APPENDIX 25-B
BASELINE COUNTRY FOODS RISK ASSESSMENT OF CHINOOK SALMON IN TEIGEN CREEK, 2010

Memorandum

DATE: November 10, 2010

TO: Greg McKillop, Project Manager

FROM: Mark Whelly, Toxicologist

CC:

SUBJECT: Baseline Country Foods Risk Assessment of Chinook Salmon in Teigen Creek, 2010

The KSM project is designed to avoid and mitigate any potential risks associated any potential adverse effects to downstream water quality and human health. This memo discusses the results of a country foods risk assessment conducted in response to requests from Aboriginal groups to investigate potential health risks related to consumption of adult salmon in Teigen and Treaty Creeks.

This study provides a valuable assessment of current baseline health risks related to local salmon consumption, and could be used for ongoing monitoring of salmon food quality to local fishers. However, it can not be used to assess potential project-related effects to human health, due to a lack of pathway for any potential chemical transfer from the aquatic environment to people. Salmon are anadromous and spend the majority of their lives in the ocean, where they accumulate more than 95% of their body mass (Groot and Margolis 1991). Also, salmon do not feed during their freshwater spawning migration. While migrating salmon can transport both nutrients and metals between marine and coastal freshwater systems in both directions (Naiman et al. 2002; Gregory-Eaves et al. 2007; Baker et al. 2009), no studies were found in the literature showing evidence that adult salmon accumulate metals during migration or spawning. Any metals in returning salmon have been accumulated in the ocean, mainly through their prey. Metals uptake through gills has not been reported to result in significant metals accumulation in salmon, likely related to the short time frame of their migration relative to their long ocean residence. Therefore, while it is highly unlikely that there would be any significant increases in metal concentrations in Teigen Creek, these increased metal concentrations would not result in increased metals in salmon, and therefore would not be transferred to humans in this way. The quality of salmon as food is a reflection of the marine environment. Any potential adverse ecological effects to salmon are being evaluated as part of the Fisheries Chapter of the EA.

The rationale and methodology used in this risk assessment follows guidance provided by Health Canada (2004). A baseline country foods risk assessment including cranberry, grouse, hare and moose was conducted previously (Rescan 2010). This memo follows the same problem formulation, conceptual model, identification of chemicals of potential concern, exposure assessment and toxicity assessment and risk characterization methods to assess potential health risk from consumption of Chinook salmon. The reader is guided to the baseline report for details on methodology.

A total of five female adult Chinook salmon were sampled for muscle tissue during their spawning run into Teigen Creek on August 13, 2010. The length of each fish ranged from 858 to 930 mm; average 898 mm). Samples were collected, frozen, and sent to ALS laboratory for analysis of total metal concentrations and moisture content.

The screening level risk assessment was conducted on the same eight metals assessed for moose, grouse, hare, and cranberry consumption in the 2010 baseline report (Table 1). The ratio of estimated daily intake (EDI) over the tolerable daily intake (TDI) provides the Exposure Ratio (ER). The recommended maximum weekly intake (RMWI) is also calculated, to compare with current weekly number of servings consumed.

Table 1. Results of Country Foods Risk Assessment of Chinook Salmon

Metal	Maximum Tissue Concentration	EDI		TDI	ER		RMWI		ILCR**
		Toddler	Adult		Toddler	Adult	Toddler	Adult	
Aluminum	0.20	0.0003	0.0001	0.3	0.001	<0.001	173	742	n/a
Arsenic	0.406	0.00056	0.00030	0.001	*0.557*	*0.302*	0.3	1.2	*2.6E-05*
Cadmium	0.004	0.000005	0.000003	0.001	0.005	0.003	29	124	n/a
Copper	0.646	0.0009	0.0005	0.125	0.007	0.004	22	96	n/a
Iron	5.22	0.0072	0.0039	0.8	0.009	0.005	18	76	n/a
Lead	0.0020	0.000003	0.000001	0.00357	0.001	<0.001	206	883	n/a
Selenium	0.277	0.00038	0.00021	0.01 to 0.045*	0.008	0.019	5	20	n/a
Zinc	3.82	0.0052	0.0028	0.7	0.007	0.004	21	91	n/a
Current Weekly Servings							1.4	1.4	

n/a = not available
Maximum Concentration is the maximum tissue metal concentration (mg/kg dry weight) in Chinook salmon (n=5) collected August 13, 2010.
EDI = Estimated Daily Intake (mg/kg body weight per day)
ER = Exposure Ratio = EDI/TDI, where TDI is the Tolerable Daily Intake (mg/kg body weight per day) provided by Health Canada (2010)
ER Values above 0.2 and ILCR values above 1 x 10E-05 are italicized
RMWI = recommended maximum weekly intake (servings per week)
ILCR = incremental lifetime cancer risk
** TDI for selenium provided by Health Canada (2010): 0.011 mg/kg bw/day for adults, 0.045mg/kg bw/day for toddlers.*
*** The average arsenic concentration (0.26 mg/kg ww) was used to calculate the ILCR based on lifetime exposure to an adult.*

