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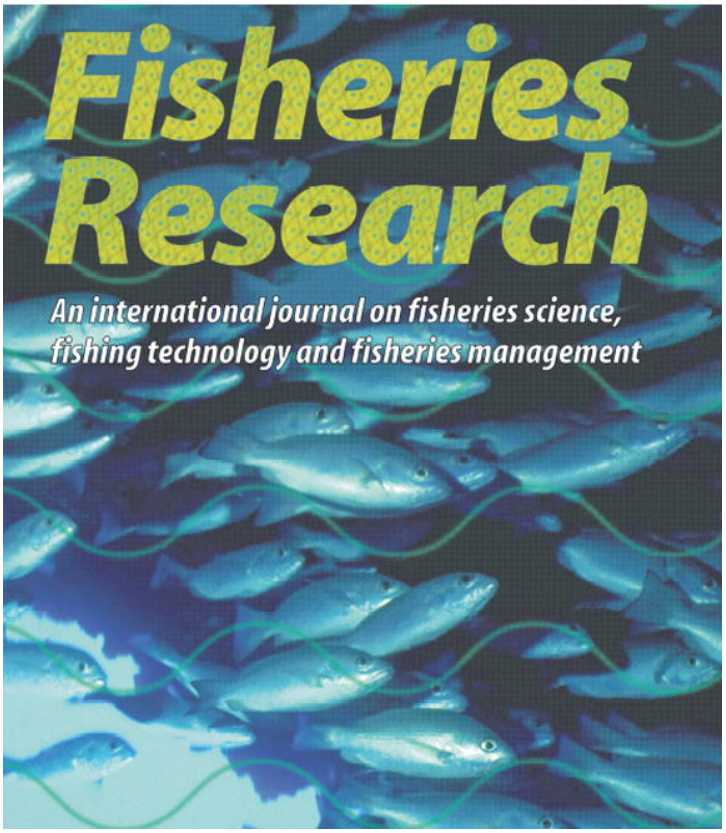

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Letter to the Editor

Response to Dr. Neil Frazer's comment on "Sea lice on adult Pacific salmon in the coastal waters of British Columbia, Canada" by R.J. Beamish et al. (2005)

The objective of the Beamish et al. (2005) study was to produce an accurate estimate of the abundances of all stages and species of sea lice on adult Pacific salmon in a major coastal ecosystem in British Columbia. The reason for the study was the concern that sea lice produced on farmed salmon may be increasing the early marine mortality of Pacific salmon. We cited Morton et al. (2004) and McVicar (2004) as sources for information relating to this concern. It is necessary to have reliable information about natural sea lice production to assess the possible impacts of the offspring of sea lice produced on farmed salmon on young Pacific salmon. Our study was the first comprehensive assessment of the abundances of all stages of *Lepeophtheirus salmonis* and *Caligus clemensi* on adult Pacific salmon off Canada's Pacific coast. Canadian commercial and recreational fishermen know that sea lice were commonly found on adult Pacific salmon, but only a few studies documented infection levels on selected species of Pacific salmon. In fact, we were not aware of any study in the subarctic Pacific that had surveyed abundances of all species and stages of sea lice on adult Pacific salmon. We recognized the excellent study of Nagasawa (2001) on sea lice production on Pacific salmon in the central North Pacific, but we noted that he reported the abundances of only gravid female *L. salmonis*.

