Report Title: Fraser River Sockeye Salmon Analysis—Lower Fraser and Strait of Georgia. Golder Assoc.s
Reviewer Name: Marvin Rosenau
Date: 22 Dec 2010

1. Identify the strengths and weaknesses of this report.

The primary strength of the report is the comprehensiveness of the issues. The primary weakness of this report is that because the authors covered so many topics, and over such a wide geographic area, they are dealt with in a relatively superficial way. There are very little in the way of data that could be considered an analysis of possible cause and effect of the sockeye collapses—lots of speculation that things didn't have an impact, but not a lot of hard-core numerical analysis. Further, some of the things that may have happened earlier on, say in the 1970's or 1980s, and had a lag effect (say, the large-scale sand removal in the lower river, forest harvest in the 1970s and 80's, which may have not impacted the spawning streams for two decades) are not dealt with because the things that they really looked at were from c.a., 1990 and onwards. Now to be totally fair, I think that the task that the consultant's were given was so large that it was impossible for them to do justice to the subject given the time frame and the resources available. And, to do a proper reporting of the issues under this subject umbrella, the paper should clearly state this.

2. Evaluate the interpretation of the available data, and the validity of any derived conclusions. Overall, does the report represent the best scientific interpretation of the available data?

Again, I would say that the data are not particularly dealt with in depth. As an example, the questions surrounding new chemicals/hormone mimics in the wastewater treatment plants since 1990 is given relatively short shrift. And the changes in water quality in the SOG show some trends that are very different from 1990, but little analysis or examination of the potential for cause and effect was undertaken. Again, to be fair, it is unlikely that the reporters had the resources to do these subjects justice, but the report should state this.

3. Are there additional quantitative or qualitative ways to evaluate the subject area not considered in this report? How could the analysis be improved?

I think the main potential issues were covered; having said that much of the analysis was not particularly quantitative (correlation, PCA, multiple regression) and for many of the issues the statement was: "Things are getting better (e.g., wastewater treatment), so we can't ascribe any declines in sockeye to this issue." While the resources to do such comprehensive analyses are certainly very large, I still think that the writers should have emphasized the links with sockeye much more clearly.

4. Are the recommendations provided in this report supportable? Do you have any further recommendations to add?

There is a lot of editorial cleanup to do. Much of the material in the EXSUM is repeated again in the text and the EXSUM should be considerably condensed, in my view. The authors should really stick to the impacts that might have realistically affected sockeye, and leave out stuff that is superfluous.

5. What information, if any, should be collected in the future to improve our understanding of this subject area?

Fish distributions and abundances for particular issues in the LM that might have influence on Fraser sockeye. For stream-rearing sockeye, there is a large effort needed in the lower mainland, particularly since Harrison Rapids fish have exploded in numbers. I would suggest that the migration routes/timing in SOG are also important as other parts of the sockeye issue suggest that it is early marine rearing that is where the mortality is likely occurring.

There is likely quite a bit of plankton and water quality information in the SOG that either needs to be collected, or material that has already been obtained, properly analyzed. However, this is outside of my sphere of experience, and I make this recommendation with some qualification.

6. Please provide any specific comments for the authors.

Comments are provided in an attached appendix to these review pages. They are comprehensive and detailed.

I am not sure why the citations are numbered in the text, sometimes, and then named in other parts. The numbering system is confusing.

I am not sure why some of the citations in the list of references have yellow highlights. This should be dealt with at some point, in my view.

General Comments

M. Rosenau December/January 2010/2011

I don't see why the Abstract has to be 10 pages long when much of this is simply repeated, again, shortly after in the body of the report.

I realize that citations are not usually put into an abstract, but because it is so long I think that there needs to be context. While the word citations are on the maps, they should have been comprehensively put in the body of the text as well. In many locations they are missing (e.g., Predicted Sockeye Micro-Habitat Use section) but the text simply refers to the maps, sometimes with numbers. Really need to have this addressed, I think.

Also, numbered citations are a lot more difficult to follow than the actual author's names.

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The specific objectives of this review and report included:

- Develop a habitat inventory of sockeye habitats in the lower Fraser River, Fraser estuary and Strait of Georgia and describe sockeye habitat use;

Some of this was accomplished (some of the reporting of migration routes in SOG), but most of it was fairly superficial (e.g., the freshwater aspects of river-rearing sockeye vis a vis Harrison River Rapids stock). It should be recognized that while the objective was laudable, for the time frame and resources it was probably an impossible task to achieve this in any rigorous way.

- Develop indicators and an inventory and review of human activities including urban, agricultural and industrial development and growth;

The topics were fairly comprehensive, but any analytical linkages in the report were fairly weak, in my view. In other words, as an example, any cause and effect of the growth of industry over the last 20, or 50 years, was not really dealt with other than to say "x" is increasing or "y" is decreasing. Most industries, to be sure, will have no obvious linkages to sockeye unless they are directly along the water, in the water, or releasing possible to contaminants in the water. But, I can assume that there will be some that would be of more concern than others. To be fair, I am not sure how you would do this without an in-depth accumulation of the data relating to particular industries—and I don't think the resources or time were available to the contactor to do this.

- Provide a synopsis of water quality and biological productivity trends in the Strait of Georgia;

This was covered fairly superficially in a quantitative way. Again, I think to do this properly would have encompassed far more than the resources that the contractors were given. But I think the report should have been open about this.

- Our review suggests that sockeye use specific key micro-habitats in freshwater and marine areas of the lower Fraser and Strait of Georgia. Migration routes in freshwater and marine habitats often have short residence periods.

The aspect of river-rearing sockeye and habitat needed to be dealt with, more comprehensively, in my view.

p. ii

- Human development across the Georgia basin has seen large changes in population size and density in urban centres. Population growth reflects increasing pressures on the environment through higher levels of water pollution, nutrients and contaminants from wastewater and runoff, conversion of vegetated lands (natural, forests, agricultural) to urban and industrial areas.

This bullet was only covered superficially in the report.

- Contaminants in the Strait of Georgia show a general decreasing trend over time, with high concentrations in dilution areas, followed by decreases associated with effluent regulation and improved treatment in recent years.

I think that the data describing this are fairly limited within the report. While this statement may be generally true, it is new contaminants that seem to have people worried, and this is what I think needs to be dealt with in the report a bit more comprehensively. And there are enormous data sets, both at the MetroVancouver WWTP's and SOG benthic studies that were not included in the report.

- The Strait of Georgia and the lower Fraser River, support a large number of non indigenous species (NIS), greater than twice the number found elsewhere on the Canada's West Coast. With the exception of intertidal benthos, the number of NIS in freshwater and marine environments have remained stable from 1990 to 2010.

I would suggest that NIS numbers are not the key concern; it would likely be a single species that causes the tipping point in an ecosystem. Most would be benign, but it may be just a single one that may be the key that ravages an ecosystem. I am thinking, as an example, rabbits in Australia. The numbers of NIS in that country are very large, yet it is a single (seemingly rather innocuous animal—the rabbit) species that has raised absolute havoc with much of the continent. Having said all of this, nothing jumps out at me as something that would have caused the collapse of sockeye with the possible (highly likely) exception of one of the sea lice species.

- Increasing population size, urban density, industrial and infrastructure development and associated land use and waste were ranked as low to moderate potential effects on juvenile and adult sockeye habitats in the lower Fraser River and adult sockeye habitats in the Fraser estuary. Although solid waste, wastewater and contaminants have remained stable over time, based on regulations, waste management programs and best practices, there is a direct link between population size, land use and waste to loss of forested urban areas and residential and industrial build-up. Changes in urban and rural land use have implications on increased sediment and erosion, nutrient and stormwater runoff which will influence adult sockeye habitat use in the lower Fraser River. Adult sockeye presently face cumulative effects leading to higher levels of stress during migration into freshwater related to pathogens and river environmental conditions.

There is very little in the report that assesses these parameters. There are a fair number of general statements, but little that is analytical.

