1.8 |
| | Max. | 4 | 3 | 4 | 4 | 3 |
| | Min. | 1 | 1 | 1 | 1 | 1 |
| | SD | .50 | .45 | .62 | .55 | .44 |
| 4 | N | 750 | 781 | 760 | 756 | 767 |
| | Mean inf. | 1.7 | 1.8 | 2.5 | 2.8 | 2.9 |
| | Max. | 4 | 3 | 4 | 4 | 5 |
| | Min | 1 | 1 | 1 | 1 | 2 |
| | SD | .53 | .50 | .60 | .66 | .67 |
| 5 | N | 874 | 1131 | 870 | 632 | 466 |
| | Mean inf. | 3.7 | 3.6 | 3.7 | 3.9 | 4.3 |
| | Max. | 5 | 5 | 5 | 5 | 5 |
| | Min. | 2 | 1 | 2 | 2 | 2 |
| | SD | .73 | .70 | .70 | .72 | .76 |
| 6 | N | 150 | 150 | 139 | 150 | 150 |
| | Mean inf. | 4.1 | 4.1 | 4.0 | 4.5 | 4.4 |
| | Max. | 5 | 5 | 5 | 5 | 5 |
| | Min. | 2 | 2 | 2 | 3 | 3 |
| | SD | .77 | .68 | .59 | .58 | .63 |
| 7 | N | 151 | 175 | 151 | 150 | 155 |
| | Mean inf. | 4.4 | 4.3 | 4.7 | 4.6 | 4.7 |
| | Max. | 5 | 5 | 5 | 5 | 5 |
| | Min | 3 | 3 | 3 | 2 | 2 |
| | SD | .57 | .59 | .45 | .59 | .53 |
| 8 | N | 1297 | 973 | 610 | 857 | 742 |
| | Mean inf. | 2.6 | 2.4 | 2.8 | 2.7 | 3.0 |
| | Max. | 5 | 5 | 5 | 5 | 5 |
| | Min. | 1 | 1 | 1 | 1 | 1 |
| | SD | .69 | .77 | .75 | .82 | .81 |

Table 4 presents mortality during the experimental period. The 78 fish in the 5th interval were killed by an overdose of anaesthetics.

Table 4. Mortality in the intervals between measurement and parasite control (Table 1.).

| Interval No. | ( U1 ) | | ( U2 ) | | |
|---|---|---|---|---|---|
| | PEN 09 | PEN 10 | PEN 11 | PEN 12 | PEN 13 |
| 1 | 32 | 21 | 23 | 15 | 16 |
| 2 | 17 | 16 | 1 | 6 | 3 |
| 3 | 53 | 27 | 14 | 7 | 11 |
| 4 | 34 | 16 | 15 | 27 | 10 |
| 5 | 67 | 94 | 60 | 36 | 111 |
| 6 | 19 | 4 | 9 | 78 | 11 |
| 7 | 27 | 8 | 3 | 2 | 3 |
| TOTAL | 259 | 186 | 125 | 171 | 165 |
| % | 4.7 | 3.4 | 3.9 | 5.3 | 5.1 |

Maturation of males was observed in measurement no.4, and at the end of the expeimental period. Few females were observed to mature during the experiment. Data on maturation are given in Table 5.

Table 5. Maturation

| Sampling No. | | ( U 1 ) | | ( U 2 ) | | |
|---|---|---|---|---|---|---|
| | | PEN 09 | PEN 10 | PEN 11 | PEN 12 | PEN 13 |
| 4 | N | 874 | 1112 | 864 | 632 | 725 |
| | Maturing | 33 | 31 | 79 | 132 | 76 |
| | % | 3.78 | 2.79 | 9.14 | 20.89 | 10.48 |
| 8 | N | 1297 | 973 | 610 | 857 | 742 |
| | Males | 23 | 32 | 36 | 23 | 25 |
| | % | 1.77 | 3.29 | 5.90 | 2.68 | 3.37 |
| | Females | 4 | 3 | 12 | 7 | 10 |
| | % | 0.31 | 0.31 | 1.97 | 0.82 | 1.35 |
| | Unident. | | | 1 | | 4 |
| Total maturation (%) | | 5.86 | 6.39 | 17.17 | 24.39 | 15.74 |

## DISCUSSION

There were no significant growth differences between any of the groups within either subexperiment. Considering the rather high degree of light reduction and the large number of fish there does not seem to be an effect of shading on growth in pen rearing of Atlantic salmon. This result does not comply with the findings of Pickering & al. (1987) for juvenile Atlantic salmon.

Mortalities varied between 5.1% and 3.4% which is low considering the degree of handling the fish were exposed to. There were no significant differences between groups.

Maturation was highest in the 40% pen in U2 and lowest in the uncovered pen, but differences were not significant. In U1 only a small number of males matured, and there were no differences between pens.

No significant differences in infection of Lepeoptheirus salmonis was found between any of the groups within U1 and U2. In some periods there rather seemed to be a gradient through the experiment related to location of the pens in the sea cage facilities (Fig.1). In measurement no.4 the infection rate was highest in the pen nearest to the shoreline, with a decreasing infection to the outermost pen. No evidence of an effect from the light reducing cover was demonstrated. The results from the pilot experiment cold therefore not be coraborated. In the pilot experiment no light could penetrate to the pen surface as the roof and walls were made of tin plates. This difference could account for the disability to reproduce the results.

In the pilot study with covered nets, fouling was drastically reduced. The picture was a bit more complicated in this experiment. Algal growth was drastically reduced in the covered pens compared to the uncovered ones. However, the decreased algal fouling seemed to give better settling conditions for marine sessile invertebrates like hydroids. These are much more difficult to clean off than algae. Also, the large population of hydroids in the covered pens seemed to cause a spreading to other parts of the sea cage unit, resulting in a very high infection rate of hydroids in all cages. Accordingly the covers did not have an overall positive effect on fouling. A light proof cover could possibly give better results.

## CONCLUSION

The way this experiment was designed there seemed to be no beneficial effects from light reducing covers. Neither were there any definite negative effects. To investigate further the results from the pilot study, full scale experiments with light proof

covers should be carried out, both with regard to parasite infection and fouling.

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