

Wild Salmon Mortality Caused by Fish-Farm Sea Lice

Martin Krkošek and Marjorie Wonham[‡]

Centre for Mathematical Biology, Department of Mathematical and Statistical Sciences and Department of Biological Sciences, University of Alberta, Edmonton, AB, Canada

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It is well established that fish farms raise sea lice levels, and that sea lice can kill juvenile salmon. This is the first study to estimate the total salmon mortality caused by farm-origin sea lice.

Research Summary

This peer-reviewed paper investigates sea lice infections of wild salmon caused by fish farms. The study shows that fish farms are changing the way wild salmon get infected with parasites. As a result, up to 95 per cent of wild juvenile pink and chum salmon are dying from sea lice infections in coastal British Columbia.

How do fish farms increase sea lice infections?

Sea lice are natural parasites of fish. The primary sea lice hosts are adult salmon. Normally, the adult fish are far offshore when the juveniles are migrating out to sea. However, fish farms put adult salmon in net pens along the migration routes. The result is a cloud of sea lice, more than 80 km long, through which the juveniles must migrate.

How do sea lice kill juvenile salmon?

Sea lice attach to fish scales and pierce through the skin to feed. At high infection levels, the parasites feed on the fish at rates greater than the fish can feed itself, and literally eat the fish alive. Since juvenile pink and chum salmon are so small – only one to two inches long – it can take only one or two sea lice to kill them.

How many juvenile salmon are killed by sea lice?

The study found that an increasing number of juvenile salmon were killed over the migration season. At least 9 per cent were killed in early spring when the sea lice population was low, and up to 95 percent were killed in late spring when the sea lice population was higher. Normally, only a small fraction of juvenile salmon survive to return as adults; sea lice infections from fish farms are reducing that small fraction even further.

Research Approach

The research was conducted by a team of biologists and mathematicians studying sea lice (*Lepeophtheirus salmonis*) on pink (*Oncorhynchus gorbuscha*) and chum (*O. keta*) salmon in coastal British Columbia. (See Map 1 and Figure 1.) The study had three phases. First, more than 14,000 fish were surveyed for sea lice along three migration routes past active fish farms. Using data and mathematical modeling, it was determined how sea lice infection levels increased as the salmon passed the farms. (See Box 1.) Second, experiments with more than 3000 fish determined the mortality effects of a range of sea lice infection levels. It was found that a single louse can kill a juvenile salmon, and that the chance of survival decreased with higher infection levels. (See Box 2.) Third, mathematical modeling was used to combine this information to estimate the overall mortality impacts of sea lice infection along the migration routes. (See Box 2.)

