LENFEST OCEAN PROGRAM

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December 14, 2007

Re: Aquaculture Impacts on Wild Salmon

Dear Colleague:

A new paper published in *Science* indicates that parasites originating from salmon farms may be driving some populations of wild salmon in British Columbia towards extinction. This research sheds greater light on one of the impacts of industrial aquaculture – an increased mortality risk for wild fish from exposure to sea lice.

To determine the impacts of aquaculture on wild salmon, Martin Krkosek and his colleagues compared pink salmon populations in rivers with salmon farms to those in rivers without farms. They also analyzed fish mortality due to sea lice, a parasite of salmon. Their research showed that recurrent sea lice outbreaks typically killed over 80% of nearby pink salmon populations. If the numbers of wild salmon continue to decrease at the rate described in the study, the affected salmon populations are projected to collapse to less than 1% of their former abundance in four years.

Enclosed is a *Lenfest Ocean Program Research Series* report summarizing the paper. Copies of the *Science* paper, along with other information about this research, may be found on our website: www.lenfestocean.org.

Sincerely,

Margaret B. Bowman
Director

Enclosure

LENFEST OCEAN PROGRAM

RESEARCH SERIES

DECEMBER 2007

A new study shows that parasites from fish farms may drive some wild salmon populations towards local extinction.

AQUACULTURE IMPACTS ON WILD SALMON

A SUMMARY OF NEW SCIENTIFIC ANALYSIS:

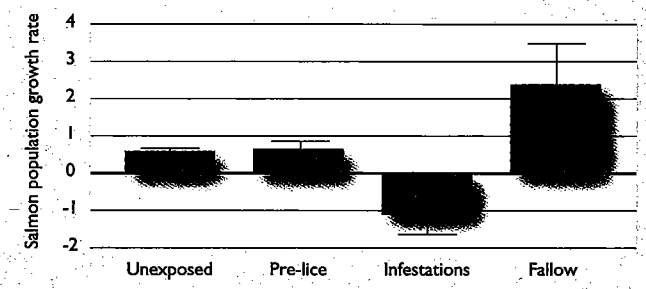
Krkošek M., J.S. Ford, A. Morton, S. Lele, R.A. Myers, and M.A. Lewis. 2007. Declining wild salmon populations in relation to parasites from farmed salmon. *Science.*

MORE THAN TWO-THIRDS of the world's salmon supply comes from aquaculture. Fish farming, however, can put wild fish at risk—wild populations are harvested to feed farmed salmon and can be negatively affected by escaped farm fish, pollution and parasites. A new study shows that parasites from salmon farms have depressed some wild salmon populations and may lead to their local extinction.

Martin Krkošek and co-authors examined the impact of parasitic sea lice from salmon farms on wild pink salmon populations along the central British Columbia coast. The study showed that recurrent sea lice outbreaks typically killed over 80 percent of the nearby pink salmon runs (a salmon "run" is a population of salmon that breeds in a certain river). The numbers of salmon have declined rapidly, and if infestations continue, the affected pink salmon populations are projected to collapse to 99 percent loss in four years, or two salmon generations. This *Lenfest Ocean Program Research Series* report is a summary of the study's findings.

FIGURE 1: HUMAN STRESSORS AND SALMON POPULATION GROWTH RATE

Human stressors	Unexposed	Pre-lice	Infestations	Fallow
Farmed Salmon	No	Few	Many	Few
Lice	No	No	Many	Few
Fishing	Yes	Yes	No	No



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IMPACTS OF AQUACULTURE ON WILD FISH

Fish aquaculture—the practice of raising fish in underwater net pens—may ease the increasing consumer pressure on wild salmon. However, it may also increase impacts on wild species in a number of ways. For example, fish farming uses large volumes of processed wild fish for feed. Farmed fish that escape from aquaculture can also interbreed with wild fish. In addition to escapees, farms can release nutrients, antibiotics, toxins, pathogens, and parasites into the environment.

