



David
Suzuki
Foundation

Fish Farms Drive Wild Salmon Toward Local Extinction

A summary of the paper *Declining wild salmon populations in relation to parasites from farm salmon*, by M. Krkosek, J.S. Ford, A. Morton, S. Lele, R.A. Myers, and M.A. Lewis, published in the peer-reviewed journal *Science* in December 2007.

‡Written by Marjorie Wonham and Martin Krkosek

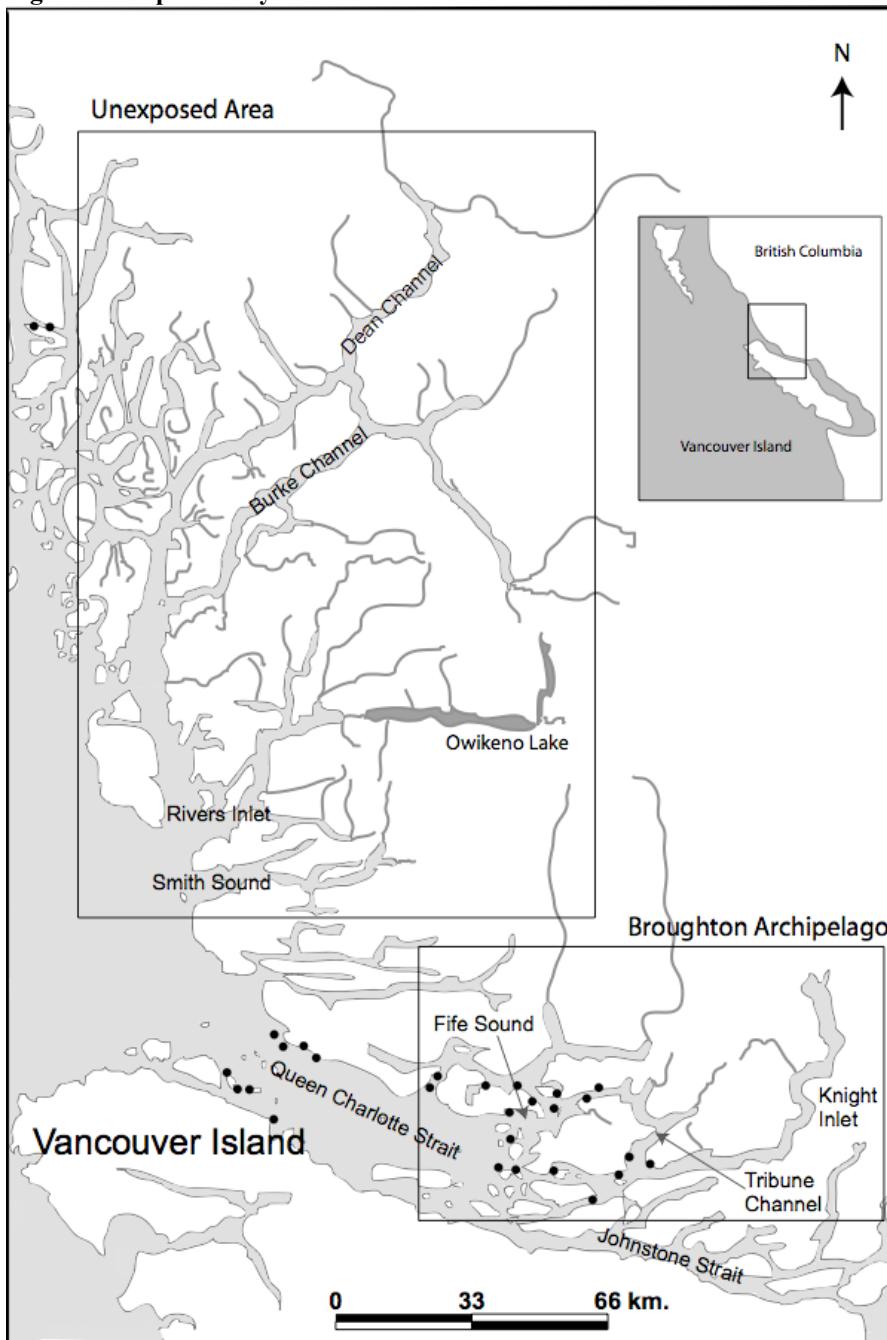
(To read the full report, go to: www.sciencemag.org/.)

