EXECUTIVE SUMMARY:

Project 1 - Infectious Diseases and Potential Impacts on Survival of Fraser River Sockeye Salmon

Numerous pathogens have been reported in sockeye salmon and a few of them have been documented to be, or are, potential causes of significant mortality in this salmon species in the Fraser River system. At present, there are no direct links between a specific pathogen and sockeye salmon survival at a population level in British Columbia. This report reviews 5 viral, 6 bacterial, 4 fungal, and 19 parasitic pathogens that are known to or could potentially infect sockeye salmon. Two idiopathic diseases are also discussed. For each pathogen, a subjective assessment of risk for causing significant disease in wild sockeye salmon in the Fraser River system is provided. This risk is based on 1) the known or suspected virulence of the pathogen to Pacific salmon in general, and specifically to sockeye salmon and 2) the likelihood that the pathogen would be prevalent in the Fraser River or British Columbia. These conclusions were based on review of the peer-reviewed literature, government documents from Fisheries and Oceans Canada (DFO), and interviews with DFO fish health scientists. I designated the following pathogens as potential "High Risk": IHN virus, three bacteria (*Vibrio anguillarum*, *Aeromonas salmonicida*, *Renibacterium salmoninarum*), and two parasites (Ich - *Ichthyophtheirus multifillis* and the myxozoan *Parvicapsula minibicornis*).

The IHN virus is well recognized as a lethal pathogen to fry sockeye salmon in freshwater. It also occurs in marine waters in BC, and has caused several outbreaks in pen-reared Atlantic salmon. Post-smolt sockeye salmon are less susceptible, but recent evidence suggests that there is variability in the virulence of this virus between isolates, and thus it is conceivable that some strains may be more pathogenic to sockeye salmon in the ocean. The three bacterial pathogens are included in the High Risk category as they are recognized as virulent pathogens in both hatcheries and netpens. *Vibrio anguillarum* is ubiquitous in the marine environment, the other two bacteria are occasionally reported in wild salmon. However, outbreaks in wild salmon, including sockeye salmon, in British Columbia have not been documented for these pathogens. In contrast, both Ich and *Parvicapsula* have been documented to be associated with pre-spawning mortality in sockeye salmon, and the latter also infects outmigrant smolts.

Pathogens assigned to the Moderate Risk category were *Flavobacterium* spp., fungi belonging to the genus *Saprolegnia*, the fungus-like pathogen *Ichthyophonus hoferi*, the PKX myxozoan, *Eubothrium* spp. tapeworms, and sea lice (*Lepeophtheirus salmonis* and *Caligus clemensi*). *Flavobacterium* and *Saprolegnia* spp. are recognized as significant, but usually opportunistic, pathogens in salmon in freshwater when environmental conditions are suboptimal, and thus could cause severe disease if the Fraser River system or marine environment is compromised. *Icthyophonus hoferi* is of concern as it recently has been increasing in Chinook salmon in the Yukon River. *Eubothrium* is one worm parasite that has been already shown to compromise wild sockeye when infections are heavy. Last, the caligid copepods were included on the list. Whereas not documented to cause mortalities in wild sockeye salmon, recent claims of sea lice killing wild pink salmon in British Columbia warrants investigations on the impact of these

copepods on post-smolt sockeye salmon. One putative disease was place designated as "Unknown". Here Dr. K. Miller-Sauders at DFO, Pacific Biological Station (PBS), Nanaimo, recently discovered an unusual gene signature suggestive of a virus infection in sockeye salmon, and temporal studies showed that these fish had reduced survival. The list agrees for the most part with one independently developed by Dr. Kyle Garver, DFO-PBS, where he concluded that IHN virus, *Parvicapsula*, and Ich are the pathogens of most concern in sockeye from this system.

All of these pathogens are endemic to British Columbia and most likely have been present in this area for centuries. Moreover, there is no evidence of an exotic salmonid pathogen being recently introduced to the Province. If there has been a dramatic increase in mortality caused by one or more of them in recent years, it is likely due to changes in the susceptibility of sockeye salmon to them or a change in the abundance in these pathogens. Environmental changes could be an underlying cause of either. Fish are very closely tied to their environment, and thus water quality and other environmental parameters play a very important role in their susceptibility and severity of diseases. Changes in water temperature, either in freshwater or seawater, are important likely candidates. Fish are cold-blooded (poikilothermic) and thus both their pathogens and the fish themselves are extremely influenced by temperature.

There are certainly many pathogens that occur in wild sockeye salmon, but their precise impacts on survival in these stocks are poorly understood. Hence, there are not firm links for these pathogens with significant demise in these sockeye populations overall, but some of these are clearly associated with prespawning mortality in freshwater. The absence of data on pathogens and diseases in wild salmon in British Columbia is a reflection of the historical research focus on fish diseases, in both the Province and other regions. Most research on salmonid diseases has been directed toward those afflicting captive fish, either in government hatcheries or private fish farms.

As with many scientific issues, more research is needed to elucidate the impacts of pathogens on Fraser River sockeye salmon. Surveys for pathogens and diseases in wild sockeye salmon must be conducted and maintained over several years to provide the needed raw data. Surveys must include proper identification of pathogens, geographic and host distribution, and abundance or severity of infection. With these data in hand, researchers can conduct the appropriate analyses to infer or document the role that these pathogens have with survival in various life stages. After a pathogen is shown to be associated with mortality, modelers, mathematicians, statisticians, and ecologists could then conduct investigations to elucidate which factors (e.g., water temperature, river flow, land use practices, netpen farming) influence the distribution and abundance of these pathogens. Isolation, identification of agents, and controlled laboratory studies are needed to elucidate the pathogenesis of newly recognized pathogens, such as the putative virus associated with specific gene functions.