A major parasite of farmed salmon is the salmon louse, *Lepeophtheirus salmonis*. As a juvenile, the louse drifts through the water seeking host fish. When it finds a fish, it latches on to the outside and feeds on the skin, muscle and blood. Its feeding activity can upset the fish's salt-water balance, lead to bacterial and viral infections, and ultimately cause death. Large adult salmon have thick scales, and can usually survive sea lice infections. Juvenile salmon, which are smaller and often do not have scales, are much more likely to sicken and die from an infection.

Most salmon farms are in coastal waters, where juvenile salmon spend their first several months of marine life. In areas without salmon farms, most wild juvenile salmon have no lice. Lice, however, can build up on salmon farms, amplifying the parasites in the surrounding environment. As the juveniles migrate past the farms, they get infected with lice, and many may die.

MAP OF STUDY AREA

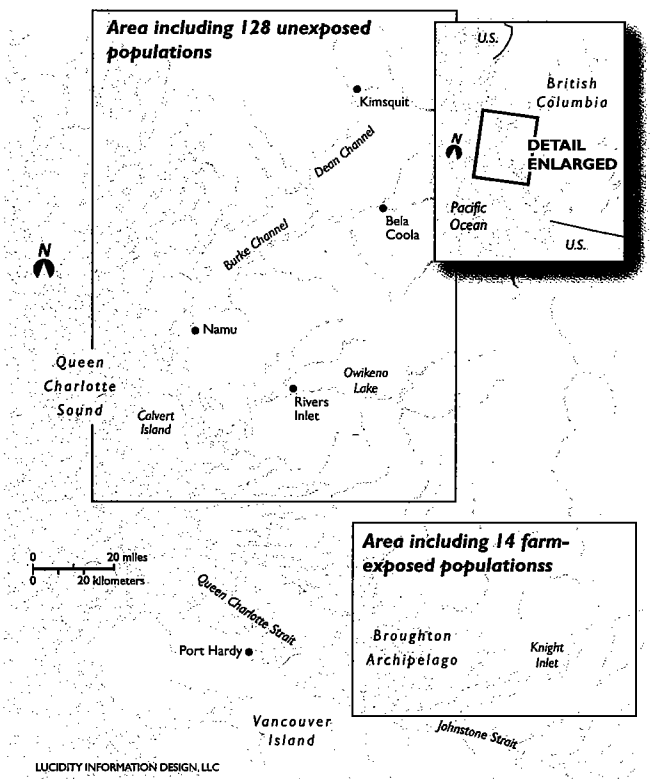

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FIGURE 2: ESTIMATED PERCENT OF EACH SALMON RUN KILLED BY LICE

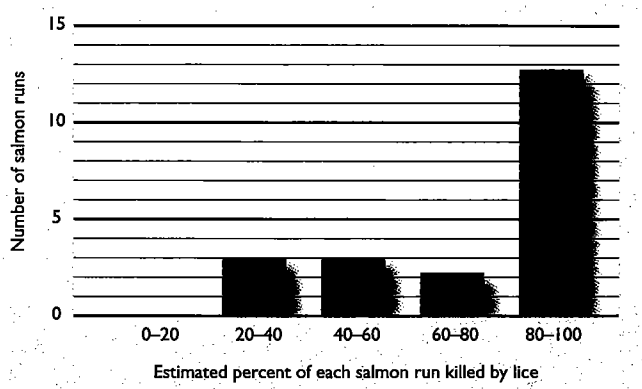
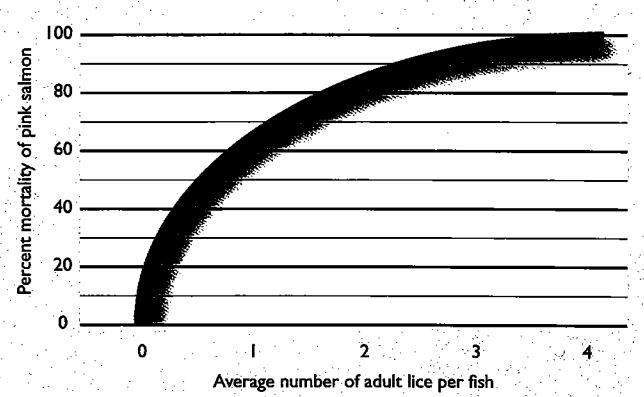