- Warming trends and variation in biophysical conditions in the Strait of Georgia were ranked as moderate to high potential effects on juvenile sockeye habitats. Changes and variation in sea surface temperatures, Fraser River discharge, timing of spring phytoplankton blooms, phytoplankton and zooplankton distribution and productivity in cool or warm years appear to have large associated effects on sockeye habitat use, and potential sockeye survival and growth during their residence period in the strait. Over the past decade the strait has experienced an ongoing warming trend to 2008 and has caused a decline to present zooplankton abundance in species like *Neocalanus*.

This bullet seems to be a pretty important observation, but little was done to comprehensively deal with this as an issue relating to the collapse of sockeye in the Fraser system. If this is the key issue, then more discussion, and examination, was needed throughout the reported in regards to the potential role in Fraser sockeye ecology and the population numbers.

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> More than 300 large industrial sites and infrastructure projects were constructed and operated in the lower Fraser River and Strait of Georgia during the past century. Approximately 70 projects were constructed and began operations from 1990 to 2010. A total of 36 private industry and public infrastructure sites were classified with low or moderate potential effects on sockeye habitats including: low effects – ferry and marine terminals, bridges, airports, smaller waste treatment plants (lower Fraser River), reservoirs and dams, aggregate pits; and moderate effects - five pulp and paper mill operations (Howe Sound, Crofton, Nanaimo, Powell River, Elk Falls), Iona Island wastewater treatment plant.

Study should have encompassed impacts that have precipitated the decline prior to the last 20 years as opposed to just over the last 20 years. Impacts may have occurred before 1990 that triggered things that only started to manifest themselves after 1990. SOW does not restrict the analysis from 1990 to 2010.

Other than listing these potential impacts vis a vis industry, there was little analysis of the potential impacts to sockeye.

> Port vessel traffic across the Strait of Georgia remained generally stable during the past decade with some decline in ship movement and tonnage in recent years associated with slower economic conditions. Cruise ship traffic has been projected to continue to rise over the next decade. Ferry traffic has remained stable throughout the past two decades.

These documented activities are listed but no real discussion as to why they may or may not be important.

Dredging in the lower Fraser River below Mission has removed more material than has inflowed into the lower river reaches over the past 3 decades. Dredging has resulted in the south arm navigation channel bed elevation level being reduced by 3 m over a 30 year dredging period. The volume of dredged material removed from the river has declined annually since the early 1990's. Specific seasonal dredging time windows have been instituted to keep all dredging activities outside the residence period of migration for juvenile sockeye salmon in the lower Fraser River.

Fraser Valley urban areas and cities are protected by over 400 km of dikes between Hope and Sand Heads. Extensive diking in the lower Fraser River was initiated in early 1900's and completed by 1950. The early network of dikes have effectively removed many of the secondary and off channel areas around Chilliwack. Dikes have been upgraded, but no new dikes have been constructed in the past two decades.

Pretty key stuff, particularly in regards to Harrison River rearing sockeye, but little analysis. Changes to pump-stations in respect to dikes have been made (quite a few upgrades) but no mention of such.

The lower Fraser River dredging has probably profoundly changed the lower river in over the last 20 years, and I think there should have been a greater analysis, or at least point to what is needed in terms of analysis, for this topic.

Biophysical conditions in the Strait of Georgia demonstrate a warming trend at all depths over the past 40 years including the past 2 decades. The Fraser River has similarly shown earlier onset of spring freshet and increases in summer temperatures. Phyotplankton spring blooms and associated spring zooplankton production are highly variable in the Strait of Georgia but associated with sea surface temperature and nutrient input from Fraser discharge. Populations of planktivorous fish, including herring and hake, have remained stable in the strait over the past 2 decades.

This is a pretty key issue; I think it needed a lot more examination.

Contaminants enter the Strait of Georgia through local discharges and longer range transport. Development in the strait (urban and industrial) have resulted in a history of contaminants (metals, organic pollutants and other chemicals) observed in the marine sediment core records of chemicals like dioxins and furans, polychlorinated biphenyls (PCBs), polybrominated diphenylethers (PBDEs), hydrocarbons, metals, and detergents. These contaminants show a general trend over time with record of contamination and entry into the strait increasing to high concentrations in dilution areas, followed by decreases associated with effluent regulation and improved treatment.

Ditto above.

p. viii

> Six pulp and paper mills have operated on the shores of the Strait of Georgia during 1990 to 2010; Squamish and Elk Falls closed in 2006 and 2010 respectively. During the 1970s and 80s, these six mills were major sources of contamination of the strait's marine environment because of they discharged large volumes of process effluents that contained pulp and bleaching chemicals including dioxins and furans. Stronger regulation and process improvement were implemented in the 1980's and have resulted in more than 100-fold reductions in loads of dioxins and furans in mill effluent. These reductions resulted in almost simultaneous reductions in levels of these compounds in crabs, although reductions were more gradual at locations such as Squamish. Contaminant concentrations have shown a decline in sediments and accumulation in marine species monitored including crabs and birds (herons and cormorants). PBDEs new chemicals like pharmaceuticals are considered to be increasing in the strait in recent years.

While this seems to be a potentially large issue, especially the PBDEs, other than mentioning it, the report doesn't really address it.

> The Strait of Georgia and the lower Fraser River, support a large number of non indigenous species (NIS), greater than twice the number found elsewhere on the Canada's West Coast. The strait's relatively large number of NIS is a function of the long history of human development and population growth, aquaculture (e.g., shellfish and finfish), shipping (associated with transport through hull fouling and ballast water), seasonal refuge habitats and a diversity of colonizable habitats. The number of invasive species in the strait has increased 40-fold since the 1880s. It has been estimated that over 117 non indigenous species (terrestrial and aquatic) have established populations in the Strait of Georgia and lower Fraser or along its shoreline and banks. The largest proportion of known introductions of NIS species in the Strait of Georgia and lower Fraser River has occurred in the marine inter and subtidal benthos during the past two decades. With the exception of intertidal benthos, the number of NIS species in freshwater and marine environments have remained stable from 1990 to 2010. This review did not specifically review sea lice (*Lepeophtheirus salmonis*) as a non indigenous species.

See comments above for the same issue; repetitive, as well, within the Ex-Sum.

p. ix

> Our results suggest that direct indicators of human development, including population size and density, land use, waste, project sites and development, marine vessel traffic, dredging, diking and contaminants, had no or very low effects of sockeye habitats and habitat use over the 1990 to 2010 period. Historically, all these indicators may have had moderate to serve effects on sockeye habitats, but this was not observed during the last 2 decades. The magnitude of potential effects and geographic extent of effects did not often have an overlap with spatial and temporal sockeye habitat use. In a number of instances, additional regulatory controls (discharge, waste, contaminants, agricultural and forestry practices, shipping, project development), improvement to industrial and municipal practices (liquid waste, contaminants), and management regimes and protocols (urban development, agricultural and forestry practices, project development, dredging, dikes) have resulted reduced potential effects on the risk of loss or degradation of sockeye habitats.

Honestly, I am not sure that the report had enough information to state that the above issues "...had no or very low effects on sockeye habitats and habitat use over the 1990 to 2010 period...". I have a general feeling that the authors might be correct, but I am not sure that the arguments in the report are really all that definitive. Of particular note are the unknown cumulative effects to the estuary habitat resulting from the cumulative effects of large-scale dredging of both the sand and gravel reaches, specifically to stream rearing sockeye. And I might add, I have seen stream rearing sockeye in the Stave and Brunette River during routine sampling efforts, during the latter part of the spring, and I suspect

that people don't have a clue what the increases in urbanization have done to these more-ephemeral fish usages.

> The final two indicators included the potential effects of biophysical conditions and non indigenous species in the lower Fraser River and Strait of Georgia on sockeye habitats. In both instances potential effects were ranked either low to moderate, or moderate to high for non indigenous species and biophysical conditions respectively. These indicators were ranked higher relative to other direct indicators of human development, due to uncertainties in potential effects related to data limitations and the understood potential wide ranging (space and time) extent of geographic area, potential magnitude and duration of exposure of these effects on sockeye habitat use, particularly for post-smolt juvenile sockeye habitat use in the Strait of Georgia. The effects of species changes to the ecosystem structure and function, and biophysical properties often strongly influenced by climate variation, on juvenile sockeye behaviour and habitat use is not unexpected given the lack of studies and information needed to monitor and interpret mechanisms.

