EXECUTIVE SUMMARY:

Project 2 - Potential Effects of Contaminants on Fraser River Sockeye Salmon

Introduction

This study was conducted to develop an Inventory of Aquatic Contaminants for the Fraser River Basin and to evaluate the potential effects of those contaminants on Fraser River sockeye salmon. A risk-based approach was used to determine if the contaminants that have been released into freshwater ecosystems within the watershed have caused or substantially contributed to the decline of Fraser River sockeye salmon over the past 20 years or to the poor returns of sockeye salmon that were observed in 2009. Implementation of this approach involved the following steps:

- Developing an Inventory of Aquatic Contaminants (which are also referred to as chemicals of potential concern or COPCs);
- Conducting a preliminary evaluation of chemicals of potential concern to identify the substances that pose potential risks to sockeye salmon (which are termed contaminants of concern or COCs) and, hence, required further evaluation;
- Conducting a detailed evaluation of the contaminants of concern to determine if their concentrations in surface water, sediment, or fish tissues were sufficient to adversely affect the survival, growth, or reproduction of sockeye salmon;
- Conducting a qualitative evaluation of the potential effects on sockeye salmon associated with exposure to endocrine disrupting chemicals and other contaminants of emerging concern; and,
- Identifying uncertainties in the assessment and key data gaps.

Inventory of Aquatic Contaminants

To support the development of an Inventory of Aquatic Contaminants, the available information on land and water uses within the Fraser River Basin was compiled. In addition, the substances that have been, or may have been, released to aquatic ecosystems in conjunction with these land and water uses were identified. Subsequent integration of this information facilitated identification of over 200 substances that may have been released into aquatic ecosystems within the study area. All of the substances included in the Inventory of Aquatic Contaminants were considered to be chemicals of potential concern.

Preliminary Evaluation of Chemicals of Potential Concern

In the preliminary evaluation, the maximum concentrations of chemicals of potential concern in water and sediment were compared to toxicity screening values, which were intended to represent no observed effect levels for aquatic organisms. The results of the preliminary

assessment indicated that a number of chemicals of potential concern exceeded the toxicity screening values in one or more environmental samples and, hence were identified as contaminants of concern. The water-borne contaminants of concern included conventional variables (total suspended solids, turbidity, pH), nutrients (nitrate, nitrite, phosphorus), major ions (chloride, fluoride, sulfate), metals (aluminum, arsenic, boron, cadmium, chromium, cobalt, copper, iron, lead, mercury, nickel, selenium, silver); and, phenols. The sediment-associated contaminants of concern included metals (arsenic, cadmium, chromium, copper, iron, lead, and nickel), phthalates [bis(2-ethylhexyl)phthalate] and, polycyclic aromatic hydrocarbons [acenaphthalene, benz(a)anthracene, and dibenz(a,h)anthracene]. These substances were retained for further evaluation in the detailed assessment of risks to sockeye salmon in the Fraser River Basin.

Many other substances in the Inventory of Aquatic Contaminants have the potential to adversely affect Fraser River sockeye salmon, including organometals, cyanides, monoaromatic hydrocarbons, chlorinated and non-chlorinated phenolic compounds, resin and fatty acids, polybrominated diphenyl ethers, hormone mimicking substances, pharmaceuticals, personal care products, wood preservation chemicals and nanoparticles. However, insufficient information was available to evaluate the hazards posed to sockeye salmon in the Fraser River associated with exposure to these contaminants. Accordingly, these substances were identified as uncertain contaminants of concern and addressed in the qualitative evaluation of endocrine disrupting chemicals and contaminants of emerging concern.