Fish farms produce over two thirds of the salmon that humans eat, but this comes with environmental and social costs. Scientists have long expressed concern over the environmental impacts of fish farming, especially on wild fish stocks. Fish farms can amplify parasites in the environment and cause damaging, even lethal, parasite infestations of juvenile wild salmon^{1,2}. This study shows that the infestations are so damaging that they threaten the viability of the affected wild pink salmon populations.

Summary

The peer-reviewed study investigates the impacts of sea lice from fish farms on returns of wild pink salmon to British Columbia's Broughton Archipelago. The results show that recurrent sea-lice infestations have driven a rapid four-year decline in the pink salmon populations. The scientists calculate that sea lice have frequently killed over 80 per cent of the annual wild salmon returns to the Broughton. The study concludes that the salmon are approaching extinction and will collapse by 99 per cent in four years, or two salmon generations, if the infestations continue.

Figure 1: Map of Study Area



The scientists compiled Fisheries and Oceans Canada data on the number of pink salmon (*Oncorhynchus gorbuscha*) returning each year to rivers in two regions of the central British Columbia coast. To the north were 128 populations (64 rivers) not exposed to salmon farms. To the south were 14 populations (seven rivers) in the Broughton Archipelago, exposed to salmon farms. Black dots show salmon farms.

Evidence

What are sea lice?

Sea lice are natural marine parasites of fish. They feed on salmon skin, muscle, and blood. The feeding can cause stress, osmotic failure, viral or bacterial infection, and ultimately death³. Sea lice frequently infect adult wild salmon⁴. Where there are no fish farms, lice infect fewer than five per cent of the juvenile wild salmon⁵. Sea lice are naturally rare on wild juvenile salmon because the adult salmon that carry the parasite are offshore when the juveniles enter the sea.

How do fish farms affect juvenile wild salmon?

Where there are no fish farms, lice infect fewer than five per cent of the juvenile wild salmon⁵. Fish farms amplify the parasite in the environment where juvenile wild salmon migrate^{1,2}. On their way to the ocean, the juvenile wild salmon pass the farms, become infected, and many die². In the Broughton Archipelago the wild juvenile salmon spend their first two to three months of marine life chronically exposed to sea lice².

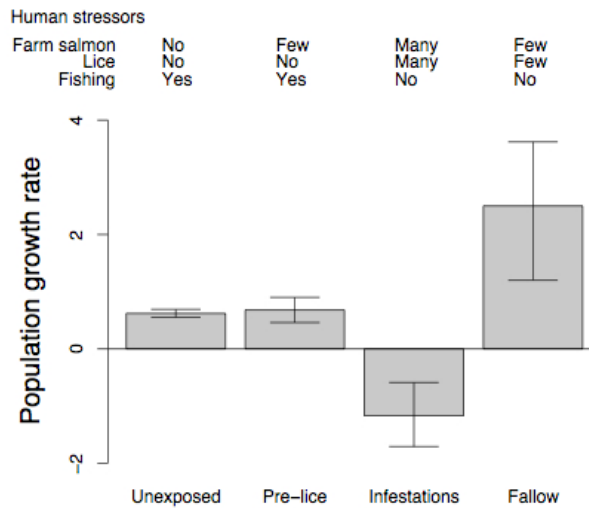
How do fish farms affect wild salmon populations?