I am not sure how the "...effects of biophysical conditions..." can be separated from the issues of the paragraph immediately above.

Environmental Management: Issues and Improvements

Somehow the points in this section seem out of place. Is it really the prerogative of this report to recommend policy or legislative changes? Shouldn't the report be sticking to "what might have been the impacts to sockeye that may account for the 20 year decline observed in the Fraser?"

p. x

Evidence Gaps, Research Needs, Uncertainties

A number of knowledge and evidence gaps, research needs, uncertainties and management regimes have become evident during our review. These include:

- Limited biological observations of sockeye micro-habitat use in lower Fraser and Strait of Georgia compared against biophysical conditions in each habitat encountered.
- Few, if any consistent time series for indicators, particularly related to biophysical condition in the Strait of Georgia. This particularly evident when considering the potential effects of climate change and variation of Fraser sockeye production.
- Few predictive or forecasting approaches based on empirical data series linked to collaborative research in the lower Fraser and Strait of Georgia.
- Development of an improved management regime to streamline and integrate a regulatory approach to marine coastal and estuary management that review and assess potential effects and long term cumulative impacts of individual and collective development and operation (urban, aquaculture, agricultural, industrial) activities.
- Limit development activities in key salmon habitat zones based on well defined understanding of habitat use in space and time.

Is it the mandate of the report to suggest limiting the development activities in key habitat zones?

p. 5

and Oceans Canada's (DFO's) Wild Salmon Policy (Stalberg et al. 2009) including: total land cover alterations, road density, water extraction, riparian disturbance, permitted waste management discharges and suspended sediment i.e. consistent with

Sentence only partial—"i.e. consistent with..."

p. 7

River-type sockeye aged 0+ originating from Harrison Lake use various sloughs and off channel areas in the lower Fraser River above the tidal area, for rearing for a period of 2 to 6 months (Map 3-B-i). The Harrison river-type sockeye fry are small sized and migrate slowly out of the Fraser River and estuary across the Strait of Georgia to use rearing habitats around the southern Gulf Islands for a residence period of 4 to 6 months. Harrison river-type sockeye juveniles were observed in the Juan De Fuca Strait and west coast Vancouver Island in February through June 1 year after emergence.

As a general comment, the lack of citations throughout the text is very frustrating. The authors need to back up their statements throughout this report.

NOTE: references need to be transferred from numbered maps sheets to reference list

2.1.1 Harrison and Lillooet Spawning

The majority of sockeye spawning habitat in the Harrison River watershed is located in Weaver Creek, a tributary to Harrison River located south of Harrison Lake (33, 51, 83, 84, 85, 92) (Map 3- B-ii). A lower proportion of

The largest run of sockeye in the Harrison watershed is now not Weaver, but Harrison Rapids.

Yellow material still missing.

Having numbers as citations is very irritating. And when you look at the citations in the References, they are alphabetical, not numerical.

p. 9

2.1.5 Pitt Spawning

Major spawning grounds in the Pitt River watershed are found in the lower 17 km of the Pitt River upstream of Pitt Lake, and in three main tributaries within this stretch of river: Corbold, Boise, and Fish Hatchery creeks (11, 23, 37, 46, 49, 54, and 83) (Map 3-B-ii). Additional spawning grounds are found in the Widgeon Creek and slough areas and comprise a small proportion of the total Pitt River sockeye salmon stock (19, 23, 41, 49, and 83). Widgeon Slough and Widgeon Slough flow into Pitt Lake near the south end of the lake on its western shore.

Adult sockeye spawners begin arriving at the Pitt River spawning grounds in the middle of August, with peak spawning activity occurring in early to mid-September (23, 83). Widgeon Creek and Widgeon Slough spawners arrive later with peak spawning activity between mid-October and the end of November (23).

Pitt River was a hatchery-augmented stock of sockeye.

p. 10

> Catch data indicate that a proportion on Pitt Lake fry behave like river-type fry, and migrate out of the lake earlier

Catch data indicate that a proportion ***<u>of</u>*** ..... not ***<u>on</u>***

Few citations; difficult to know whether the author's statements have any rigor.

> nursery lakes. Smaller 0+ river-type Harrison sockeye fry appear to have an alternative strategy and use lower Fraser River sloughs and off channels above the tidal mixing areas of the Fraser, as nursery habitats for 4 to 6 months. Survey records show that sockeye do not use the Fraser estuary for any prolonged periods of residence as nursery habitats.

Pretty key part of the freshwater habitat issues. Now that the Harrison Rapids stock of sockeye is one of the larger ones (>1 million), issues surrounding habitat in the lower river become of more concern.

Not that it is a big thing but Maria Slough sockeye—a very small January/February spawning run—was not included in the report.

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Put together by ex IPSFC staff
1989

APPENDIX ____.

Summary of Habitat Impacts Affecting Sockeye Streams in the Fraser River Drainage

A) Lower Fraser District

i) Chilliwack River: sockeye spawn at the upper end of Chilliwack Lake. The major habitat problem is extensive logging throughout the area. Terrain is steep and slopes are unstable.

ii) Dolly Varden Creek (Upper Chilliwack): spawning in lake and upstream for 3 km. Watershed currently quite stable as no logging occurs to U.S. border. Some logging on U.S. side. Road proposed to border, bridge crossing required. Regional District are considering installing flow control structures which could impede access. U.S. authorities are considering hydro development. Future logging likely.

iii) Hopedale Slough: minor spawning lower 8 km. Agricultural area, heavily dyked, poor spawning quality.

.../2

ix) Cogburn Creek: tributary to Harrison Lake. Sockeye presence reported. Watershed subject to extensive logging, and is unstable as a result.

x) Big Silver Creek: tributary to Harrison Lake. Spawning throughout. Watershed has been logged extensively since 1920, with the lower watershed having all timber removed or burned. Booming and sorting at the mouth. Flows are very unstable.

xi) Maria Slough: spawning scattered from first culvert to Camp Road. The area around the slough is logged and there is extensive agriculture adjacent. Heavy aquatic plant growth and heavy siltation are a problem.

xii) Gallagher Creek (Mahood Creek): tributary to Johnson Slough. Spawning on gravel bars. Small amount of private timber sale logging. Hydro line and gas pipeline cross the stream. Heavy siltation downstream.

p. 11

heterogeneity and distribution. Micro-habitat use appears to be associated with surface and tidal currents and the heterogeneous distribution of zooplankton prey (Campbell and Dower 2008). The residence period in the Strait of Georgia, and level of spatial heterogeneity in distribution, and potentially sockeye school size, may be related to warm or cooler conditions in the Strait of Georgia and the availability and productivity of zooplankton prey (e.g., calanoid copepod abundance) (El-Sabaawi et al. 2010). Sockeye swimming speeds are related to fish size, and are often > 20 km / day. Sockeye schools may have a prolonged period of residence in the Strait of Georgia during years of favourable conditions. If environmental and productivity (food supply) conditions

The authors switch from a "number" referencing style (i.e., (34)) to a "name" reference style (i.e., (Campbell and Dower 2008)). The "number" style is very irritating in the text of the report as it is difficult to read and, in my opinion, should be dispensed with. I understand why it is needed for the maps (space conservation), but this is not necessary in the main text of the report.

This behavioural pattern is reflected in pulses of returning adult sockeye migrating through either the southern Juan De Fuca route, or more recently through the northern diversion route through Johnstone Strait. Adult habitat use in the southern or northern route is associated with Pacific Ocean currents and environmental

"Juan de Fuca", not "Juan De Fuca".

Few citations; I found it difficult to know whether the author's statements have any rigor if statements are not backed up and switching back and forth to the maps is somewhat confusing.

p. 12

3.1 Population (Size, Density)

Population size and density are general indicators of pressure from human development on the environment and projections show where the potential greatest pressures are and can potentially occur in the future on land and marine areas. Trends in population size and density were derived from 1986, 1996 and 2006 national and provincial census data for regional districts (Map 5-A) and municipalities (Map 5-B).

