Affidavit #1 of Catherine Michielsens
Sworn December 15, 2010

COMMISSION OF INQUIRY INTO THE DECLINE OF SOCKEYE SALMON IN THE FRASER RIVER

In the matter of Her Excellency the Governor General in Council, on the recommendation of the Prime Minister, directing that Commission do issue under Part 1 of the *Inquiries Act* and under the Great Seal of Canada appointing the Honourable Bruce Cohen as Commissioner to conduct an inquiry into the decline of the sockeye salmon in the Fraser River

AFFIDAVIT #1 OF CATHERINE MICHIELSENS

I, Catherine Michielsens, of 600 – 1155 Robson Street, Vancouver, British Columbia, MAKE OATH AND SAY THAT:

1. I am employed by the Pacific Salmon Commission as a quantitative fisheries biologist and as such, I have personal knowledge of the matters hereinafter deposed to except where stated to be based on information and belief, and where so stated I believe them to be true.

2. This affidavit is prepared in response to a request for information from commission counsel regarding in-season run-size assessment.

3. In or about October 2010, I was provided with a series of questions from commission counsel with respect to which I was asked to prepare written answers. A true copy of this document is attached to my affidavit as **Exhibit "A".**

4. I prepared a document which set out the questions asked and my written responses. A true copy of this document is attached to my affidavit as **Exhibit "B".**

5. To the best of my knowledge, the responses set out in Exhibit "B" are true and accurate, and I adopt them as if stated in my affidavit.

SWORN before me in the City of Vancouver, British Columbia, on December 15, 2010	)))))))	
Commissioner for taking Affidavits in the Province of British Columbia		CATHERINE MICHIELSENS

Tam C. Boyar
Barrister & Solicitor
Hunter Litigation Chambers
2100 - 1040 West Georgia Street
Vancouver, B.C. V6E 4H1
Telephone: 604-891-2406

Run-size assessment questions for Dr. Catherine Michielsens

Witness background

1. Education
2. Work experience prior to the PSC
3. How long at the PSC

[Note: questions 1-3 can be ignored if you can provide us with a current CV.]

4. Please provide a job description for your current position including who you report to, who reports to you and your responsibilities/duties that relate to the management of Fraser River sockeye.

Run-size

5. Please describe (in no more than 4 pages) how run-size estimates are generated throughout the season, including a description of the following:
   a. the data inputs to the run-size models;
   b. the assumptions used by the run-size models; and
   c. the uncertainties associated with the run-size estimates produced by the models.
6. How (if it does) does the use of a particular pre-season run-size probability level affect in-season run-size estimations?
7. Are run-size estimates provided only for each of the four run-timing groups or are they also provided on a stock basis? If provided on a stock basis, please explain which individual stocks have run-size estimates.

Expansion lines

[Note: If you are not the appropriate person to ask about this, please let us who is know and you do not need to answer these questions.]

8. Please explain what expansion lines are, how they are generated and how they are used by the PSC (in no more than 4 pages), including a description of the following:
   a. the data inputs;
   b. the assumptions; and
   c. the uncertainties associated with the use of expansion lines.

This is Exhibit "A" referred to in the
Affidavit of C. Michielsens
Sworn before me at Vancouver
This 15th day of December 2010

A Commissioner for taking
Affidavits for British Columbia

This is Exhibit "B" referred to in the Affidavit of C. Michielsens

Sworn before me at Vancouver

This 15th day of December 2010

A Commissioner for taking Affidavits for British Columbia

Catherine Michielsens' answers to Run-size assessment questions (25 October 2010)

Background:

1. PhD in fisheries stock assessment from Imperial College (University of London, UK)

2. Ten years experience in the application of Bayesian methods for fisheries stock assessment and decision analysis to provide management advice, in particular for Pacific and Atlantic salmon stocks.
   - 2007-currently: Quantitative fisheries biologist, Pacific Salmon Commission, Canada
   - 2003-2007: Post-doc at the Finnish Game and Fisheries Research Institute, Finland
   - 2000-2003: PhD in fisheries stock assessment at Imperial College (University of London), UK

3. Joined the Pacific Salmon Commission 3 years ago to integrate the various pieces of information and data on Fraser River Sockeye salmon within the in-season assessment of the different stocks and extend the assessment to account for risk and uncertainty when providing management advice.