Our paper reported sea lice levels on five major species of adult Pacific salmon. The main study area in Queen Charlotte Strait is a common commercial fishing area because of the abundances of adult Pacific salmon. It is also an area that contains fish farms along the coast. We observed that virtually 100% of all adult Pacific salmon were infected with sea lice (Beamish et al., 2005). In general, pink and sockeye salmon sampled in Queen Charlotte Strait had average intensities (number of sea lice on infected fish) of all stages of both species of sea lice of 51.1 and 41.1, respectively. Coho and chinook salmon had lower average intensities of 18.5 and 15.9, respectively. We sampled adult Pacific salmon in Smith and Rivers inlets, north of Queen Charlotte Strait, as it was an area with no fish farms. The prevalence (percentage of fish with sea lice) and intensities of sea lice on adult Pacific salmon in this reference area were similar to those in Queen Charlotte Strait (Beamish et al., 2005). The percentage of sea lice in the chalimus stage (the chalimus stage is attached to the fish by a frontal filament) was about equal in each study area; 58.2% in Queen Charlotte Strait and 60.8% in Smith and Rivers inlets. The chalimus stage of *C. clemensi* accounted for 76.6% of all *C. clemensi* stages in both areas combined. The chalimus stage of *L. salmonis* in both areas was 37.4% of all stages. These observations showed that sea lice were abundant on adult Pacific salmon and that new infections were occurring on Pacific salmon in the study areas.

Dr. Frazer appears to question the relevance of our choice of Smith and Rivers inlets as a reference area, stating that the area was not significantly different from Queen Charlotte Strait. However, later in his comments he uses the results of a study by Morton et al. (2004) in Smith and Rivers inlets to conclude that there were "very large differences in lice abundances on juveniles in the two areas" (a reference to a comparison between Smith and Rivers inlets and the area around fish farms located to the east of Queen Charlotte Strait). Dr. Frazer's reference to the data collected by Morton et al. (2004) in Smith and Rivers inlets emphasizes the importance of studying the natural production of sea lice.

In their paper, Morton et al. (2004) report that they sampled 250 juvenile pink and chum salmon collected in Rivers Inlet from May 13 to July 4, 2002 and 48 juvenile pink and chum salmon in Smith Inlet collected from June 6 to July 3, 2002. They did not detect any sea lice on the fish collected from Rivers Inlet and found one *C. clemensi* on a fish in the Smith Inlet sample. Our estimate of sea lice abundances on juvenile Pacific salmon in Smith and Rivers Inlets were larger than reported in Morton et al. (2004). We captured juvenile Pacific salmon in our survey in Smith and Rivers inlets in early August in 2003 and reported the results in Beamish et al. (2007). Our sea lice prevalence estimates are from juvenile Pacific salmon captured in trawls. We use only the chalimus stage as an index of minimum infection levels because the chalimus is attached to the fish and is less likely than the mobile stage to be lost during trawling and would not be transferred from other fish in the net. Using only chalimus stages, we recorded prevalences in Smith Inlet on juvenile pink, chum, sockeye and coho salmon of 2.0%, 9.5%, 5.0% and 3.8%, respectively (Table 1). The prevalences of the chalimus stage in Rivers Inlet on juvenile pink, chum, sockeye, coho and chinook were 33.3%, 22.0%, 60.7%, 14.3%, and 3.1%, respectively (Table 1). These estimates are for chalimus stages only and show that natural infections of sea lice were occurring on juvenile Pacific salmon in early August 2003, consistent with

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Table 1
Sea lice on juvenile Pacific salmon collected in Smith Inlet, 6 August 2003 and Rivers Inlet, 7 August 2003

	Smith Inlet				Rivers Inlet			
	Number of fish	Average length in mm (S.D.)	Number of chalimus	Prevalence of chalimus (%)	Number of fish	Average length in mm (S.D.)	Number of chalimus	Prevalence of chalimus (%)
Pink salmon	50	137 (12.6)	1	2.0	3	151 (13.4)	1	33.3
Chum salmon	63	169 (24.2)	6	9.5	41	179 (19.0)	9	22.0
Sockeye salmon	20	112 (16.6)	1	5.0	61	98 (23.0)	76	60.7
Coho salmon	26	234 (25.1)	1	3.8	35	214 (27.8)	5	14.3
Chinook salmon	0	–	–	–	65	176 (42.6)	2	3.1

the interpretation that new infections of sea lice were occurring on adult and juvenile Pacific salmon at the time that adult Pacific salmon were returning to coastal areas.