The most visible effects on the environment and potentially on sockeye habitats from growth in the Greater Vancouver area, is the potential loss of habitat to urban and industrial development. Population size and density in most of regional districts and in all municipalities, increased by 150% over the past 20 years. Urban land areas in Vancouver have only increased 2.5% in the same time period (MOE 2006), reflecting an increase in urban density (e.g., City of Vancouver). Urban areas and cities around the lower Fraser River comprise greater than 80% of the population in the study area. Cities like Surrey and Abbotsford showed the greatest level of growth within the study area.

Within the section *3.1 Indicators of Human Development*, there are considerable numbers of statements that, while likely correct, have little empirical evidence for in the main body of the report. As an example, *"The proportion of municipalities now using secondary and tertiary wastewater treatment have increased over the last 20 years and have led to reduced tonnage of BOD and TSS in the environment (Map 9-B)."* The data for this particular parameter do not go back to 1990 and, in any event, it appears that for the data that are presented on the map, Annacis Island, one of the key hot spots, is increasing in some of the variables. I think the report needs to be more empirical in its description, as I find such statements vague, and with little accompanying analysis.

p. 13

3.2 Land Use

Natural environments, including forests, wetlands, estuaries, and the riparian zones along streams, lakes, and coastal shorelines, have been degraded or lost, and agricultural lands have been removed from production to provide lands for residences, recreation, transportation and industry. Urban development leads to enhanced transportation, and increased impervious road and building areas. Vegetated land areas provide improved filters and buffers to rainfall and stronger links to recharging ground and surface waters. Larger densities and population size also lead to higher levels of water pollution, nutrients and contaminants from wastewater and runoff.

I am not sure that this really says much in respect to how these impacts may or may not have potentially affected sockeye. If the statement was made: "There are no significant sockeye populations in the lower mainland in areas of changing land use." and there were data to demonstrate that, I could find the report of more use.

I point out that I could have used the above train of thought for many of the topics in the report, but at the risk of being repetitive, I will let the authors deal with this as I believe the issue is obvious.

p. 15

3.6 Dredging and Diking Activities

Dredging in the lower Fraser River below Mission has removed more material than has in-flowed into the lower river reaches over the past 3 decades (Map 11-A). Dredging has resulted in the south arm navigation channel bed elevation level being reduced by 3 m over a 30 year dredging period. The volume of dredged material removed from the river has declined annually since the early 1990's. Specific seasonal dredging time windows have been instituted to keep all dredging activities outside the residence period of migration for juvenile sockeye salmon in the lower Fraser River.

Fraser Valley urban areas and cities are protected by over 400 km of dikes between Hope and Sand Heads (Map 11-B). Extensive diking in the lower Fraser River was first initiated in early 1900's and completed by 1950. The early network of dikes have effectively removed many of the secondary and off channel areas around Chilliwack. Dikes have been upgraded over the past two decades, but no new dikes have been constructed in the past two decades.

I am quite concerned that the issue of dredging for navigation, particularly in the sand reach, has been given short shrift. It is almost certain that the massive removals in the thalweg has affected the intertidal zone, which may be sockeye habitat at certain times of the year. This is a particular concern vis a vis river rearing sockeye and earlier statements in respect to how important the lower river is for these fish (Harrison Rapids). Ironically, Harrison Rapids fish have increased in numbers at rates well beyond the other lake-rearing stocks, so the anecdotal information suggests that it may not be an issue; but it still needs to be looked at.

Likewise there have been a fair number of dike upgrades but the most problematic of these are the changes to pump-stations, some of which has actually been positive.

p. 16

3.7 Sea Surface Temperature, Salinity, Prevailing Winds and Fraser Discharge

Incomplete

Biophysical conditions in the Strait of Georgia demonstrate a warming trend at all depths over the past 40 years including the past 2 decades. The Fraser River has similarly shown earlier onset of spring freshet and increases in summer temperatures.

Map 12-A SST, SSS, prevailing winds

Map 12-B SST across SOG

Missing material.

3.8 Phytoplankton and Higher Trophic levels in the Strait of Georgia

Incomplete – waiting on DFO data

Phyotplankton spring blooms and associated spring zooplankton production are highly variable in the Strait of Georgia but associated with sea surface temperature and nutrient input from Fraser discharge. Populations of planktivorous fish, including herring and hake, have remained stable in the strait over the past 2 decades.

Map 12-C chlorophyll – spring bloom – harmful algae (Rensel results – note all algae samples were taken in coastal areas associated with aquaculture sites are local areas of eutrophication. Although false red tides and *Heterosigma* like blooms occur associated with warmer nutrient rich conditions, these are often locally distribution with limited overlap with preferred juvenile sockeye habitats

Map 12-D – zooplankton (*Neocalanus*), fish

Missing material.

How do we know that populations of herring and hake have remained stable over the last two decades?

p. 16-17

3.9 Contaminated materials in the Strait of Georgia and the lower Fraser

Contaminants enter the Strait of Georgia through local discharges and longer range transport. Urban and industrial growth and development in the strait have resulted in a history of contaminants (metals, organic pollutants and other chemicals) observed in the marine sediment core records of chemicals like dioxins and furans, polychlorinated biphenyls (PCBs), polybrominated diphenylethers (PBDEs), hydrocarbons, metals, and detergents. These contaminants show a general decreasing trend over time, with high concentrations in dilution areas, followed by decreases associated with effluent regulation and improved treatment (Map 13-A).

Six pulp and paper mills have operated on the shores of the Strait of Georgia during the period from 1990 to 2010; Squamish and Elk Falls closed in 2006 and 2010 respectively (Map 13-B). During the 1970s and 80s, these six mills were major sources of contamination of the strait's marine environment because of they discharged large volumes of process effluents that contained pulp and bleaching chemicals including dioxins and furans. Stronger regulation and process improvement were implemented in the 1980's and have resulted in more than 100-fold reductions in loads of dioxins and furans in mill effluent. These reductions resulted in almost

simultaneous reductions in levels of these compounds in crabs, although reductions were more gradual at locations such as Squamish. Contaminant concentrations have shown a decline in sediments and accumulation in marine species monitored including crabs and birds (herons and cormorants). PBDEs and new chemicals like pharmaceuticals are considered to be increasing in the strait in recent years.

This section is pretty data poor. To be fair, however, to be comprehensive would require a very comprehensive effort that probably isn't encompassed in the contract.

3.10 Occurrence of non indigenous species.

The Strait of Georgia and the lower Fraser River, support a large number of non indigenous species (NIS), greater than twice the number found elsewhere on the Canada's West Coast (Map 14). The strait's relatively large number of NIS is a function of the long history of human development and population growth, aquaculture (e.g., shellfish and finfish), shipping (associated with transport through hull fouling and ballast water), seasonal refuge habitats, and a diversity of colonizable habitats. The number of invasive species in the strait has increased 40-fold since the 1880s. It has been estimated that over 117 NIS (terrestrial and aquatic) have established populations in the Strait of Georgia and lower Fraser or along its shoreline and banks. The largest proportion of known introductions of NIS in the Strait of Georgia and lower Fraser River has occurred in the marine inter and subtidal benthos during the past two decades. With the exception of intertidal benthos, the number of NIS in freshwater and marine environments have remained stable from 1990 to 2010. This review did not specifically review sea lice (*Lepeophtheirus salmonis*) as a non indigenous species.

I am concerned that this topic has been given short shrift. Encompassed in this issue are native species that may have disappeared over the last 50 years due to over-exploitation/habitat destruction/contaminants but which may have sprung back up in terms of numbers due to resolving some of those issues. I think of marine mammals as an example (and which are being covered elsewhere), and think that it is probably not a big issue, but still might warrant a few minutes of thought.

Our results suggest that direct indicators of human development, including population size and density, land use, waste, project sites and development, marine vessel traffic, dredging, diking, and contaminants, had no or very low effects of sockeye habitats and habitat use over the 1990 to 2010 period. Historically, all these indicators may have had moderate to serve effects on sockeye habitats, but this was not observed during the last 2 decades. The magnitude of potential effects and geographic extent of effects did not often have an overlap with spatial and temporal sockeye habitat use. In a number of instances, additional regulatory controls (discharge, waste, contaminants, agricultural and forestry practices, shipping, project development), improvement to industrial and municipal practices (liquid waste, contaminants), and management regimes and protocols (urban development, agricultural and forestry practices, project development, dredging, dikes) have resulted reduced potential effects on the risk of loss or degradation of sockeye habitats.