4. Responsible for the development and implementation of new in-season stock assessment models for Fraser sockeye salmon that give a more accurate account of the uncertainty associated with the run size. Staff resource person regarding risk and uncertainty. I report to the Chief biologist, Mike Lapointe and have no one reporting to me.

Run-size:

5. Run size estimates are predicted in-season using a Bayesian cumulative normal model. The cumulative normal model compares the reconstructed daily migration pattern to ideal run-timing curves, assuming the run is normally distributed. By assuming the run follows this idealized pattern, the run size can be estimated once the 50% migration date (i.e., the date 50% of the run has migrated past the reference location, which corresponds to the peak of the normal distribution) has been identified, by doubling the abundance up to that date. Prior to observing the peak of the run, there is considerable uncertainty about the run size. Based on initial observations before the peak of the run, the estimates can indicate the run to be either earlier and smaller than forecast, or later and larger than forecast. The uncertainty about the actual size of the run is estimated using Bayesian methodology. The Bayesian version of the cumulative normal model relies on additional information (pre-season forecasts of run size and timing, expected duration of the run, average historical expansion line estimates and pre-season forecasts of diversion rate) to reduce the uncertainty and keep the run size estimates within realistic bounds. This prior information is incorporated within the Bayesian model through the use of prior probability distributions (priors). These priors indicate a range of values that are assumed plausible for the various model parameters and depending on the shape of the prior probability distribution indicate which parameter values are assumed more plausible than others. Theoretically the Bayesian

version of the cumulative normal model should provide more stable estimates since it relies on both in-season data as well as historical data. Indeed, retrospective analyses confirm that incorporating prior knowledge is especially advantageous before the 50% migration date is known.

The data used to predict the in-season run size estimate using the cumulative normal model are as follows:

- Catch-per-unit-effort (CPUE) data from test fishing vessels using gillnets during the early part of the fishing season and purse seines for the latter part of the season. Test fishing vessels in Johnstone Strait (Area 12) and Juan de Fuca Strait (Area 20) collect CPUE data during the migration of salmon to the Fraser River. These data provide an early indicator of relative day to day changes in abundance. Daily abundance past the test fishery assessment sites is estimated from CPUE data and estimates of historic catchability. For Early Stuart, Early Summer, Summer-run and Birkenhead stock groups, these estimates of daily abundance are used by default, until 6 days later more accurate estimates are reconstructed from the sum of catch and the daily abundance of sockeye migrating past Mission. However, because other Late-run stocks (i.e. Harrison, Weaver, Portage, Late-Shuswap, Cultus) delay their upstream migration for variable periods, daily abundance estimates cannot be updated with Mission data and thus the estimates for these stocks rely almost entirely on test fishery CPUE data.
- Hydro-acoustic data collected at Mission. Daily abundance or "escapement" at Mission is estimated using a split-beam hydroacoustic system on the south shore (i.e., "left bank") of the Fraser River, combined with a downward looking split-beam system mounted on a vessel that transects the river. Both of these systems operate 24-hrs a day. Daily estimates of fish abundance past Mission are produced by combining estimates from the shore-based and vessel-based split-beam systems. These daily abundance estimates are more accurate than the daily abundance estimates derived from the test fishing CPUE data.
- Stock identification data based on DNA and scale pattern analyses. Such analyses involve comparing the attributes of individuals in mixture samples (e.g., from mixed-stock fisheries) to attributes of pure samples obtained from the spawning grounds of each of the named stocks (i.e., "standards" or "baselines"). The main attributes used to identify Fraser sockeye stocks are scale patterns that reflect lacustrine (freshwater) growing conditions during their first year of life and analysis of microsatellite DNA.
- Catch data. Historically, in-season run size models were based on commercial catch data due to the large proportion of the run caught by the fishery. However, because of the irregularity of commercial catches and associated inconsistencies in harvest rates, catches are now only used in combination with estimates of daily abundance at Mission to reconstruct the run.