The new study by Krkosek et al. in *Science* documents the severity of the sea-lice infestations for pink salmon populations. Since sea-lice infestations began in 2001, the Broughton Archipelago pink salmon have rapidly declined (Box 1). During this time sea lice have killed over 80 per cent of the pink salmon returning annually to the Broughton (Box 2). The scientists conclude the pink salmon are approaching extinction and expect a 99 per cent collapse in four years, or two salmon generations, if the infestations continue.



Figure 2. Juvenile pink salmon infected with sea lice.

Box 1. Sea-lice infestations drive wild salmon toward extinction



The scientists analyzed Canadian government data on pink salmon population from rivers on the central British Columbia coast (Figure 1). They organized the data into four groups according to whether or not the populations were exposed to salmon farms before and during the sea-lice infestations:

1. Unexposed - Wild salmon from rivers just north of where the salmon farms are located (years of data: 1970-present);
2. Pre-infestation – Wild salmon from rivers near salmon farms but before sea-lice infestations (1970-2000);
3. Infestation – Wild salmon from rivers near salmon farms during sea-lice infestations (2001-present); and
4. Fallow – Wild salmon from rivers near salmon farms but when many of the farms were closed (2003).

The scientists calculated the population growth rates for each group. A positive growth rate means the salmon are stable or increasing. A negative growth rate means the salmon are declining to extinction.

Unexposed populations were very similar to exposed populations before the infestations, when both groups supported commercial fishing. When the infestations of the exposed populations began, their population growth rate declined and the fishery was closed. When the farms were closed, sea lice declined, and the populations improved.

The scientists found that during the infestations, the exposed populations were not only depressed, but also rapidly declining. Based on the rate of decline, the scientists calculated that, if the infestations continue, the pink salmon populations will decline to extinction (99 per cent collapse) in a further two salmon generations (four years).

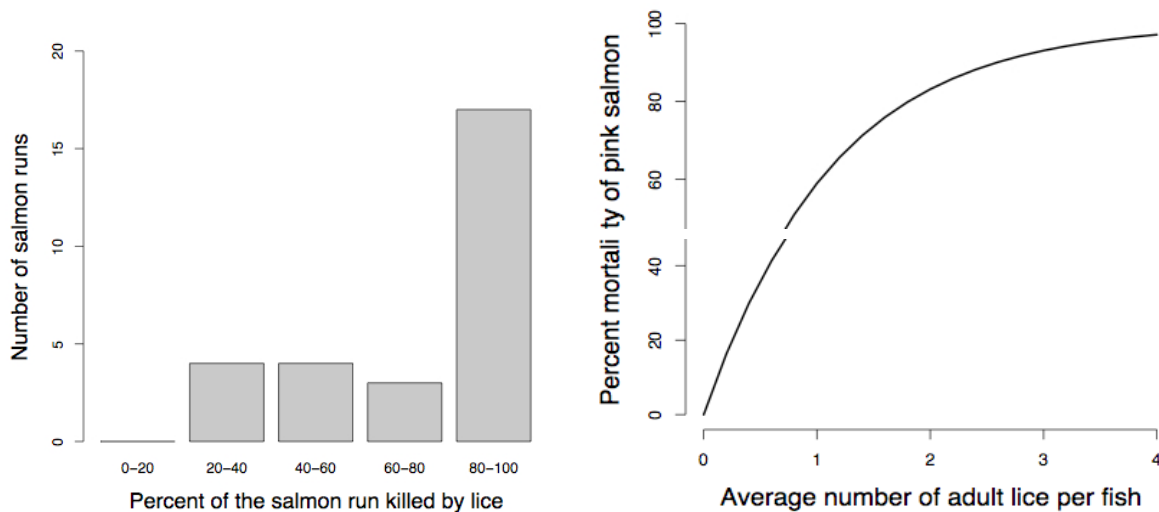
Can closing salmon farms help wild salmon?

