Exhibit B

Additional Information on Salmon Feedlot Amplification of Sea Lice

Sea lice are small marine copepods that occur naturally in the Northern Hemisphere. Sea lice are ectoparasites that attach to the outside of fish, either on skin, fins, or gills, and feed off of their blood, tissue and mucus. The term 'sea lice' refers to several small crustacean species of the family Caligidae that live and feed on fish. At least thirteen different species of sea lice live in British Columbia waters. Only *Caligus clemensi*, *Lepeophtheirus cuneifer* and *Lepeophtheirus salmonis* have been reported on feedlot and wild salmon in British Columbia. *L. salmonis* is almost always found only on salmon. In British Columbia waters, *C. clemensi* and *L. salmonis* may damage both feedlot and wild salmon, and are a major concern both for the aquaculture industry and for wild salmon conservation. While *L. salmonis* is often more prevalent and more damaging than *C. clemensi* (Kabata 1988; Morton et al. 2004), studies in the Broughton Archipelago in 2003 indicated that 20% of chum salmon were infected with *C. clemensi* and only 7% with *L. salmonis* (Gallaugher et al. 2004). *C. clemensi* are host generalists and therefore jump more frequently between hosts, increasing their ability to transfer pathogens fish to fish.

Sea lice have a life cycle involving ten different stages, but can only attach to fish during a short stage known as the 'copepodid' stage and can only harm salmon in successive stages during which lice attach to and feed upon the host fishes' body tissues and blood. Sea lice normally do not harm adult salmon because the scale integrity and body mass of adult salmon makes them tolerant to the stresses imposed by sea lice. However, even small numbers of sea lice may harm or kill juvenile salmon prior to scale development. As few as five lice may seriously harm a juvenile Atlantic salmon of 15 grams or less, while 11 or more can kill it (WWSS 2001; Costello 2009). Morton and Routledge (2005) showed that short-term mortality of wild juvenile pink and chum salmon is increased by infestations of just 1 to 3 sea lice. Small numbers of lice can harm or kill salmon indirectly, by increasing the fishes' stress levels and weakening their immune systems. A "load" of only one louse per gram of fish can be lethal (Finstad 2002; Costello 2009). Weakened salmon are more prone to infections and parasites. The open wounds caused by sea lice allow diseases and parasites to enter the fishes' bodies (Mustafa et al. 2001). A salmon fry or smolt infected by sea lice can suffer stress, osmotic failure, viral or bacterial infection, serious fin damage, skin erosion, constant bleeding, deep open wounds, and sometimes death (Mustafa et al. 2001; Bright and Dionne 2005). Smaller and younger salmon are more at risk to either the lice or to disease, and higher densities of sea lice are more likely to cause stress, disease, and death to young, small or weak salmon (Johnson 1998).

Some species of salmon are more susceptible to sea lice than others: adult pink salmon generally carry the most lice (5.8 adult sea lice per fish) and have the most infected population (92% of adult pink salmon have sea lice); coho are the most resistant to lice, although even they are susceptible; Chinook and Atlantic salmon have mid-range susceptibility (Nagasawa et al. 1993; Connors et al. 2010a,b). Louse-induced mortality of pink salmon can exceed 80% (Krkosek et al. 2007). Morton et al. (2008) showed that for pink and chum salmon in the Broughton Archipelago, salmon feedlot exposure was the only consistently significant predictor of sea lice abundance; as well as evidence suggesting salmon feedlots are associated with sea lice infestations of sockeye salmon and larval Pacific herring (*Clupea pallasii*).

It is also possible and likely for sea lice to carry diseases between feedlot and wild salmon. There are a variety of ways diseases may be transferred from feedlot fish to wild sockeye, including horizontal transfer of shed pathogens, via feedlot salmon escapees, via movement of infected sea lice (vectoring), and through discharge of untreated "blood water" from processing facilities (Dill 2011). Sea lice as a disease vector has already been shown for Infectious Salmon Anemia virus (ISAv) on the Atlantic coast (Dannevig and Thorud 1999; USDA 2002) and proper sea lice management at salmon feedlots is required to prevent the spread of ISA virus (Hammell and Dohoo 2005). The furunculosis bacterium has also been found on the bodies of sea lice, making it likely that sea lice spread this disease as well (Johnson 1998). There are a number of studies showing that sea lice may be vectoring numerous diseases from feedlot to wild fish, such as Infectious Pancreatic Necrosis virus, Salmonid alpha virus, ISA virus, IHN virus, Furunculosis, bacteria (such as *Tenacibaculum maritimum, Pseudomonas fluorescens*, and *Vibrio* spp.), and microsporidian, *Paranucleospora theridion* (Nylund et al. 1991, 1993, 1994; Nese and Enger 1993; Rolland and Nylund 1998; Johnson et al. 2004; Hammell and Doho 2005; Karlsen et al. 2005; Barker et al. 2009; Lewis et al. 2010; Stull et al. 2010; Nylund et al. 2011; and see Dill 2011).