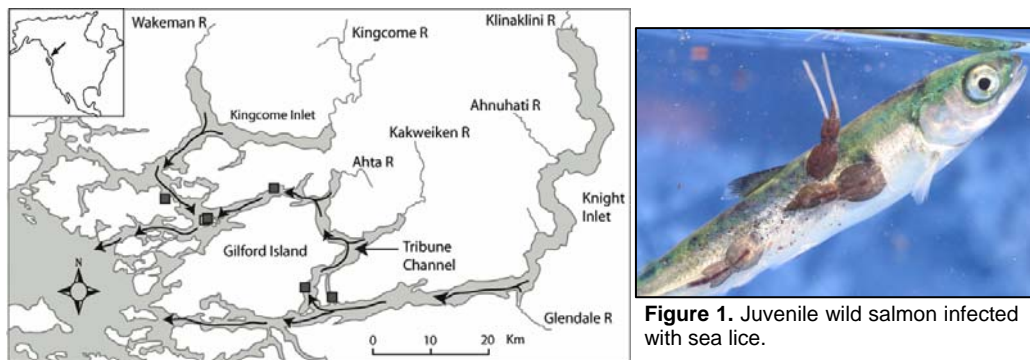


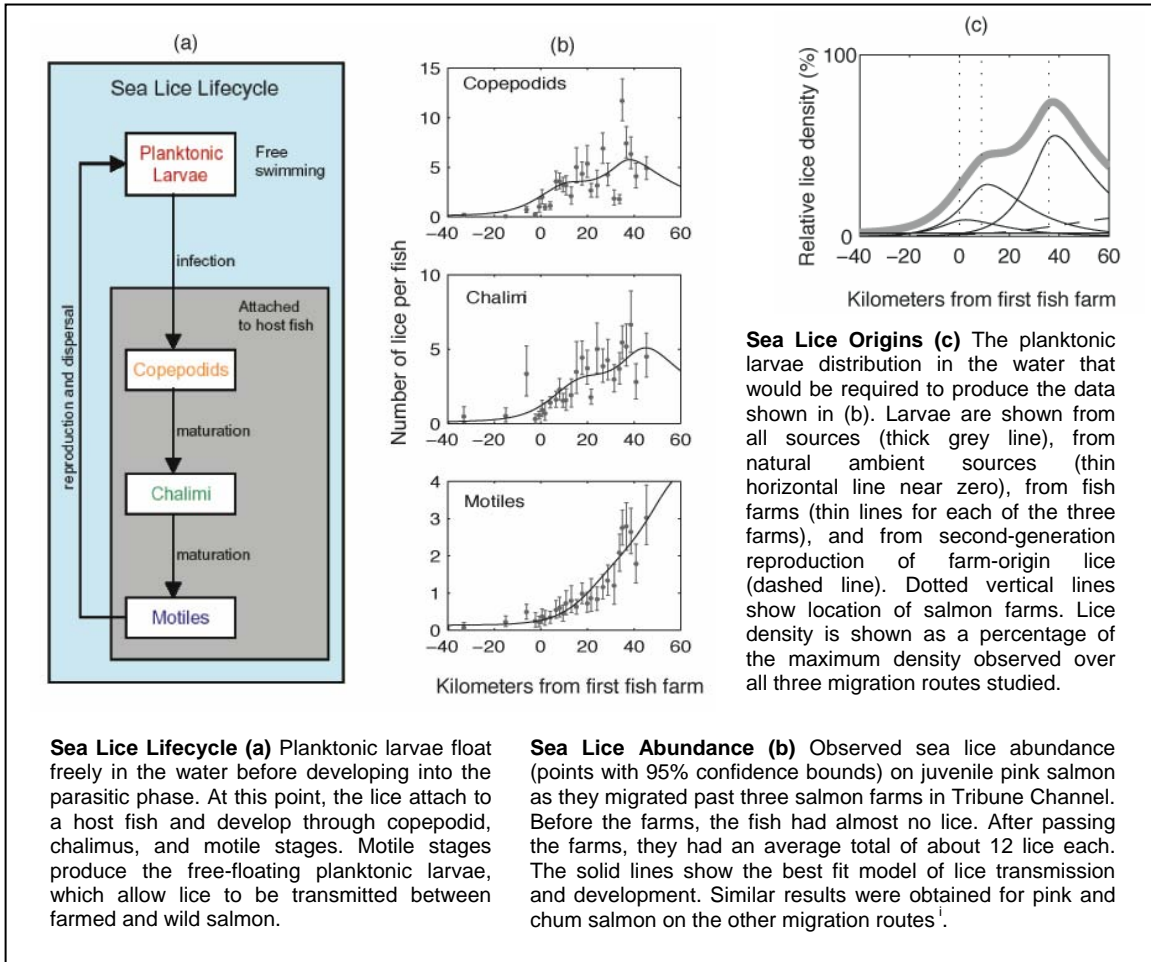
Figure 1. Juvenile wild salmon infected with sea lice.

Map 1. Wild juvenile pink and chum salmon migration routes in the Broughton Archipelago, British Columbia, off the northern end of Vancouver Island, Canada. The fish migrate seaward along three major routes – Kingcome Inlet, Tribune Channel, and Knight Inlet. A total of 14,255 juvenile salmon were non-lethally sampledⁱⁱⁱ for sea lice at 1-3 km intervals along the three routes (for 40, 80, and 60 km, respectively) in 2004 and 2005. Each migration route had 2 or 3 active fish farms during those seasons (shown on map as shaded boxes).

Fish farms increase sea lice infections

Fish surveys showed that wild juvenile salmon carry a low level of lice before they reach the fish farms, and a much higher level once they pass the farms. (See Box 1.) As the fish continue out to sea, their lice reproduce and create a second generation of parasites that further increases the infection levels. Mathematical modeling showed that farms are the primary source of lice, raising the density of infectious larvae above natural background levels along at least 80 km of the salmon migration route. This distance is covered in the first two and a half months of a juvenile salmon's life, when it is approximately one to two inches long. The results of this survey and modeling are consistent with those of a previous study of a single farm in this region in 2003ⁱⁱ, and extend those results more broadly to three migration routes and seven farms.