I think that the authors have covered off the issues a bit too superficially. I am not sure that the details in regards to things like contaminants (types of contaminants) are necessarily that clear. Further, I am not sure that I would be so confident about the issues associated with dredging (the port authority has taken out way too much material, over the last 30 years, and there is likely lag-time effects on the shallow intertidal zones that have never been properly assessed, and/or the contaminants given the upsurge in endocrine disrupters and other new mimickers/chemicals that would have come on line in the last 20 years.

p. 19-23

4.3 Environnemental Management in Sockeye Habitats

Canada's and British Columbia's oceans, coasts and inland waters are governed by a complex series of policies, regulations, and laws managed by federal, provincial, and municipal/regional governments. All BC coastal areas are also subject to First Nations traditional territorial claims.

This complex legislation suggests a further need to streamline and integrate an regulatory approach to marine coastal and estuary management that review and assessment of potential effects and long term cumulative impacts of individual and collective development and operation (urban, agricultural, industrial) activities. Canada has not adopted the United Nations Convention on the Law of the Sea, established in 1982 and does not have a law for shoreline management. The United States has a specific Coastal Zone Management Act designed to coordinate planning, conserve and protect shorelines, estuaries, riparian areas and large river corridors.

In my view, the section entitled, *4.3 Environmental Management in Sockeye Habitats* is largely superficial and, as written, could be eliminated from this report. Key to this is that much of the legislation or initiative is largely not implemented, and for this section to have any "meat" to it would require an in-depth analysis of what works and what doesn't.

Spell "Environmental", not "Environnemental".

p.22

4.3.6 Coordinated Regulatory Review Framework

I would leave this section out. This stuff is largely irrelevant to sockeye management (from direct personal observation and experience) and I don't think it is really part of the TOR.

p. 23

4.4 Environmental Management: Issues and Improvements

Environmental Management: Issues and Improvements I like this section as written, but am not sure it is particularly relevant to the questions that the report is trying to articulate.

p. 24-25

4.5 Evidence Gaps, Research Needs, Uncertainties

- Limited biological observations of sockeye micro-habitat use in lower Fraser and Strait of Georgia compared against biophysical conditions in each habitat encountered.

I suggest that there needs to be an explanation in regards to what is meant by micro-habitat use .

- Few, if any consistent time series for indicators. This includes; (a) monitoring water quality indicators in the lower Fraser associated environmental pressure from urban growth and development, and (b) monitoring biophysical condition across the Strait of Georgia.

I am not sure what this means. The suggestion, earlier on in the report, was that these were not issues of concern. If they are not, why are these issues considered to be data gaps?

- Few predictive or forecasting approaches based on empirical data series linked to collaborative research in the lower Fraser and Strait of Georgia.

This sentence doesn't mean anything to me.

- Development of an improved management regime to streamline and integrate a regulatory approach to marine coastal and estuary management that review and assess potential effects and long term cumulative impacts of individual and collective development and operation (urban, aquaculture, agricultural, industrial) activities.

I am not sure how this relates specifically to sockeye collapses in the Fraser River.

- Limit development activities in key salmon habitat zones based on well defined understanding of habitat use in space and time.

This is good, but does it relate to the decline of sockeye in the Fraser River watershed.

- Interactions and potential overlap between sockeye habitats and caged reared fin fish (fish farms) sites

I agree with this statement but is this part of the terms of reference of this study?

4.6 Key Findings

- Our review suggests that sockeye use specific key micro-habitats in freshwater and marine areas of the lower Fraser and Strait of Georgia. Migration routes in freshwater and marine habitats often have short residence periods.

This statement is contrary to the statement, above, in *4.5 Evidence Gaps, Research Needs, Uncertainties*, which indicates that there is limited information in this regards. Either the authors know what is going on, or they don't and can't make such broad, sweeping statements.

- Key juvenile habitats in the Strait of Georgia are used as migration routes by schooling sockeye. Sockeye appear to select micro-habitats associated with northward flowing Strait of Georgia surface currents and eastern and western migration corridors oriented by prevailing winds and strong surface currents and the heterogeneous distribution of zooplankton prey.

I am not sure that there was any real description or quantification of "micro-habitats". Perhaps the report can articulate this more clearly.

- Human development across the Georgia basin has seen large changes in population size and density in urban centres. Population growth reflects increasing pressures on the environment through higher levels of water pollution, nutrients and contaminants from wastewater and runoff, conversion of vegetated lands (natural, forests, agricultural) to urban and industrial areas.

This would suggest that human development is a major issue, but the conclusions of the report suggest it is not. These diametrically opposed positions need to be reconciled.

- Contaminants in the Strait of Georgia show a general decreasing trend over time, with high concentrations in dilution areas, followed by decreases associated with effluent regulation and improved treatment in recent years.

I suggest that the quality of the wastewater treatment has changed whereby things such as endocrine mimickers/disrupters may have become more prevalent over the last two decades. Many of these constituents are not captured by current wastewater treatment and they are the issue on the public's mind.

- The Strait of Georgia and the lower Fraser River, support a large number of non indigenous species (NIS), greater than twice the number found elsewhere on the Canada's West Coast. With the exception of intertidal benthos, the number of NIS in freshwater and marine environments have remained stable from 1990 to 2010.

What are they? Predators? Competitors? Parasites? Directly on sockeye? On a key food item of sockeye? Is it possible that there are one or two key new NIS's that may be limited in number but profoundly affect sockeye?

- Increasing population size, urban density, industrial and infrastructure development and associated land use and waste were ranked as low to moderate potential effects on juvenile and adult sockeye habitats in the lower Fraser River and adult sockeye habitats in the Fraser estuary. Although solid waste, wastewater and contaminants have remained stable over time, based on regulations, waste management programs and best practices, there is a direct link between population size, land use and waste to loss of forested urban areas and residential and industrial build-up. Changes in urban and rural land use have implications on increased sediment and erosion, nutrient and stormwater runoff which will influence adult sockeye habitat use in the lower Fraser River. Adult sockeye presently face cumulative effects leading to higher levels of stress during migration into freshwater related to pathogens and river environmental conditions.

My sense is that, earlier on the report, these issues were largely dismissed as not likely having great impacts on sockeye. These two positions need to be reconciled.

- Warming trends and variation in biophysical conditions in the Strait of Georgia were ranked as moderate to high potential effects on juvenile sockeye habitats. Changes and variation in sea surface temperatures, Fraser River discharge, timing of spring phytoplankton blooms, phytoplankton and zooplankton distribution and productivity in cool or warm years appear to have large associated effects on sockeye habitat use, and potential sockeye survival and growth during their residence period in the strait. Over the past decade the strait has experienced an ongoing warming trend to 2008 and has caused a decline to present zooplankton abundance in species like *Neocalanus*.

So, was this the actual cause of the 1990-2009 collapse of Fraser River sockeye? I am not sure that the report provides any definitive evidence, one way or another, but the statements above suggest that it may have been “the cause”.

p. 26

5.0 CLOSURE

closure

Not sure what this means.

Map Report

Need to put page numbers on the sheets.

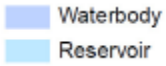
Need Reference page for the citations.

p. 1

Map 1: Characteristics of the Lower Fraser River and Strait of Georgia Study Area

The lower Fraser River and its estuary are turbid as a result of accumulation of suspended sediment supplied from a combination of glacial flour and insoluble silts and clays from bedrock and erosion of glacial deposits of fine sediment on river banks, particularly through the middle Fraser upstream of Hope.

The stream is really only turbid seven months of the year. December, January, February and the first three weeks of March are often have a high degree of clarity.



These two legend parameters are almost indistinguishable on the map.

p. 2

Map 2: Regional Districts in Lower Fraser River and Strait of Georgia Study Area

Very tiny font. The format of the production (page size) will be important.

