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A proposed life history strategy for the salmon louse, *Lepeophtheirus salmonis* in the subarctic Pacific

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Abstract

The sea louse, *Lepeophtheirus salmonis*, is commonly found on Pacific salmon that are rearing in the central North Pacific Ocean and adjacent seas (subarctic Pacific). Large numbers of sea lice have also been observed on all species of adult Pacific salmon when they return to coastal marine areas in the summer during their spawning migration. We propose that the transport of sea lice into coastal areas is a strategy employed by *L. salmonis* to improve their productivity by improving the transmission potential of the infectious stage when host densities are decreased in the open ocean and increased in the coastal areas. Juveniles of the species of Pacific salmon inhabit the same areas at the same time as the returning adult salmon and, according to the proposed strategy, will become infected from sea lice on the adult Pacific salmon. Juvenile pink, chum and sockeye salmon will carry these sea lice into the open ocean when they migrate away from the coastal areas later in the year. The offspring of these sea lice on pink, chum and sockeye would infect Pacific salmon on the high seas and thus maintain high abundances of sea lice. Juvenile coho and chinook salmon that remain in the coastal areas would serve as hosts for the sea lice over the winter. The sea lice on these resident coho and chinook salmon would infect juvenile Pacific salmon that enter the ocean in the early spring. The strategy would result in the infection of juvenile Pacific salmon throughout their range in all coastal areas.

Keywords: *Lepeophtheirus salmonis*; Sea lice life history; Pacific salmon; British Columbia

1. Introduction

Salmon farming is an important and developing industry in the province of British Columbia, producing 70–80,000 t in 2003 and 2004. This compares to a wild Pacific salmon catch of all species of 38.4 t in 2003 and 25.6 t in 2004. In 2005, there were 126 salmon farms licensed of which 86 were growing salmon. Farmed salmon is currently the major agricultural export in the province.

There is concern that salmon farming may harm wild Pacific salmon (*Oncorhynchus* spp.). One concern is that sea lice produced on farmed salmon will cause a mortality of wild salmon that is additive and not compensatory to their natural mortality. Understanding and managing any impact of sea lice produced from salmon in farms requires an understanding of the natural production of sea lice. There are two species of sea lice that are found on farmed

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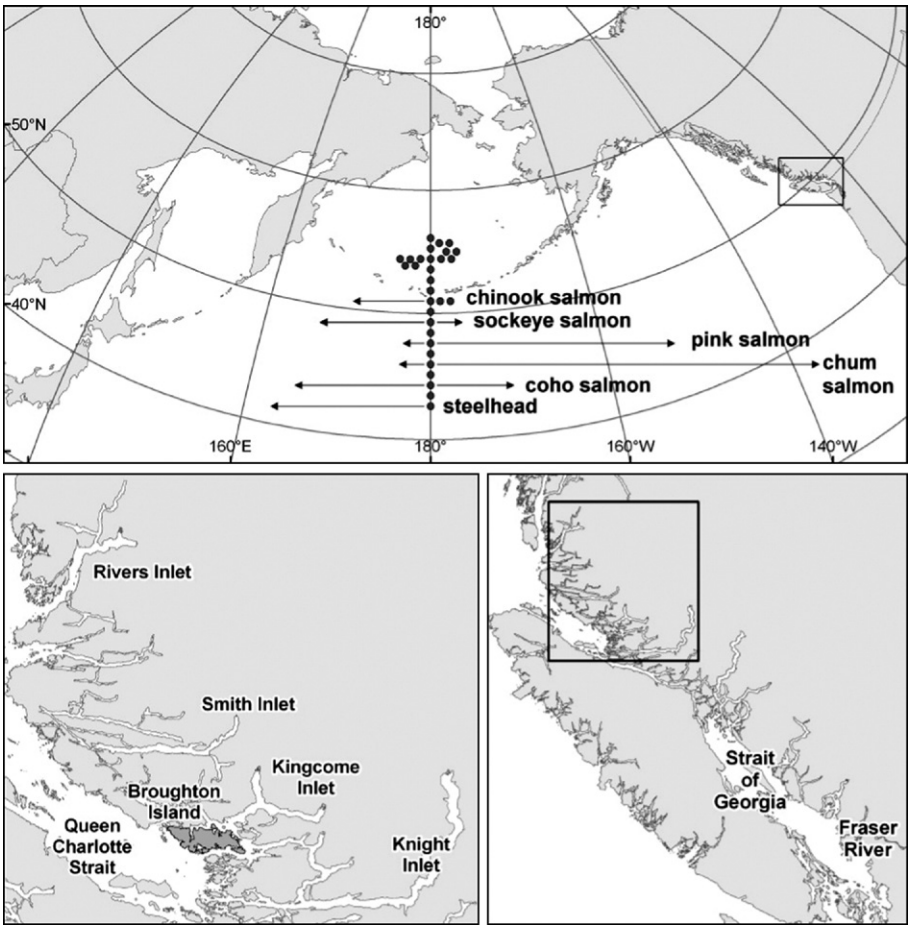

Fig. 1. (A)Study area showing the location of the sets (●) fished in the central North Pacific in this study and by Nagasawa (2001). The horizontal arrows show the extent of the distribution of Pacific salmon of Asian origin east of the fishing locations (→) and the extent of the distribution of Pacific salmon of North American origin west of the fishing locations (←). Also shown is the sampling area off the coast of British Columbia, inset (B). The study area in the central coast region of British Columbia showing the Strait of Georgia, Fraser River, inset (C). Location of sampling areas.

salmon in British Columbia (Beamish et al., 2006); however, it is *Lepeophtheirus salmonis* that is of immediate concern. Despite the widespread distribution of *L. salmonis* and the early recognition of its potential impact on commercial mariculture (Kabata, 1973), little is known about the natural factors that affect its population dynamics (Tully and Nolan, 2002). This is particularly notable in the subarctic Pacific (North Pacific Ocean and adjacent seas) where Pacific salmon dominate the daytime fish biomass in the surface waters (Beamish et al., 2005a).

L. salmonis, the salmon louse, is a common parasite on Pacific salmon in the North Pacific and on the species in the genus *Salmo* in the North Atlantic (Kabata, 1979). The life cycle has five phases and ten stages (Johnson and Albright, 1991; Schram, 1993), with the survival of an individual sea louse depending on the relatively short-lived and planktonic copepodid stage finding a suitable host. After the egg hatches there are two nauplii stages that develop in 4 days at 10 °C into the infectious copepodid stage (Johnson and Albright, 1991). It is not known how long the copepodid may live at different temperatures but at temperatures of about 10 °C to 15 °C, which occur in the central North Pacific in the summer, the copepodid may live approximately 5 days (Wooten et al., 1982; Voth, 1972; Brooks, 2005). Recognizing that there is a short time available for the copepodid to find a host, it is impressive that *L. salmonis* is so successful. Its success is even more remarkable when one considers that the host Pacific salmon are highly migratory and anadromous. In particular, there is a major reduction in the biomass of all Pacific salmon in the open ocean after the adult fish leave the high seas in the spring and summer and begin their spawning migration. Beamish et al. (2005a) estimated that between 1990 and 1999 the average annual biomass of adult Pacific salmon returning to coastal areas around the subarctic Pacific was 1.42 million t. Because large