Sea lice have infested wild juvenile pink salmon in the Broughton Archipelago since 2001⁶. In one of these years, 2003, a primary juvenile salmon migration route was fallowed, sea lice abundance declined⁷, and the pink salmon populations improved⁸. The new study by Krkosek et al. in *Science* confirms this pattern, suggesting that the pink salmon populations have the capacity to rebound if the farms are closed (Box 1).

How do fish farming impacts compare to fishing?

Sea lice are more damaging to the wild pink salmon than fishing. When sea-lice infestations began in the Broughton Archipelago, pink salmon populations collapsed and the commercial fishery was closed. Although the fishery remained closed, sea lice continued to drive the pink salmon toward extinction. Just north of the Broughton Archipelago, there are no salmon farms, no sea lice infestations, and the salmon populations continue to support commercial fishing.

Box 2. Sea-lice infestations frequently kill over 80 per cent of wild salmon returns



The scientists calculated the proportion of the annual pink salmon returns to the Broughton Archipelago that were killed by sea lice by combining the government salmon data with data on sea-lice infections of the juvenile salmon. The estimates, made for each river in each year between 2002 and 2006, show that over 80 per cent of the runs were frequently killed by lice. The scientists then combined the data in a mathematical model that shows the sensitivity of wild salmon populations to sea lice. As the number of adult lice per fish increases the proportion of the returning salmon run that is killed rapidly rises.

Acknowledgements

This work was funded by the Natural Science and Engineering Research Council of Canada, the Canadian National Research Council Mathematics of Information Technology and Complex Systems program, the David Suzuki Foundation, the National Geographic Society, Tides Canada, a Bill Shostak Wildlife Award, the Lenfest Ocean Program, Census of Marine Life, and a Canada Research Chair.

References

- ¹ Krkosek, M., Lewis, M.A., & Volpe, J.P. (2005) Transmission dynamics of parasitic sea lice from farm to wild salmon. *Proceedings of the Royal Society of London Series B*, 272: 689-696.
- ² Krkosek, 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* 103:15506-15510.
- ³ Pike, A.W. & Wadsworth, S.L. (2000) Sealice on salmonids: their biology and control. *Advances in Parasitology* 44:233-337.
- ⁴ Beamish, R.J., Neville, C.M., Sweeting, R.M., Ambers, N. 2005. Sea lice on adult Pacific salmon in the coastal waters of central British Columbia, Canada. *Fisheries Research* 76:198-208.
- ⁵ Krkosek, M., Gottesfeld, A., Proctor, B., Rolston, D. Carr-Harris, C., & Lewis, M.A., (2007) Effects of host migration, diversity, and aquaculture on sea lice threats to wild Pacific salmon populations. *Proceedings of the Royal Society of London Series B*.
- ⁶ Morton, A. & Williams, R. (2003) First report of the salmon louse, *Lepeophtheirus salmonis*, infestation on juvenile pink salmon, *Oncorhynchus gorbuscha*, in nearshore habitat. *Canadian Field Naturalist*. 117: 634-641.
- ⁷ Morton, A., Routledge, R.D., & Williams, R. (2005) Temporal patterns of sea louse infestation of Pacific salmon in relation to the fallowing of Atlantic salmon farms. *North American Journal of Fisheries Management*. 25: 811-821.
- ⁸ Beamish, R.J., Jones, S., Neville, C.E., Sweeting, R., Karreman, G., Saksida, S. & Gordon, E. (2006) Exceptional marine survival of pink salmon that entered the marine environment in 2003 suggest that farmed Atlantic salmon and Pacific salmon can coexist successfully in a marine ecosystem on the Pacific coast of Canada. *ICES Journal of Marine Science* 63:1326-1337.
- ⁹ Myers, R.A., Bowen, K.G., Barrowman, N.J. (1999) Maximum reproductive rate of fish at low population sizes. *Canadian Journal of Fisheries and Aquatic Sciences* 56:2404-2419.