FIGURE 3: PINK SALMON MORTALITY AND NUMBER OF LICE PER FISH



CLOSING SALMON FARMS MAY HELP REBUILD WILD SALMON POPULATIONS

Pink salmon populations in the Broughton Archipelago collapsed in 2002 following a major sea lice infestation. As a result, the commercial fishery was closed and in 2003 several salmon farms in the area were temporarily closed. Sea lice abundance declined in 2003, and the wild salmon populations increased.

STUDY DETAILS

The scientists analyzed Canadian government data on the number of pink salmon returning to rivers on the Central coast of British Columbia from 1970 to 2006. They organized the data into groups according to whether or not the populations were exposed to salmon farms before and during the sea lice infestations. The four groups were:

1. **Unexposed**—Wild salmon from rivers just north of where the salmon farms are located (years of data: 1970–2006);
2. **Pre-infestation**—Wild salmon from rivers near salmon farms but before sea lice infestations (years of data: 1970–2000);
3. **Infestation**—Wild salmon from rivers near salmon farms during sea lice infestations (years of data: 2001–2006); and
4. **Fallow**—Wild salmon from rivers near salmon farms but when many of the farms were closed (year of data: 2003).

The scientists calculated the population growth rate, which is the number of offspring surviving per parent each year, for each group (Figure 1). A positive growth rate means the salmon are stable or increasing. A negative growth rate means the salmon are declining towards extinction.

The results show that the growth rates of unexposed salmon populations were very similar to exposed populations before the infestations (the "Pre-infestation" group), when both groups supported commercial fishing. When the infestations of the exposed populations began (the "Infestation" group), their population growth rate declined and the fishery was closed. When the farms were closed (the "Fallow" group), sea lice declined, and the salmon 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 predicted that, if the infestations continue, the pink salmon populations will decline to extinction (99 percent collapse) in a further two salmon generations (four years).

For the final step in the analysis, the scientists combined the salmon data with a separate data set on sea lice abundances in the exposed populations. They calculated how many salmon in each year and in each river were missing because they were killed by lice. In most of the populations exposed to sea lice, over 80 percent of the expected number of returning adult salmon had been killed by lice as juveniles (Figure 2). The analysis reveals the high vulnerability of pink salmon populations to sea lice (Figure 3).

FISH FARM IMPACTS CAN EXCEED THOSE OF 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 towards 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.

CONCLUSIONS

Krkošek and his colleagues found three main results:

- Pink salmon populations known to be experiencing sea lice infestations were depressed and declining whereas the other populations remained productive.
- If sea lice infestations continue, affected pink salmon populations will collapse by 99 percent in a further two salmon generations (four years).
- The sea lice typically killed over 80 percent of the fish in each salmon run.

Literature Cited

Morton, A. and R. Routledge. 2005. Mortality rates for juvenile pink *Oncorhynchus gorbuscha* and chum *O. keta* salmon infested with sea lice *Lepeophtheirus salmonis* in the Broughton Archipelago. *Alaska Fisheries Bulletin,* Vol. 11(2).

About the Authors

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The Lenfest Ocean Program was established in 2004 by the Lenfest Foundation and is managed by the Pew Environment Group. For more information about the Program or a copy of the Science paper, please visit www.lenfestocean.org or contact us at info@lenfestocean.org.

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LENFEST OCEAN PROGRAM

Lenfest Ocean Program: Protecting Ocean Life Through Marine Science
The Lenfest Ocean Program supports scientific research aimed at forging new solutions to the challenges facing the global marine environment.

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