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Short communication

Geographical and temporal variation in abundance of salmon lice (*Lepeophtheirus salmonis*) on salmon (*Salmo salar* L.)

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Surveys in the area around Austevoll Aquaculture Research station have failed to reveal the presence of a large number of the free-swimming stages of salmon lice in the water column. However, lice were abundant on salmon held in cages in this area. Lice-free salmon were used as collectors of lice at three sites chosen at varying distances from other known sources of lice (salmonid fish farms). The abundance of lice on salmon at particular sites was found to vary during the year and also between years. During the study period, variations were correlated with temperature, increased abundance occurring at higher temperatures (>6°C). Comparisons between sites during the period with the highest temperatures showed that lice abundance was negatively correlated with distance to other salmon farms in the area. During periods of colder temperatures (<6°C) lice abundance was positively correlated with distance to salmonid fish farms. In January 1995, it was possible to predict that 1995 would be a year with heavy lice burdens. The basis of the prediction was the accumulated difference between average temperature during the period 1978–1996 and the sea temperature for the 4-month period preceding the settling period.

Key words: abundance, geographical variation, salmon lice, temporal variation.

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Introduction

The first three stages of salmon lice, which are free-swimming, are very difficult to find in nature (Tully and Whelan, 1993; Costelloe *et al.*, 1996). A total of 107 larvae were found in 335 samples of sea water (1 to 5 m^3) (Boxaspen, 1995). Since 1992, the Institute of Marine Research, Austevoll Aquaculture Research Station (IMR), has conducted studies in which Atlantic salmon have been used as collectors to estimate the abundance of salmon lice at different times of the year and in different locations (Hevrøy and Mikalsen, 1994; Boxaspen, 1995). In Norway it is widely believed that salmon lice do not multiply during the winter months and usually disappear at this time. Some of our results, however, indicated that this is not the case and in this study we document the variation in abundance of salmon lice during the winter months.

Materials and methods

The study sites were situated south of Bergen, Norway (60°05′N 05°16′E) on the east coast of the island of Huftarøy 6 km due east of the mainland. The current in the area is predominantly north–south. Three sites around IMR were used in this study. Sites I and II lie within a bay area 200 m apart, but separated by a peninsula, and Site III is on the outside of the bay about 600 m from the other sites. Site I had never been used for salmon farming, Site II was being fallowed from salmon production (Bron *et al.*, 1993) with only halibut and cod present in the other cages, and Site III had other salmon present. Mobile salmon lice may be found on halibut and cod but cannot complete their life cycle on these species. The nearest salmon farm is located 2 km north of Site III, with three more farms in the area but at a greater distance from the study sites. There are few salmon rivers in the area

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Table 1. Date of commencement of experiments, numbers and mean weight of the salmon (± 1 s.d.) in each cage.

Start of exposure	No. of salmon in cage	Mean weight ± s.d.
18 January 1994	80	0.97 kg ± 0.19
8 November 1994	35	1.9 kg ± 0.37
3 January 1995	100	0.33 kg ± 0.55
3 April 1995	100	0.66 kg ± 0.11

and the number of wild salmon and sea trout in the area is low.

A total of four cages (5 × 5 × 5 m) were used in the experiments. At Site I only the experimental cage was present. At Site II, the experimental cage was placed in the middle of a farm. Site III is a full-scale farm where there have been serious infections of lice in the inshore areas. For the purposes of this experiment, one cage was placed inshore and one offshore.

Each cage was stocked with approximately 70 kg of salmon, except for the third experimental period commencing on 3 January 1995 when approximately 33 kg of salmon were used (Table 1). The use of three successive groups of salmon in the second winter was necessary because of the heavy lice burden on the fish. When the level of lice was high the salmon were taken out of the experiment and replaced with lice-free salmon.

Salmon lice were counted on 30 anaesthetized salmon from each cage at intervals of approximately 1 month, except in the cages containing only 35 salmon, where only 15 salmon were sampled. The salmon were returned to their cages after the lice had been counted.