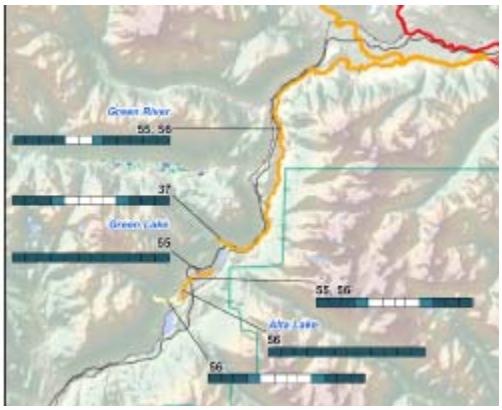
p. 3

Map 3: Key Map for Adult and Juvenile Fraser Sockeye Habitat Use in the Lower Fraser River and Strait of Georgia

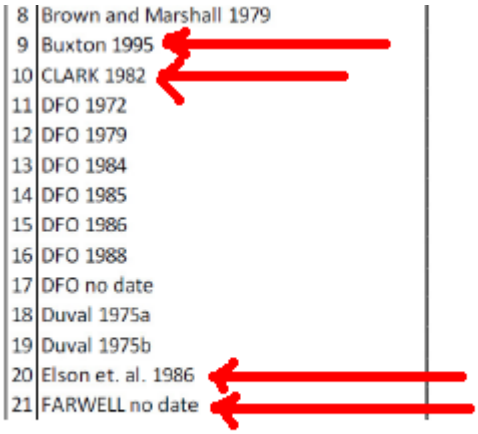
The marine environments have two colors of blue. Is this significant? The colors do not exactly match the bathymetric lines.

p. 4

Map 3-A-i: Juvenile Fraser Sockeye Habitat Use in the Lillooet Sub Basin of the Lower Fraser River

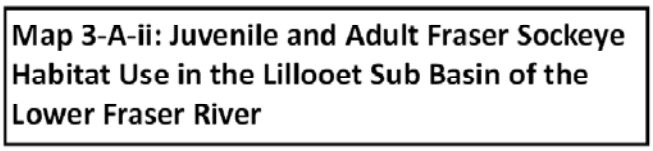


Do the Green River and Green Lake have sockeye?



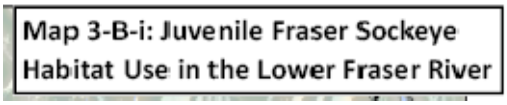
Need to keep font consistent.

p. 5



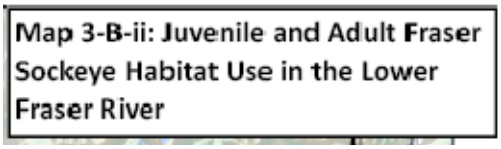
Comments as for maps above relating to font sizes, references, etc.

p. 6



References? Same as previous map?

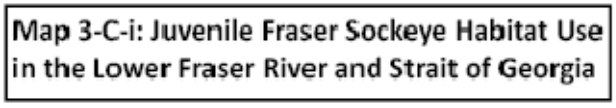
p. 7



References? Same as previous map?

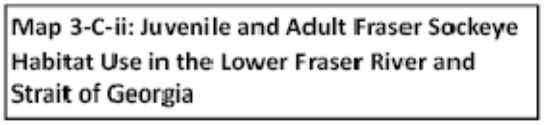
Also, this map suggests that urbanization over the last 20 years might have had a very large impact on non-natal rearing of stream-rearing sockeye given the extent of the distribution of fish in the LM.

p. 8



No additional comments.

p. 9



No additional comments.

p.10

Map 3-D: Adult Migration Routes and Habitat Use in the Lower Fraser River and Strait of Georgia

No additional comments.

p. 11

Map 4-A: Concept Model of Juvenile Sockeye Micro-Habitat Use and Migration in the Lower Fraser River and Strait of Georgia

April to July

Warm Low Productivity Year

Juvenile sockeye habitat use, residence period and migration routes were integrated into a concept model based on existing information and observations to derive a pattern of micro-habitat use and distribution.

Who's model is this? Is this a new model, or does it belong to one of the authors listed below? I am trying to get a sense of the model's rigor. A more complete explanation of this work needs to be written out.

p. 12

Map 4-B: Concept Model of Juvenile Sockeye Micro-Habitat Use and Migration in the Lower Fraser River and Strait of Georgia

April to July

Cool High Productivity Year

Ditto comments for Map 4-A:

P. 13

Map 5-A: Regional District Population Size and Density in the Lower Fraser River and Strait of Georgia

I like this figure, for other reasons, but I am not sure if this is particularly relevant.

p. 14

Map 6-A: Regional District Agricultural Land Use and Area in the Lower Fraser River and Strait of Georgia

Source: Agricultural data for the study area was collected from the 1986 to 2006 Agricultural Census data tables. In some cases, data was aggregated to reflect changes in Regional District delineations or changes in how data was

Sentence not completed.

"Data were..." not "Data was..."

I am not sure how graphs of change in agricultural activity over the last several decades really link impacts to sockeye habitats. I point out that there has been radical changes to the way that agriculture is conducted in the eastern Fraser Valley, in the last 2 or 3 decades, for example. It seems to me that a more in-depth analysis needs to be accomplished if this section is to have any real meaning. If you can link it to non-natal rearing of stream-rearing sockeye in agricultural streams...then okay. Otherwise it may be prudent to leave out.

p. 15

Map 6-B: Regional District Agricultural Crop Area and Livestock Production in the Lower Fraser River and Strait of Georgia

Farm animal production and management practices have changed over the past half century and have greatly improved control to limit potential nutrient runoff associated with farm animal waste.

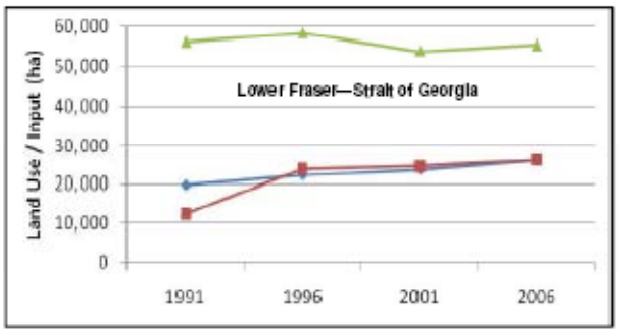
As someone who grew up on a farm in the eastern Fraser Valley, and has written a major report for the PFRCC on the subject, I am inclined to disagree and believe that things are getting worse for a variety of reasons. Sockeye may not be a species that is largely being impacted, but I don't believe that salmon are now more protected than 20 years ago. Largely this has to do with the industrialization of the industry in SW BC and the associated practices.

The large number of small graphs, with a number of lines on each figure, are confusing to me. I am not sure what they mean in respect to sockeye, specifically. See the comments for the previous page, as well.

p. 16

Map 6-C: Regional District Agricultural Land Use Practices and Applications in the Lower Fraser River and Strait of Georgia

Agricultural practices and application of herbicides, pesticides (both insecticides and fungicides) and fertilizers to farm lands and crops has remained consistent or shown a slight decline in use and land area application during the past 2 decades. Herbicide, pesticide and fertilizer use for crops and the associated land runoff, local discharge and transport have been identified in aquatic habitats and a variety of freshwater and marine species in the Lower Fraser River and Strait of Georgia (i.e., Johannessen et al. 2008). Due to regulation and best practices, herbicides, pesticides and fertilizers concentrations in aquatic ecosystems have demonstrated a trend over time associated with early use in the 1950's, concentration increase and subsequent decrease in use to present (see Map 14).



The text and the figures do not jive. Herbicides, pesticides and fungicides look to me that they are increasing, and statistically, fertilizers are probably stable, and not a "slight decline".

p.17

Map 7-A: Forest Timber Volume in the Lower Fraser River and Strait of Georgia

While the volumes of harvested timber have decreased, there is often a lag between when wood is removed and when spawning/rearing streams start to unravel. Note that the peak of the wood removal is pre-FPC.

Map 8: Industrial and Public Projects, Sites and Infrastructure in the Lower Fraser River and Strait of Georgia

This page has very little meaningful information in it, in my opinion. That doesn't mean that there aren't individual or multiple stressors to sockeye within the figure presented—or maybe not; it is just that putting a figure like this doesn't really tell me too much. If you are going to present this issue as something that may affect sockeye, I think more information has to be put forwards in regards to the types of industry, what they are doing, what contaminant loads they are putting into the water, what changes to the aquatic habitat might be happening, etc.