Box 1. Sea Lice Infection



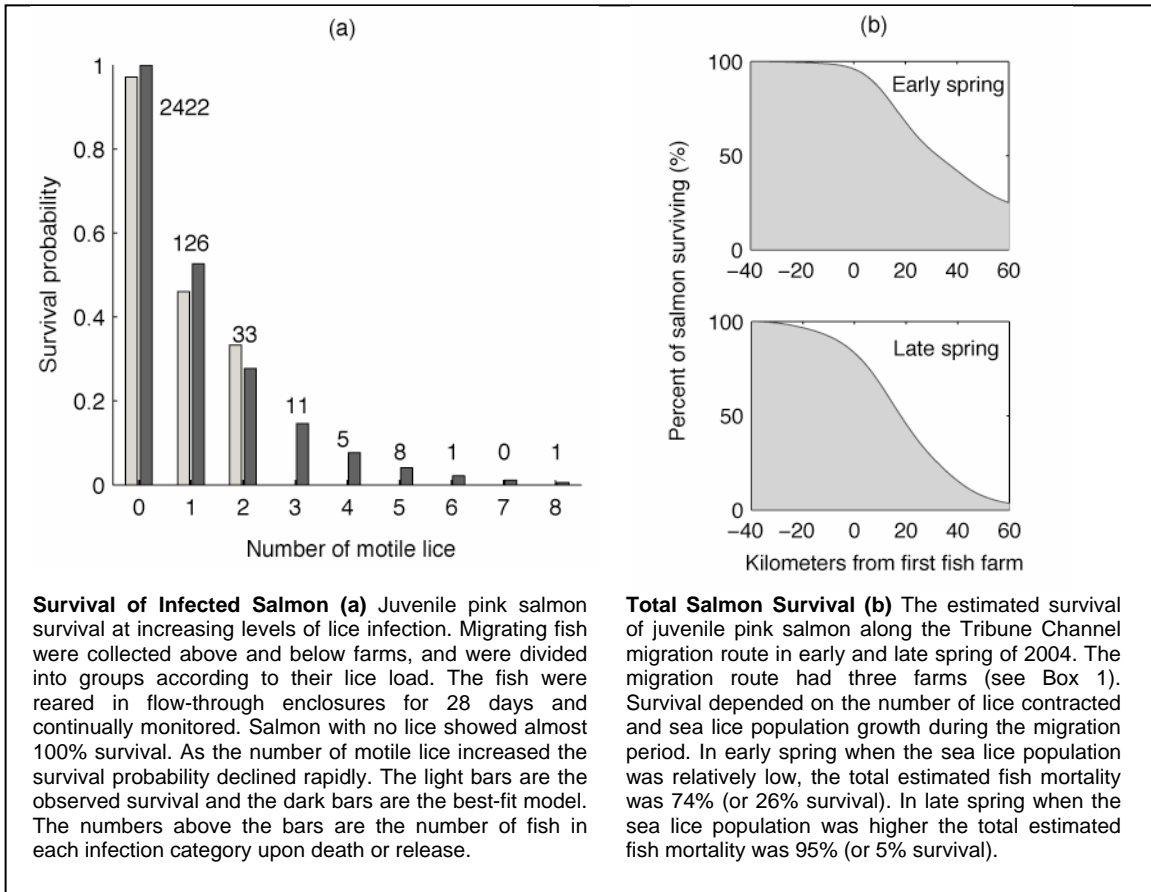
Sea lice infections can kill juvenile salmon

Survival experiments showed that almost all the uninfected juvenile salmon survived. (See Box 2.) A single louse reduced a salmon’s survival to approximately 50%, and survival continued to decrease with added lice. A mathematical model was created to predict fish survival over time, as the lice grow and reproduce. To predict the overall salmon mortality caused by fish farms, the survival model was combined with the lice infection model. The total mortality in migrating juveniles attributed to farm-origin lice ranged from 9-95%. This range encompasses major seasonal variation in the sea lice population level, and minor differences between pink and chum salmon and among migration routes.

Implications

Aquaculture has grown by 10% annually over the last decade. This study shows that large-scale salmon farming can have a dramatic negative impact on native wild salmon stocks. Fish farms can therefore be a threat to the survival of salmon stocks already reduced by other human activities.

Box 2. Salmon Survival and Mortality



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References

ⁱ Krkošek, M., Lewis, M. A., Morton, A., Frazer, L. N., & Volpe, J. P. 2006 Epizootics of wild fish induced by farm fish. *Proceedings of the National Academy of Sciences of the United States of America* in press, to be published in the online Early Edition, Oct. 2-6, 2006.

ⁱⁱ Krkošek, M., Lewis, M. A., & Volpe, J. P. 2005a Transmission dynamics of parasitic sea lice from farm to wild salmon. *Proceedings of the Royal Society of London Series B* v. 269, pp. 335-343.

ⁱⁱⁱ Krkošek, M., Morton, A., & Volpe, J. P. 2005b Non-lethal assessment of juvenile pink and chum salmon for parasitic sea lice infections and fish health. *Transactions of the American Fisheries Society* v. 134, pp. 711-716.