Results and discussion

First period: 18 January to 9 June 1994

The abundance of salmon lice increased throughout the period of exposure (Fig. 1). In March, Site I had a significantly higher level of lice than the other sites (Mann-Whitney U-test, $p=0.0001$). The abundance of lice increased markedly (4–5 fold) between May and June at Sites II and III. In June, when the experiment was terminated, Site I had a significantly lower level of lice than the other sites (Mann-Whitney U-test, $p=0.001$).

Second period: 8 November 1994 to 23 May 1995

During the winter of 1994/1995 massive settling of salmon lice occurred, initially between November 1994 and January 1995, and again during the second exposure interval from mid-January to the end of March (Fig. 2). The abundance of lice was significantly higher at Site I (Mann-Whitney U-test, $p=0.0001$) than at the other sites. There were no significant differences between the sites in the final exposure period from April to mid-May. The outer cage at Site III tended to experience lower levels of lice than the other cage at this site.

Site I lies in the inner bay area and the higher level of lice early in the year may be explained by the longer development period for the lice at colder temperatures (Johnson and Albright, 1991). The free-swimming stages

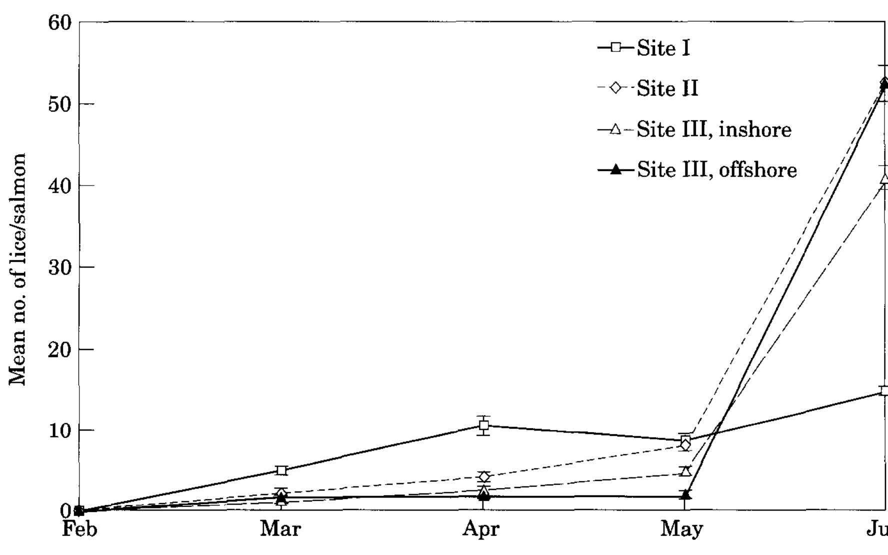

Figure 1. Mean abundance (± 1 s.d.) of salmon lice on groups of salmon at three different sites from February to June 1994 (n=30).