In a related study (Beamish et al., 2007) we proposed that the infection of juvenile Pacific salmon that had an overlapping distribution with adult Pacific salmon may be part of a life history strategy of *L. salmonis* to improve their productivity by increasing the transmission potential of the infectious stage when host densities are decreased in the open ocean and increased in coastal areas. Juvenile coho and chinook salmon collected using hook and line gear in Queen Charlotte Strait in August 2004 had a prevalence of sea lice of 90–100% and an intensity of about one sea louse per infected fish. Samples of juvenile coho and chinook salmon collected with hook and line gear in November 2004 continued to have a high prevalence of sea lice (87–93%) and the intensity had increased to about four sea lice per infected fish for coho and chinook salmon (Beamish et al., 2007). The mobile stage of *L. salmonis* was the dominant sea lice on these fish. These samples indicated that juvenile coho and chinook salmon that remained in the coastal areas in the winter had a high prevalence of sea lice. We proposed that sea lice on these coho and chinook salmon would be a source of infection on juvenile Pacific salmon entering the ocean in the following spring (Beamish et al., 2007).

We concluded in Beamish et al. (2005) that adult Pacific salmon may carry sea lice into all costal areas around the rim of the subarctic Pacific and Dr. Frazer reinforces our conclusion when he argues that sea lice levels on adult Pacific salmon may be similar over large areas of the coast. The major conclusion in Beamish et al. (2005) was that sea lice were a common parasite of adult Pacific salmon in the coastal ecosystems we sampled. The intensities of sea lice indicated that natural production of sea lice could be large during the coastal migration of adult Pacific salmon. This large abundance of sea lice could be of concern to the salmon farming industry depending on the location of their net pens.

Dr. Frazer's comments are partly related to our paper and partly to his own unpublished ideas about sea lice transmission from farmed salmon to wild juvenile Pacific salmon. We responded only to his comments about the Beamish et al. (2005) paper. His analysis of sea lice transmission from farmed salmon to juvenile Pacific salmon is a separate issue and his own idea. We note that his assertion that juvenile Pacific salmon are "ill-equipped to resist" the infection of sea lice is an important statement that needs to be supported with appropriate citations.

Dr. Frazer's main criticism of our paper appears to be his comment that, "the reader who is only passingly familiar with the phenologies of sea lice and Pacific salmon is thus invited to conclude that salmon farming has no effect on the abundance of sea lice on juvenile Pacific salmon, although the authors carefully refrain from making such a statement." We think that readers, reviewers and editors of papers that cite our study will understand that we are reporting natural sea lice levels on adult Pacific salmon and the potential of the offspring of these sea lice to infect juvenile Pacific salmon and farmed salmon. There are no data in our paper relating to the transmission of sea lice on farmed salmon to juvenile Pacific salmon in the vicinity of salmon farms.

References

Beamish, R.J., Neville, C.M., Sweeting, R.M., Ambers, N.J., 2005. Sea lice on adult Pacific salmon in the coastal waters of Central British Columbia, Canada. Fish. Res. 76, 198–208.

Beamish, R.J., Neville, C.M., Sweeting, R.M., Jones, S.R.M., Ambers, N., Gordon, E.K., Hunter, K.L., McDonald, T.E., Johnson, S.C., 2007. A proposed life history strategy for the salmon louse, *Lepeophtheirus salmonis,* in the subarctic Pacific. Aquaculture, in press.

McVicar, A.H., 2004. Management actions in relation to the controversy about salmon lice infections in fish farms as a hazard to wild salmonid populations. Aquacult. Res. 35, 751–758.

Morton, A., Routledge, R., Peet, C., Ladwig, A., 2004. Sea lice (*Lepeophtheirus salmonis*) infection rates on juvenile pink (*Oncorhynchus gorbuscha*) and chum (*Oncorhynchus keta*) salmon in the nearshore marine environment of British Columbia, Canada. Can. J. Fish. Aquat. Sci. 61, 147–157.

Nagasawa, K., 2001. Annual changes in the population size of salmon louse *Lepeoptheirus salmonis* (Copepoda: Caligidae) on high-seas pacific Salmon (*Oncorhynchus* spp.), and relationship to host abundance. Hydrobiologia 453/454, 411–416.

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