Additional info used for in-season run size estimation as prior probability distributions within the Bayesian cumulative normal model:

- The pre-season run size forecast based on historic stock-recruit data (as provided by DFO).
- Pre-season 50% migration timing estimate based on sea-surface temperature (SST) and eastward current speed index in the Gulf of Alaska (as provided by DFO).
- In-season 50% migration timing estimate based on timing estimates of earlier run timing groups and the correlation between timing estimates for different run timing groups.
- Pre-season diversion rate estimates based on SST (as provided by DFO).
- In-season catchability or expansion line estimate based on historic cpue and post-season run size data.

Major assumptions:

- The run is normally distributed.
- Stock ID, hydro-acoustics based daily abundance estimates and commercial catches are assumed to be imprecise, but representative of the true pattern changes in the daily abundance of each stock group for which run size estimates are generated.

The following uncertainties have been accounted for by the Bayesian cumulative normal model used to estimate the total run size:

- Run size uncertainty: The probability distribution for run size accounts for uncertainty by describing the range of possible values that the run size can attain and the probability of each value within that range.
- Uncertainty about the 50% migration timing of the run
- Uncertainty about the spread of the run
- Uncertainty about the catchability or expansion line which in combination with the cpue data provide an indication of the uncertainty in the daily abundance estimates
- Observation/process uncertainty/error: These errors explain why the observations deviate from the bell-shaped distribution.

6. Pre-season run-size probability levels have NO influence on the in-season run size estimates. However, the FULL probability distribution of the preseason run size is used as a prior probability distribution within the in-season run size model and as such has an impact of the in-season run size estimates. Prior probability distributions (priors) on run size indicate the possible range of the run size at the start of the season. The priors on run size are pre-season forecasts derived through stock-recruit analysis using historic stock-recruit data. These data are independent of the data used to estimate the run size in-season. At the start of the season, in-season data are limited so the prior (or pre-season forecast) will largely determine the posterior probability distribution (posterior) of the run size, i.e., the in-season run size estimate. Prior to observing the peak of the run it is very difficult to estimate the run size. The run can either be early and small or later and large. Because of the lack of run-size information before the peak of the run is observed, in-season estimates of run size are influenced by the pre-season forecast. Once the peak of the run is observed, however, the influence of the pre-season forecast on the run size estimate is reduced substantially. As

more in-season data accumulates towards the end of the season, the Bayesian cumulative normal model will ignore the pre-season forecast in favor of the in-season data.

7. Pre-season run size estimates are provided for each of the four run timing groups as well as for 19 individual stocks for which historic stock-recruit data are available. The remaining stocks are grouped under miscellaneous stocks.
   In-season, run-size estimates are provided for each of the four run-timing groups. In addition, run size estimates are also provided for some subgroups or individual stocks where sufficient amounts of data, especially stock ID data, are available to derive stock or sub-group cpue, catch and daily abundance estimates. Because run size estimates for individual stocks may vary substantially from year to year, the groups of stocks for which individual or sub-group run size estimates are available, may differ. In 2009, in-season run size estimates were provided for the following stocks or stock-groups: Early Stuart, Early Misc, Scotch/Seymour/N.Thompson, Chilko/Quesnel, Late Stuart/Stellako, Harrison, Birkenhead and Late Run stocks without Harrison.

Expansion lines:

8. Expansion lines are factors used to extrapolate the relative index of abundance in marine test fisheries (cpue data) to absolute abundance. The inverse expansion line is called the "catchability". Historic annual expansion lines are generated based on historic cpue data and historic run size estimates for individual years. Expansion lines differ from year to year and expansion line estimates used for in-season assessment need to take this uncertainty into account. To account for uncertainty in the expansion line, a prior probability distribution for the expansion line is derived using historic data within an hierarchical model structure. Using hierarchical models, we can estimate both the average expansion line and the variation in expansion lines across years. These models then predict the expansion line for a year for which no data has been observed based on the average across the years and the variation from year to year. The amount of uncertainty in the expansion line will affect the uncertainty in the in-season run size estimates.