What is important, from a sockeye view, is that things that happened a decade or two before 1990 may have only started to be felt, from a fish perspective, some decades later. Key issues that need to be addressed, in my view are:

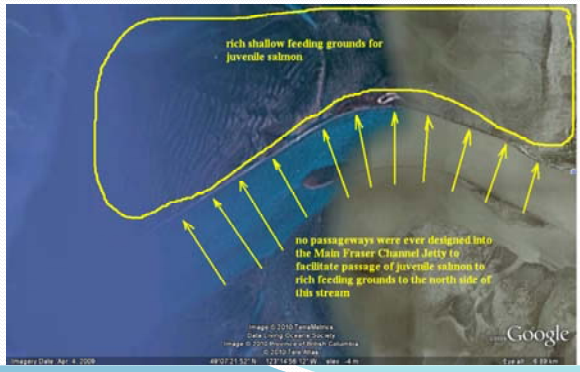
Key to the productivity of salmon utilizing the Fraser estuary is the large, shallow tidal flats that are abundant here—fish production is reduced when the young salmon are partially or completely restricted from these rich feeding grounds

The BC Ferry causeway disrupted the normal feeding behaviour of juvenile salmon and other estuarine species

Loss of easy access to near-shore feeding habitats for juvenile salmon as a result of a flawed design for the Roberts Bank Superport

North Arm Jetty sends juvenile salmon out to sea rather than allowing easy access to productive feeding grounds

Main Fraser Channel Jetty blocks juvenile fish from easily entering rich feeding grounds to the north of the structure



History of Large-Woody Debris in the Lower Fraser River

When the early explorers came to the Fraser River, there was a large-woody debris jam from Georgia Strait to Kanaka Creek 50 km upstream.

Around 150 years of "snagging" (large woody-debris removal) for navigation has destroyed this key habitat feature.

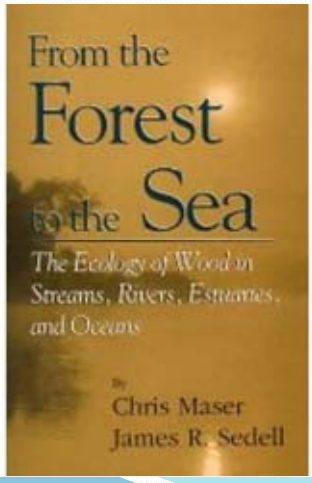
Massive losses of large-woody-debris habitat also results from the destruction of this key habitat feature each year at the Laidlaw wood trap near Hope—most of this is not logging debris but is natural

The Myth—from "THE LOG SALVAGE PROJECT"

"Stray logs are destroying marshes in the Fraser River Estuary. Useable wood is going to waste. Our green business project will help clear debris, restore marsh habitat, utilize otherwise wasted wood, and create ongoing employment."

The Reality—large woody debris is important fish habitat in streams and estuaries.

Large-wood structure is important not only in small salmon streams but salmon estuaries as well



This an important habitat feature of the Fraser River Estuary must be replaced

Map 9-A: Solid Waste in the Lower Fraser River and Strait of Georgia

There are a lot of issues that may be of interest in the lower river (large historical solid waste dumps) that may have affected (or not) the estuarine part of the stream that are glossed over here. Simply, however, that the dumping has slowed, doesn't mean that the affects from earlier (in the 1970s, 1980s, and 1990s) don't have a lag time of impact.

p. 20

Map 9-B: Liquid Waste from Wastewater Treatment Plants in the Lower Fraser River

My questions in this section revolve around issues that are emerging, basically, new compounds, such as endocrine disrupters, etc., that may have been trivial 20 years ago. Volume is not equivalent to quality of affect; this figure glosses over the newly-emerging contaminants in the lower river.

p. 21

Map 10: Marine Vessel Traffic and Tonnage in the Lower Fraser River and Strait of Georgia

I am not sure how this figure provides a definitive analysis of the effects of tanker traffic.

p. 22

Map 11-A: Navigation Channels, Channel Characteristics, Dredging and Disposal at Sea in the Lower Fraser River and Strait of Georgia

My view is that this needs to be address more rigorously than has been done in the paper to date.

Sediment removal

a. The Gravel reach—Tranmer Bar in 2011, for example, is an identified river-rearing sockeye fry bar that is slated for destruction this upcoming winter. The issue surrounding lowering flood profile via gravel removal in the gravel reach is almost certainly false. There is an extensive amount of information relating to this subject. While the issue of 2+ smolt migration and rearing is probably a major issue in regards to gravel removal, the issues surrounding 1+ river rearing sockeye fry, particularly downstream of Harrison are likely significant.

b. The Sand reach

Dredging has radically altered the habitat characteristics of the Fraser estuary over the last century and a half. Furthermore, little inventory and assessment, no mitigation, no compensation is required by the authorizing agencies for the destruction of this key habitat feature

Pre-European settlement—2 meters maximum depth

Post-European settlement—12 meters maximum depth

Sand removal for navigation in the lower Fraser River routinely and excessively removes far more sediment than is safe for sustainable river management and ecosystems

"Net Infill" compares "Actual Removed from River" against the "70% of Sediment Forecast" (i.e. what is still available to be dredged in keeping with sustainable sediment removal).

"Percentage of Forecast Removed" compares actual removed against the sediment bed load forecast.

SEDIMENT FORECAST VS REMOVALS 1997-2007 (all values in millions of cubic metres)

Year	Sediment Forecast (0.177mm to 2.000mm)	70% of Sediment Forecast	Actual Removed From River (>0.177mm)	Actual Removed Less Capital Dredging (>0.177mm)	Net Infill Or (Net Removal)	% of Forecast Removed	
1997/98	4.70	3.30	1.32	1.32	1.98	28.1%	UNDER
1998/99	1.11	0.78	1.00	1.00	(0.22)	90.1%	OVER
1999/00	4.50	3.15	1.85	1.85	1.30	41.1%	UNDER
2000/01	1.70	1.19	1.20	1.20	(0.01)	70.6%	
2001/02	0.72	0.50	0.76	0.55	(0.05)	76.4%	
2002/03	2.98	2.09	2.79	2.31	(0.22)	77.5%	
2003/04	0.61	0.43	1.61	1.45	(1.02)	237.7%	WAY OVER
2004/05	0.55	0.39	1.96	1.67	(1.28)	303.6%	WAY OVER
2005/06	0.99	0.70	3.22	2.54	(1.84)	185.8%	WAY OVER
2006/07	0.79	0.55	3.18	2.44	(1.89)	308.9%	WAY OVER
1997/98 to 2006/07	18.65	13.08	18.89	16.33	(3.25)	87.6%	

Large-scale Dredging of the lower Fraser River Affects the Estuary Through:

- upstream degradation (erosion) of the main channel (thalweg).
- lateral erosion of sensitive wetland and shallow-water areas.
- damage of infrastructure (dikes, bridges, pipelines) resulting in instream construction activity which affects aquatic ecosystems.
- entrainment of aquatic organisms in the cutter-suction dredge

- The authorizations for dredging in the Fraser River estuary have not required, by the agencies, any meaningful assessment of habitat impacts, nor mitigation or compensation of these impacts.
- This is in contravention of the Canada Fisheries Act and its no-net-loss policies.
- The public needs to understand that dredging in the Fraser River estuary constitutes a large-scale Canada Fisheries Act Section 35 HADD (Harmful Alteration, Destruction or Disruption of Habitat) and Fisheries and Oceans Canada has failed to meet its statutory mandate in respect to this issue.

p. 23

Map 11-B: Diking in the Lower Fraser River

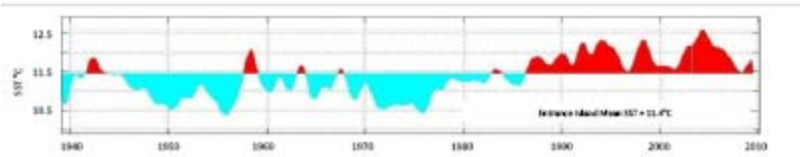
There are some major projects on the books for the Chlliwack area, specifically on Hope Slough, and involving pump houses.

p. 24

Map 12-A: Water Properties in the Strait of Georgia

The top two graphs are confusing. My gut feeling is that this topic is far too important and far too complex to be dealt with in one page.