Non-Carcinogenic Risk

For assessment of the non-carcinogenic health risk for metals, an ER below 0.2 represents exposure that does not pose a significant health risk (Health Canada, 2004b). This ER criterium is considered appropriate because this assessment only considered country foods effects. It is assumed that people are exposed to metals through multiple sources (soil intake, water, air, other foods, and potentially cigarettes). It is noted that ER values above 0.2 do not necessarily indicate any health risk is present, due to uncertainties from the other pathways, exposure estimation, and safety factors built into the toxicity reference values supported by Health Canada. Values above 0.2 provide an indication that further assessment and evaluation of exposure and effects may be required.

The calculated ERs for salmon consumption were acceptable (<0.2) for seven of the metals (aluminium, cadmium, copper, iron, lead, selenium and zinc) for both toddlers and adults. Exposure was orders of magnitude below levels related to potential health risk. This indicates that none of the seven metals poses a health risk related to eating salmon from Teigen Creek. The recommended maximum weekly intakes (RMWI) were calculated for each metal and ranged from 5 to 206 servings per week for toddlers, and from 20 to 883 servings per week for adults. This means that local people can continue to consume fish based on the current estimated rate of consumption (average of 1.4 servings of salmon per week).

In the absence of specific consumption information from the four other Aboriginal groups, the consumption rates were based on a study of Tahltan communities in 2005 and 2006 (Jin 2006). Any information from Aboriginal groups will be useful in verifying or adjusting the exposure assessment. No carcinogenic risk was evaluated since none of these seven metals have been designated a slope factor.

However, the calculated ER for arsenic exceeded 0.2 based on the maximum arsenic concentration found among the five salmon. The ERs were 0.56 for toddlers and 0.30 for adults. The RMWIs based on these estimated arsenic risks were 0.3 servings per week for toddlers and 1.2 servings per week for adults, both recommended values below the current consumption rate of 1.4 weekly servings.

Although the arsenic ER values are above 0.2, and by association the RMWIs are exceeded, it is highly unlikely that the consumption Chinook salmon from Teigen Creek is a human health risk. All other metals showed that exposure was orders of magnitude below that required to consider potential health risks. Only arsenic was shown to have an ER above 0.2, and this value remained below 1, indicating that total arsenic exposure from salmon remains well below the threshold for health risks, assuming no other major sources of arsenic to people. When the average arsenic concentration was used in assessment, the resulting ERs were reduced to 0.36 (toddler) and 0.19 (adult). Furthermore, in seafood including salmon, it has been clearly shown that the bulk of arsenic (92 to 99% depending on species) is present as arsenobetaine which is relatively nontoxic (Schoof et al. 1999; Foran et al 2004; Slejkovic et al. 2004). The TDI assigned by Health Canada is applicable to total inorganic arsenic, therefore the risk assessment was overly cautious in assessing arsenic, since the TDI for arsenobetaine would be an order of magnitude higher than that for inorganic arsenic. Consideration of both the predominantly organic form of arsenic speciation and the ER values remaining below 1 indicate that arsenic poses no health risk to people consuming Chinook salmon in Teigen Creek. Safety factors inherent in the calculation of the TDI provide another factor for reducing health concern.