Sea lice are intolerant of fresh water and usually detach from adult salmon when they migrate up freshwater rivers to spawn, or fall off and die within a couple days to a few weeks (Finstad and Bjorn 1995; MacVicar 1997). Thus, under natural conditions, vulnerable salmon fry are born in a lice-free environment in fresh water. Under natural conditions, when juvenile wild salmon enter the coastal waters for the first time in spring, their adult counterparts, as well as the sea lice, are miles offshore. These fry will not encounter sea lice until some weeks after marine entry, at which time they will have sufficient body mass and scale fortification to withstand the impacts of sea lice.

Natural populations of sea lice seldom harm wild salmon; however, salmon feedlots alter natural sea lice transmission dynamics and amplify sea lice populations (Kabata 1970; MacKinnon 1997; Bakke and Harris 1998; Krkosek et al. 2005). Stocking hundreds of thousands to millions of fish in small pens in confined waters makes fish feedlots ideal breeding grounds for parasites such as sea lice, and drastically increases the number of lice in surrounding waters. Stress levels associated with crowding make feedlot salmon more susceptible to lice infestation and most of British Columbia’s feedlot salmon are Atlantic salmon, which are inherently more susceptible to sea lice than many other salmon species (Johnson and Albright 1992; MacKinnon 1997; Bakke and Harris 1998; Fast et al. 2002).

Studies in Norway, Ireland, and Scotland suggest that most sea lice larvae originate on feedlot salmon, and that densities of larval and adult lice are much higher in feedlots than in the wild (Tully and Whelan 1993; Costelloe et al. 1998; Butler 1999; Heuch and Mo 2001; Bjorn 2002; Costello 2009). Wild salmon captured near salmon feedlots in Europe carried an average of 100 lice per fish, while salmon captured away from feedlots carried an average of 13 lice (Finstad 2002). Assuming that the Norwegian regulation allowing a maximum of 0.5 gravid (pregnant) female lice/fish on salmon feedlots was followed, an estimated 29 billion sea lice eggs may have been produced by Norwegian feedlot salmon in the year 2000 (Heuch and Mo 2001). Another study on Scotland’s west coast feedlots found that feedlot salmon produced 78 to 97% of all Scottish lice, and that wild salmon produced fewer than 1%, while escapees from salmon feedlots accounted for the remainder (Butler 2002).

Though it is impossible to determine exactly how many sea lice eggs can be produced by lice from a single salmon feedlot, scientists can estimate lice egg production, and even the limited industry data on sea lice numbers at British Columbia salmon feedlots that has been made public shows incredible amplification of sea lice (Marty et al. 2010b). Krkosek et al. (2010) showed that exponential population growth of lice within a feedlot, rather than sustained louse immigration from wild sources, drive lice outbreaks on British Columbia salmon feedlots. Twelve active salmon feedlots in the Broughton Archipelago containing between 1 and 5 million Atlantic salmon were estimated to host over 6 million gravid sea lice that produced 1.6 billion eggs during two weeks in the winter of 2003 to 2004 (Orr 2007). Nearly 1.7 million infectious larval lice can be produced at one salmon feedlot alone, twice a month. The British Columbia aquaculture industry reports an average 0.05 of gravid (egg bearing) female lice sea lice per fish. A typical British Columbia salmon feedlot has over half a million or more salmon, which translates to over 25,000 egg bearing female lice and approximately 6.25 million sea louse eggs, based on a conservative estimate of 250 eggs per female in a two week period. Given an average egg survival rate of 26.8% (Johnson and Albright 1991), approximately 1.675 million infectious larval lice could be produced at a single feedlot twice a month. However, companies normally wait until their feedlot reaches the government's treatment threshold of three motile lice per fish before consulting a veterinarian. By the time medicated feed is delivered, administered and takes effect, lice levels could be much higher. British Columbia continually has salmon feedlots with hundreds of thousands of fish reaching levels of 10 lice per fish. Keeping in mind these are only estimates based on the limited data industry provides and considering the more than one hundred salmon feedlots in the Broughton Archipelago, Georgia Strait and along the British Columbia coast, it is easy to understand why sea lice from salmon feedlots are such a problem.