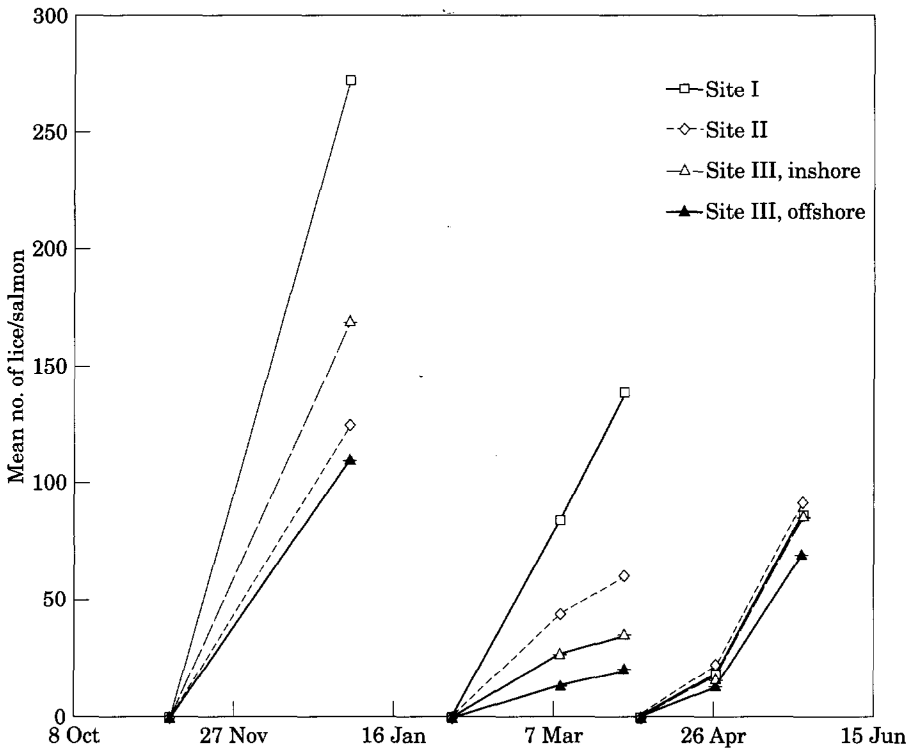

Figure 2. Mean abundance (± 1 s.d.) of salmon lice on groups of salmon for three successive periods of exposure and at three different sites from 8 November 1994 to 23 May 1995 (n=30). (Note the difference in scale from Fig. 1).

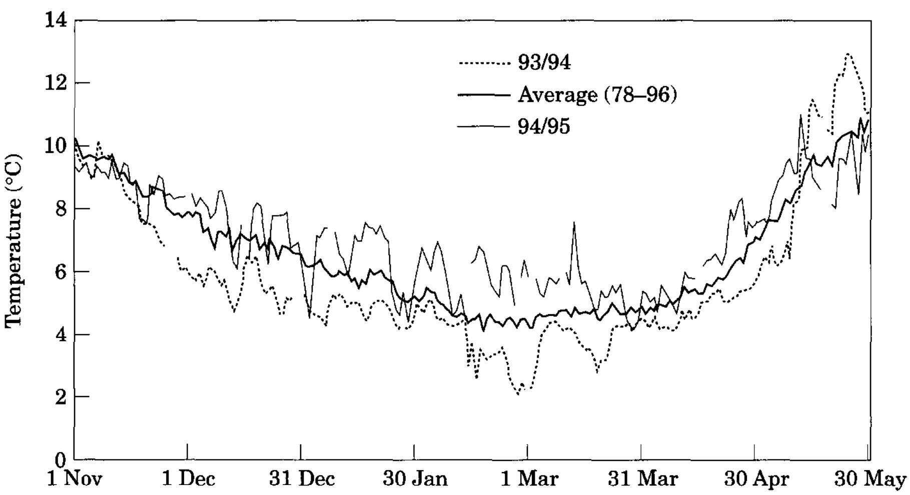

Figure 3. Water temperature profile in the sea at a depth of 2 m from 1 November to 30 May for the 2 years of the study compared with the average temperature for the same period during 1978–1996.

need a longer time to reach the infective stage at low temperatures, thus providing the means to travel further from the source, believed to be salmon farms in the area, the nearest of which is in the outer region of Site III. The tidal range in the area is only 1 m. However a larger survey of the current systems in the area is needed to investigate transfer rates.

Comparison between years

The results for the winter of 1993/1994 were similar to earlier years, with a slow increase in abundance of salmon lice as the sea temperature increased. The abundance of lice in the winter of 1994/1995 was significantly higher than in 1993/1994 (Mann-Whitney

U-test, p=0.001) and on the basis of information provided by salmon farmers we believe this to be a periodic phenomenon.

The seawater temperature profiles differed during the two experimental periods. Comparison with historical water temperature records indicated that the average temperature in the winter of 1993/1994 was 0.68°C lower than the long-term (1978–1996) average, while in 1994/1995 it was 0.38°C higher than the average (Fig. 3).

The higher abundance of lice in 1994/1995 compared to 1993/1994 may be related to the higher overall seawater temperatures.

The difference in size and number of salmon used in the different exposure periods may be a limitation on the interpretation of the results, since the surface area available to the lice would vary. However, for three of the four exposure periods (first winter and the first and third periods in the second winter), the biomass was within the range of 66 to 78 kg per cage in all cages.

The results indicate that counts of salmon lice and temperature data during the winter may be combined to predict the development of salmon lice numbers during the summer. However, further investigations are needed on the effects of water currents and sources of salmon lice before a working hypothesis can be developed.

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