There are further assumptions and uncertainties related to this assessment which suggest that health risks from arsenic were overestimated. First, it was assumed that all salmon consumed by local people would be caught in Teigen Creek, which is highly unlikely given the large number of watersheds that Aboriginal groups have identified as important fishing locations. Teigen Creek has only been included in site lists by some of the Aboriginal groups whose asserted territories directly overlap this watershed. Second, the actual frequency of salmon consumption from local streams (ie not ocean salmon from stores) may also be lower than 73 meals per year, which would lower exposure further. The use of adult consumption frequency (73 meals per year) may be an overestimate of how much toddlers actually consume. Third, arsenic tissue concentrations in salmon from different areas could be expected to differ from those of Teigen Creek, depending on growth rates and metal accumulation in the ocean over several years. Annual variation in salmon tissue metal concentrations is also unknown. Fourth, metal concentrations in Teigen Creek salmon were well within normal ranges when compared to results of a study of wild Chinook salmon which reported total arsenic concentrations two to five times higher (Kelly et al. 2008). In summary, arsenic exposure to people who eat salmon is generally not a health concern given its nontoxic form in fish and its relative overestimation in this exposure assessment. Nonetheless, comprehensive water quality, aquatic biology, sediment quality, and fisheries monitoring will be conducted as required through all project phases to assess potential effects in the immediate downstream receiving environments (e.g. South Teigen Creek, North Treaty Creek). Any potential ecological effects at these upstream would thereby require attention, and would thus protect all sites further downstream of the Project (e.g. Bell-Irving River, Nass River, Meziadin Lake).

Carcinogenic Risk

For assessment of carcinogenic health risk from metals, the incremental lifetime cancer risk (ILCR) is calculated based on an adult human lifespan of 80 years. An ILCR value of 1.0×10^{-5} (1 case of cancer

in 100,000 people) is considered "essentially negligible" by Health Canada (2004c), and thereby represents an accepted level of cancer risk on a population level. Arsenic is the only chemical of potential concern with an associated slope factor for calculation of a cancer risk.

The ILCR for arsenic in salmon was 2.6×10^{-5} for an adult, which is similar to the level considered as a negligible risk. The ILCR used the average arsenic concentration in Chinook tissue rather than the maximum concentration, to provide a realistic lifetime exposure scenario for adults.

The current Canadian and provincial maximum acceptable concentration of arsenic in drinking water is 0.01 mg/L (Health Canada, 2007). For an adult drinking only 1 L of tap water per day for their 80 year lifespan, an ILCR of 4.7×10^{-5} is estimated, which is almost twice as high as the ILCR for arsenic in Chinook salmon. Many adults drink two to three times this volume of tap water daily, especially those that exercise regularly. Nonetheless, the Health Canada drinking water quality guideline is not lower due to economic or technical feasibility in arsenic water treatment on a large population scale. Thus drinking Canadian tap water results in an ILCR above what is normally considered acceptable. Consumption of Chinook salmon poses less health risk than drinking tap water based on this assessment. Given that arsenic is not considered elevated in salmon and that the ILCR for salmon is below that considered safe by Health Canada for drinking water, the salmon are considered safe for consumption. People can continue to consume salmon at levels which they are accustomed.

Risk assessment requires consideration of both positive and negative effects from any given food in order to provide a balanced evaluation of health risks. Wild salmon is an excellent protein source low in calories and saturated fats, and lower in organic chemicals than farmed salmon (Kelly et al. 2008). Important health benefits have been related to adequate intake of omega-3 highly unsaturated fatty acids which can be obtained from oily fish including salmon. These fatty acids are believed to reduce the likelihood of cardiovascular disease, inflammatory responses and conditions, and certain cancers, while enhancing brain and ocular development and function (Horrocks and Yeo 1999; Shahidi and Miraliakbari 2004).

Conclusions

This country foods assessment integrated information from Chinook salmon tissue samples collected in Teigen Creek, coupled with community interview data collected in Tahltan communities, to evaluate potential health risks to local fish consumers. There are many assumptions and uncertainties associated with the risk assessment, particularly linked the exposure assessment. Future information on local salmon consumption patterns (serving sizes, meal frequency) could be used to more accurately characterize exposure to arsenic and assess potential health risks in a more realistic approach.

Regardless, the results of the assessment indicate that no significant health risk is posed by consuming salmon, and that the known benefits of regular salmon consumption outweigh any potential risks. Seven of the metals showed levels far below any levels for concern. Arsenic showed concentrations at which potential health concerns require further consideration. However, because arsenic is stored in a nontoxic form in salmon, it does not pose a threat to people who eat it. Furthermore, levels in Teigen Creek salmon are far below those seen in other parts of BC, indicating that they are within normal ranges. People can continue to consume salmon at the rates assumed in this assessment.

It is emphasized that assessment of salmon as a food provides important advice in terms of recommended consumption rates and evaluation of current health concerns. However, adult salmon can not be used in monitoring for potential human health effects from the KSM Project, since salmon are mainly a marine species and do not feed upon return to freshwater systems. Any potential future increase in a metal in salmon is reflective of changes in the Pacific Ocean and estuarine zones.

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