Detailed Evaluation of the Potential Effects of Contaminants of Concern

In the next step of the process, the list of contaminants of concern was refined to eliminate those substances that were unlikely to be risk drivers. Then, a detailed evaluation was conducted to determine if the concentrations of any of the contaminants of concern in surface water, sediment, or fish tissues in the Fraser River or its tributaries were sufficient to adversely affect the survival, growth, or reproduction of sockeye salmon. In this evaluation, more realistic estimates of exposure to contaminants of concern (i.e., 95th percentile concentrations) were compared to toxicity reference values (toxicity thresholds), which represent lowest observed effect levels of contaminants of concern for sockeye salmon or other salmonid fishes. The results of this assessment indicated that exposure to contaminated surface water and sediment or accumulation of contaminants in fish tissues pose potential hazards to sockeye salmon utilizing spawning, rearing, or migration habitats within the Fraser River Basin. The substances that occurred in water at concentrations sufficient to adversely affect the survival, growth, or reproduction of Fraser River sockeye salmon included total suspended solids, six metals (aluminum, chromium, copper, iron, mercury and silver), and phenols. However, analyses of water quality index scores and measures of productivity (i.e., Ricker residuals) suggested that declines in sockeye salmon abundance over the past 20 years or in 2009 were not likely caused by the substances considered in the water quality index. While the results of the sediment risk assessment showed that the concentrations of iron and nickel were elevated at various

locations within the basin, exposure to these contaminants of concern in sediment is unlikely to be sufficient to adversely affect the survival, growth or reproduction of sockeye salmon. Nevertheless, the concentrations of selenium, and 2,3,7,8-tetrachlorodibenzo-p-dioxin toxic equivalents, occurred or are likely to have occurred in salmon eggs at concentrations sufficient to adversely affect sockeye salmon reproduction.

Evaluation of Effects of Endocrine Disrupting Chemicals and Contaminants of Emerging Concern

Due to limitations on the availability of exposure data and/or toxicity thresholds, a qualitative evaluation was conducted to assess the potential effects on Fraser River sockeye salmon associated with exposure to endocrine disruption chemicals and contaminants of emerging concern. The results of this eco-epidemiological evaluation indicate that it is unlikely that exposure to these contaminants is the sole cause of the observed patterns in sockeye salmon abundance, either over the past 20 years or in 2009. However, contaminant exposures cannot be ruled out as a potential contributing factor for responses of Fraser River sockeye salmon over the past two decades and/or for the low returns of sockeye salmon to the river in 2009.

Uncertainty and Data Gap Analysis

There are a number of sources of uncertainty in assessments of risk to the sockeye salmon associated with exposure to contaminants in the Fraser River Basin, including uncertainties in the conceptual model, uncertainties in the effects assessment, and uncertainties in the exposure assessment. The results of the uncertainty analysis indicated that there are a number of key data gaps that substantively affect the confidence that can be placed in the evaluation of the potential effects of contaminants on Fraser River sockeye salmon. The most important of these uncertainties is the general absence of data that describe the nature and extent (both spatial and temporal) of contamination by total suspended solids, major ions, nutrients, metals, and other chemicals of potential concern in spawning and rearing habitats within the watershed. In addition, data on the concentrations of endocrine disrupting chemicals and other contaminants of emerging concern are generally lacking throughout the study area.

Conclusions and Recommendations

This study was conducted to determine if aquatic contaminants caused or substantially contributed to declines in the abundance of sockeye salmon over the past two decades and/or the low returns of sockeye salmon to the Fraser River in 2009. While limitations on the available data make it difficult to answer this question conclusively, the results of this study suggest that:

- Exposure to contaminants in surface water, sediments, or fish tissues is not the primary factor influencing the productivity or abundance of Fraser River sockeye salmon over the past 20 years or in 2009.
- There is a strong possibility that exposure to contaminants of concern, endocrine disrupting chemicals, and/or contaminants of emerging concern has contributed to the decline of sockeye salmon abundance in the Fraser River Basin over the past 20 years.

This evaluation of the effects of contaminants on Fraser River sockeye salmon was constrained by a number of key data gaps. As insufficient data were available to fully assess the role of contaminant exposures in the declines of sockeye salmon over the past two decades or the low returns of sockeye salmon to the Fraser River in 2009, a number of recommendations are offered to enhance the probability that the data and information required to conduct a more comprehensive evaluation are available in the future.