A study in the Broughton Archipelago found that sea lice were almost 9 times more abundant on juvenile wild salmon near feedlots holding adult salmon and 5 times more abundant near feedlots holding smolts, than in areas distant from fish feedlots (Morton et al. 2004). The study found that 90% of juvenile pink and chum salmon sampled near salmon feedlots in the Broughton Archipelago were infected with more than 1.6 lice per gram of host mass, a proposed lethal limit when the lice reach mobile stages. Sea lice abundance was near zero in all areas without salmon feedlots. Salinity and temperature differences could not account for the higher infestation rates near the fish feedlots. The Broughton Archipelago has nearly 100 discreet wild spawning areas in 64 rivers, large enough for scientists to evaluate control areas which have no salmon feedlots. The most immature life stages dominated the lice population throughout the study, suggesting the source of lice was a stationary, local salmonid population, i.e. the salmon feedlots. No such wild population could be identified.

Krkosek et al. (2005) showed that sea louse infection pressure imposed by an isolated salmon feedlot in British Columbia was four orders of magnitude greater than ambient levels, resulting in a maximum infection pressure near the feedlot that was 73 times greater than ambient levels and exceeded ambient levels for 30 km along the two wild salmon migration corridors. The feedlot-produced cohort of lice parasitizing the wild juvenile hosts reached reproductive maturity and produced a second generation of lice that re-infected the juvenile salmon. This raised the infection pressure from the feedlot by an additional order of magnitude, with a composite infection pressure that exceeded ambient levels for 75 km of the two migration routes. This research concluded that a commercial salmon feedlot directly contributes sea lice to the ambient habitat approximately 30,000 times greater than the natural production of sea lice in an area of equal size.

There have been a few studies purporting to counter the overwhelming scientific evidence that sea lice are magnified and then transmitted from feedlot to wild salmon and the strong associations between salmon feedlots and recurrent infestations of wild juvenile salmon in British Columbia. For example, the contention of Brooks (2005) that ocean temperatures and salinities prevent transmission of lice from feedlot salmon to sympatric wild juvenile pink and chum salmon was based on flawed interpretations, misleading analysis and incomplete evaluation of scientific literature (Krkosek et al. 2005). A DFO lab study testing salmon lice resistance (Jones et al. 2008) claimed that Pacific salmon are resistant to damage from sea lice except in their extreme infancy when first leaving their natal rivers. However, this limited study exposed juvenile pink salmon to infective stages of lice for only a few hours, resulting in artificially low mortality rates. Migrating wild juvenile salmon, like those in the Broughton Archipelago, are exposed to lice for weeks or months. An independent scientific study (Krkosek et al. 2009) that examined the process of sea louse transfer to wild juvenile salmon in the field where salmon are exposed to sea lice over a longer period of time reached entirely different conclusions. Particularly telling is a study of salmon feedlots in a primary salmon migratory corridor in British Columbia which removed their stock of feedlot-raised salmon in 2003, resulting in both a decline in sea lice populations and an increase in wild salmon survival rates (Morton et al. 2005; Beamish et al. 2006). A recent study responding to and evaluating previous claims of no impacts to wild salmon from sea lice on salmon feedlots showed that that sea lice abundance on feedlots is negatively correlated with productivity of both pink and coho salmon in the Broughton Archipelago (Krkosek et al. 2011). This study analyzed fish feedlot data and pink salmon and coho salmon data from 1970 to 2009 over a wide geographic area in the Broughton Archipelago, and found up to 80% higher mortality for juvenile wild salmon that swam near fish feedlots when sea lice populations were high among feedlot fish compared to those that did not swim near fish feedlots.

British Columbia aquaculture companies report their sea lice and disease information to a central database overseen by their industry association, the British Columbia Salmon Farmers Association (BCSFA). This association provides monthly reports summarizing sea lice abundance by region to the British Columbia Ministry of Agriculture and Lands (BCMAL). The public only sees summarized data reported online by BCMAL. This coarse information has little value for researchers or concerned citizens, nor has the BCMAL data been properly evaluated. Every year scientists report elevated levels of lice on wild juvenile salmon near fully-stocked salmon feedlots. Current monitoring, managing, and auditing are clearly not effectively protecting wild salmon. The aquaculture industry’s primary concern is the impact of sea lice on the health of feedlot fish, and the reduction in the number of lesions caused by sea lice infection. Protection of wild fish, which requires a much more precautionary approach, is not the industry’s concern or responsibility.