The SST figure, in particular, suggests that the key to the whole sockeye collapse may be embodied in that one issue. But very little overview is given this issue.



At first flush, this figure seems really important to consider given the time frame of the red in the graph versus the time frame of the collapse of sockeye in the Fraser (1990-2009).

It seems to me that this data set needs more consideration than has been given to date.

While this issue may be of key importance, the analysis of the subject in this report is virtually non-existent. This is a major oversight in my opinion.

Add references—Mason and Cummins 2007 with discussion of wamring trends over past decade in strait.

"warming", not "wamring"

p. 25

Map 12-B: Water Properties in the Strait of Georgia

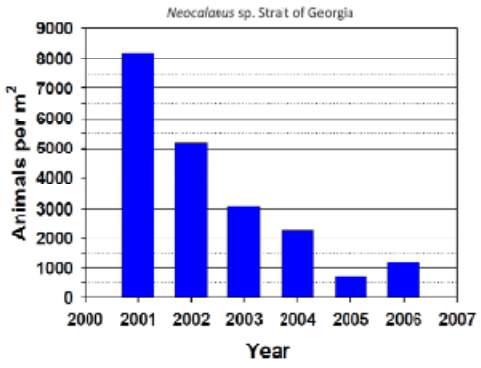
Ditto comments for Map 12-A in respect to the short shrift the subject is being given. Again, my gut feeling is that this topic is far too important and far too complex to be dealt with in one page. While this issue may be of key importance, the analysis of the subject in this report is virtually non-existent. This is a major oversight in my opinion.

p. 26

Map 12-C: Biological Properties in the Strait of Georgia (Phytoplankton)

Ditto above.

p. 27



DRAFT—Incomplete

Map 12-D: Biological Characteristics of the Strait of Georgia (Zooplankton and Fish)

Waiting on DFO zooplankton data

Herring data available

I have no idea what this page or figure means.

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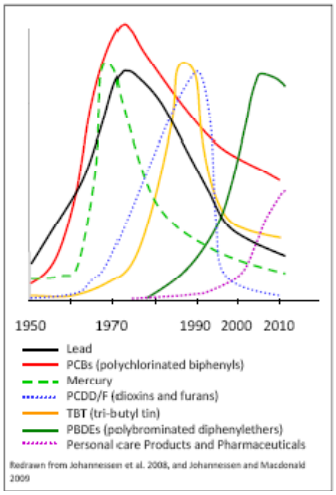

Map 13-A: Contaminants in the Strait of Georgia

The discharge and concentration of contaminants into the Strait of Georgia and Lower Fraser River is associated with potential effects on Fraser sockeye salmon like loss and degradation of habitats and introduction of toxins and pathogens. , increased competition and predation.

Contaminants enter the Strait of Georgia through local discharges and longer range transport. Urban and industrial growth and development in the strait have resulted in a history of contaminants (metals, organic pollutants and other chemicals) observed in the marine sediment core records of chemicals like dioxins and furans, polychlorinated biphenyls (PCBs), polybrominated diphenylethers (PBDEs), hydrocarbons, metals, and detergents. These contaminants show a general trend over time with record of contamination and entry into the strait increasing to high concentrations in dilution areas, followed by decreases associated with effluent regulation and improved treatment.

Add Heron and Cormorant egg studies associated with declines in furans and dioxins.

Add harbor seal fat tissues study results.

To me this page is largely meaningless in terms of any useful information (and an understanding of its rigor).

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Map 13-B: Water Quality in the Lower Fraser River and Strait of Georgia

Source: Pollution Prevention and Assessment, Environmental Protection, Environment Canada 2005

I don't know where the data presented in this page came from.

PBDEs new chemicals like pharmaceuticals are considered to be increasing in the strait in recent years.

This is a pretty key statement, and is on the minds of most people right now, and was not answered by the report.

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DRAFT

Map 14: Non Indigenous Species in the Lower Fraser River and Strait of Georgia

I think that simply listing these species is an incomplete analysis of the potential impacts.

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DRAFT

Map 15: Key Sockeye Habitats in the Lower Fraser River and Strait of Georgia

No comment.

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DRAFT

Map 16-A: Potential Interaction between Large Industrial and Public Projects, Sites and Infrastructure in the Lower Fraser River and Strait of Georgia with Key Fraser Sockeye Salmon Habitats

To be completed

I don't see an analysis of impacts, here.

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DRAFT

Map 16-B: Potential Interaction between Large Industrial and Public Projects, Sites and Infrastructure in the Lower Fraser River and Strait of Georgia with Key Life History Based Fraser Sockeye Salmon Habitats

To be completed.

Ditto thoughts on page above.

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DRAFT

Map 17: Potential Risk of Loss or Degradation of Sockeye Habitats in the Lower Fraser River and Strait of Georgia

Ranking of the potential effects on sockeye habitats was developed by assigning each indicator a level of effect across an ordinal scale from nil, low, moderate, high to severe. Rankings were assigned through a combination expert opinion across the project team, and the review summary of the information for each of the ten indicators individually based on: (i) extent of geographic area of effect and overlap with sockeye habitat, (ii) magnitude of effect on sockeye habitats, and (iii) duration of effects exposure (indicator activity and sockeye residence period). Indicators (Maps 16-A, 16-B) were evaluated against juvenile and adult life history stage habitat use independently (Maps 3, 4, and 15) and presented here across five regions in the study area to classify potential risk of loss or degradation on key Fraser sockeye habitats during the 1990 to 2010 time period. Changes in indicators were examined through results presented in Maps 5 to 14 and used to evaluate the extent of spatial or temporal overlap (Maps 16 -A, 16-B) with key sockeye habitats presented in Maps 3, 4 and 15.

It is not clear to me how the rankings were made, and how rigorous the rankings are. I think more explanation is required.

Warming trends and variation in biophysical conditions in the Strait of Georgia were ranked as moderate to high potential effects on juvenile sockeye habitats. Changes and variation in sea surface temperatures, Fraser River discharge, timing of spring phytoplankton blooms, phytoplankton and zooplankton distribution and productivity in cool or warm years appear to have large associated effects on sockeye habitat use, and potential sockeye survival and growth during their residence period in the strait. Over the past decade the strait has experienced an ongoing warming trend to 2008 and has caused a decline to present zooplankton abundance in species like *Neocalanus* (Campbell and Dower 2008, El-Sabaawi et al. 2009a, b, Sastri and Dower 2009).

There are a number of fairly strong statements in this paragraph and I am not sure that the report has the information or the analysis to be able to state them (e.g., ...large associated effects...). I think the authors have to reconsider what they have said, why they have said it, to what they should say.

DRAFT

Map 7-B: Distribution of Forest Harvesting in the Lower Fraser River and Strait of Georgia

Forest harvesting was active in the 1980's and early 1990's in sub basins supporting key sockeye spawning habitats in the Harrison (Birkenhead), Pitt (upper Pitt River), and Chilliwack watersheds. The decline in areas harvested in the past two decades is consistent with patterns off declining harvested timber volumes in Map 10 and reflects regulations mandated under the Forest Practices Code.

The distribution of pulp and paper mills across the Strait of Georgia and associated water quality issues are presented in Maps 8 and 14-A respectively.

Areas of forest harvest disturbance were mapped based on BC Ministry of Forest and Range Vegetation Resource Inventory data for Crown lands separated into the following time periods: 1986-1990, 1991-1995, 1996-2000, 2000-2005, and after 2005. No information was readily available for private lands on Vancouver Island north of Victoria.

Year	Harvested Crown Land Area (ha)
1986-1990	28011
1991-1995	14649
1996-2000	10946
2001-2005	4151
2006-2009	1964
Total	**59722**

Simply because the harvesting took place earlier than 1990, doesn't mean that the impacts didn't occur a decade or two later. Note that the Pitt River would have been subject to extensive forest harvest (and the upper Harrison) right adjacent to the spawning streams yet there is little consideration of these affects.