EXECUTIVE SUMMARY

Project 5D: Impacts of salmon farms on Fraser River sockeye salmon: Results of the Dill investigation

Open net pen aquaculture, as currently practiced in British Columbia, has the potential to create problems for wild salmon populations because the pens are open to the environment, allowing wastes, chemicals and pathogens to move freely back and forth.
Indeed, wild salmon populations have tended to decline wherever this form of aquaculture is practiced, although the reason for this is not always apparent. In one of the best studied cases, wild Pacific salmon in the Broughton Archipelago, BC appear to have been negatively impacted by sea lice from fish farms.

Declines in Fraser River sockeye salmon returns, and in particular the spectacular crash of 2009, have led many to wonder whether fish farms could be implicated, given that most of the migrating sockeye have to pass through the narrow channels among the Discovery Islands, dotted with numerous Atlantic salmon and Chinook salmon farms, on their way north out of the Strait of Georgia.

The hypothesis that there is an effect of farms on sockeye survival was tested by examining the support for its predictions that there would be negative relationships between fish farm production levels - and such farm metrics as lice levels, disease levels and farm mortality rates - and Fraser sockeye survival. These various relationships were statistically analyzed and reported separately to the Commission by Dr. Brendan Connors (Connors B. 2011. Examination of relationships between salmon aquaculture and sockeye salmon population dynamics. Cohen Commission Tech. Rept. 5B).

Unfortunately, it turned out that the data provided by Provincial government (BCMAL) and the BC Salmon Farmers Association (BCSFA) were insufficient in both quantity and quality to allow a rigorous analyses capable of answering these questions with certainty. The biggest problem was the very short length of the time series available for analysis, basically only 4-5 year classes.

However a longer-term analysis, using production data since 1982, did reveal a relationship between farm production and salmon survival, i.e., the greater the farm production the lower the

survival of the sockeye. This analysis also revealed a very interesting interaction with pink salmon abundance in the North Pacific Ocean: the negative effect of the farms appeared stronger when pink salmon were more abundant, suggesting that any farm effect may be mediated through changes in the growth and/or competitive ability of the sockeye.

Despite the *a priori* predictions, these results cannot be considered conclusive, as they are only correlations in the data. However, the fact that the 2006 brood year interacted with half as many pink salmon as the 2005 brood year, and that the corresponding 2010 returns were much greater than those in 2009, suggests that the Connors statistical model may be capturing some underlying causal relationships, and thus motivates the search for what these might be.

Several potential drivers of any farm effect were considered. If such an effect exists, it is most likely to be due to either disease or sea lice, or both. Impacts on sockeye from other factors, such as escapes or waste and chemical inputs and their effects on the benthic and pelagic zooplankton communities, are likely to be quite local and unlikely to be sufficient, alone or in concert, to cause either the long-term population declines or the especially low returns in 2009. However, the cumulative impacts of several farms in close proximity have not been adequately addressed.

The viral and/or bacterial pathogens considered the most risky to wild sockeye are *Renibacterium salmoninarum* (causing bacterial kidney disease, BKD), the IHN virus (causing infectious hematopoietic necrosis, IHN) and *Aeromonas salmonicida* (causing furunculosis). There are a variety of ways these may be transferred from farmed fish to wild sockeye, including horizontal transfer of shed pathogens, via farmed salmon escapees, via movement of infected sea lice (vectoring), and through discharge of untreated "blood water" from processing facilities. Horizontal transfer and vectoring by sea lice are likely to be the most important routes of transmission, but the role of processing facilities needs to be examined further.

ISA (infectious salmon anemia) has not been confirmed on BC fish farms, but several of the veterinary records refer to symptoms that are highly suggestive. A close watch should be kept for indications of this disease, and biosecurity rigidly enforced, since ISA could be devastating to BC wild salmon populations. Recently there have been reports of a possible retrovirus (the so-called "Miller virus"); its role in Fraser sockeye declines is currently uncertain. It is suspected to be a contributory factor to the recently elevated levels of pre-spawning mortality (PSM) in adult

Fraser sockeye, but PSM is not the cause of reduced survival as examined in this report, since the definition of “recruits” includes any mortalities due to PSM. Thus we are looking for the cause of declining survival over and above whatever effects this virus has on returning adults. Of course this does not exonerate the involvement of this presumed virus in mortality of sockeye at earlier life stages.

It is naïve to believe that the present report, and the Cohen Commission in general, will identify *the* cause of the sockeye salmon decline, and in particular the return failure of 2009. Nature is complex and factors do not act in isolation on the population dynamics of any species. Pathogens from fish farms are just one factor among many that may influence the mortality rate of sockeye. There are several ways in which these various factors may interact, and a number of these are discussed. Although some are hypothetical at this stage of our knowledge, they highlight the complexities in the real world system in which farms and wild sockeye are embedded, and caution against any simplistic single-factor explanation.

There are a number of knowledge gaps surrounding the farm-wild fish interaction, in particular those related to the dynamics of disease transfer. These are listed in a separate section of the report. Several management options are also briefly considered, with closed containment being the preferred option if it can be shown to be economically feasible, a hypothesis currently under test by several such facilities in BC, both land-based and in the ocean.

It must be understood that the short time series of data available for this investigation precluded identifying salmon farms as an important driver of the decline of Fraser sockeye. But it must be equally understood that at this stage of our knowledge is it not possible to say they are *not* implicated. It is recommended that a well-organized farm database be maintained in an ongoing fashion by Fisheries and Oceans Canada, and that annual analyses of the sort performed by Dr. Connors be conducted to firm up conclusions as more data become available.