EXECUTIVE SUMMARY:

Project 5B: Examination of relationships between salmon aquaculture and sockeye salmon population dynamics

The objective of this technical report is to quantitatively evaluate the relationship between Fraser River sockeye salmon productivity and (a) sea louse (*Lepeophtheirus salmonis* and *Caligus clemensi*) abundance on farmed salmon, (b) disease frequency and occurrence on farmed salmon, (c) mortalities of farmed salmon, and (d) salmon farm production. These analyses are intended to inform the work of other contractors who are preparing comprehensive reports on salmon aquaculture and Fraser River sockeye salmon dynamics for the Cohen Commission.

While the focus of this report is Fraser River sockeye salmon I included data on non-Fraser River populations insofar as they informed the analysis as reference populations for the aquaculture variables considered. The salmon farm data examined in this report was provided by the British Columbia Salmon Farmers Association, the British Columbia Ministry of Agriculture and Lands and the British Columbia Ministry of Environment and was compiled by Korman (2011). Because it is well established that oceanographic conditions can influence sockeye survival I attempted to account for their influence during early marine life when examining relationships between aquaculture and sockeye dynamics. Specifically, I calculated average sea surface temperature (SST) anomalies in the winter preceding the entry of juvenile sockeye into the marine environment, as a measure of oceanographic conditions in early marine life

The first part of this report relates sockeye survival anomalies to aquaculture variables. Survival anomalies were calculated as population specific residuals of the Ricker or Larkin stock recruit relationship (depending on which better described stock specific density-dependence) fit to spawner abundance and SST in early marine life. I related survival anomalies to (a) sea louse abundance on farmed salmon in the spring/summer of the year of sockeye marine entry, (b) the occurrence of high-risk pathogens on farmed salmon in the year sockeye migrate to sea, (c) the proportion of farmed fish that died of disease or unknown causes (“fresh silvers” in industry jargon) in the spring/summer in the year sockeye migrate to sea, and (d) the number of salmon being raised in salmon farms in the spring/summer in the year sockeye migrate to sea. My analyses found no statistical support for a relationship between these aquaculture variables and sockeye survival anomalies.

The analyses in the first part of this report are based on short time series of aquaculture variables, beginning no earlier than 2003, with low statistical power to detect

relationships should they truly exist. One dataset that does span the entire sockeye time series is the production of farmed salmon (in metric tonnes) compiled by Fisheries and Oceans Canada management area since salmon farming began in British Columbia in the early 1980s. In the second part of this report I related sockeye productivity (i.e., the natural logarithm of the ratio of adult returns [recruits] to the number of spawners that produced them) to this complete time series of salmon farm production as well as two other factors that have been independently identified as likely contributors to declines in Fraser River sockeye salmon: (1) oceanographic conditions and (2) competition with pink salmon in the North Pacific Ocean. This approach allowed for a quantitative comparison of the strength of the relationship between sockeye dynamics and salmon farm production while explicitly accounting for the influence of oceanographic conditions and the abundance of pink salmon in the North Pacific as well as interactions among these hypothesized drivers.

The results of this analysis suggest that increasing farmed salmon production, SST and pink salmon abundance increases sockeye salmon mortality. In addition, the influence of aquaculture production on sockeye mortality was predicted to be greater when SST anomalies are negative (i.e., cool for British Columbia populations) and when pink salmon abundance in the North Pacific Ocean is high. However, there was large uncertainty around these estimated effects, which precludes drawing strong inference from these results.

The relationships described in this report are correlative, do not on their own establish causation and should be re-examined as more information becomes available. An unavoidable consequence of the structure of the data sets I examined is that multiple populations are compared to environmental time series that have identical values for each population. This makes it more likely that some factor external to the analysis is responsible for the patterns observed. A stronger test of the relationship between sockeye salmon dynamics and aquaculture variables would include independent measures of salmon farm variables for each sockeye population. Because finer scale data on aquaculture are not available, the relationships described in this report should be interpreted with caution. Nonetheless, these findings should be considered a first step towards understanding the role open net pen salmon aquaculture may play in influencing Fraser River sockeye salmon population dynamics.