Affidavit #1 of Michael Folkes
Sworn Dec 14, 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 OF MICHAEL FOLKES**

I, Michael Folkes, of 3190 Hammond Bay Road, Nanaimo, British Columbia, MAKE OATH AND SAY THAT:

1. I am employed by the Government of Canada as a salmon stock assessment biologist, within the Salmon Assessment Section of the Salmon and Freshwater Ecosystems Division, Science Branch, Department of Fisheries and Oceans. 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 pre-season forecasting of Fraser River sockeye diversion rate and run-timing.

3. In or about September 2010, I was provided with a series of questions from commission counsel with respect to which I was asked to prepare written answers.

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 "**A**".

5. I adopt the responses set out in Exhibit "**A**" as true statements as if contained within my affidavit.

6. My *curriculum vitae* ("*CV*") sets out a true statement of my education and work history. A true copy of my CV is attached to my affidavit as Exhibit "**B**".

SWORN before me in the City of Nanaimo, British Columbia, on Dec 14, 2010

Commissioner for taking Affidavits in the Province of British Columbia

MICHAEL FOLKES

DOMINIQUE ROELANTS
*Barrister & Solicitor*
41 CHAPEL ST.
NANAIMO, B.C. V9R 5H3

**Interview questions for Michael Folkes**

**1. Witness background [Note: you do not need to answer questions 1.a. to 1.d. if you can provide us with a current *CV*.]**

*CV attached.*

**e. 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.**

*I am a salmon stock assessment biologist, within the Salmon Assessment Section of the Salmon and Freshwater Ecosystems (SAFE) Division (Science Branch), located at Pacific Biological Station, Nanaimo. I report to Arlene Tompkins, head of the Salmon Assessment Section.*

*My current duties associated with management of Fraser River Sockeye are the annual data analysis and preparation of two return timing forecasts and two northern diversion forecasts. These forecasts are submitted as four separate memos to the Canadian co-chair of the Pacific Salmon Commission's Fraser River Panel. Additionally I was a member of the Cultus Sockeye Recovery Team from inception until it was disbanded, and have been a member of the Cultus Sockeye Conservation Team since its establishment My role on both teams has been as an analytical biologist evaluating extinction risks under long term environmental variation and harvest.*

**2. Forecasting: run-timing**

**a. Please describe briefly (i.e. no more than 1-2 pages) how run-timing forecasts are generated.**

*The run timing forecast is a prediction of the median (i.e. 50%) return timing date, which equates to the most probable calendar date when half of the run of a particular stock are expected to have passed by a geographic location on their return migration. Two run timing forecasts are produced prior to each fishing season. Each forecast is used in pre-season fishery planning by the Pacific Salmon Commission's Fraser river panel technical committee. The first forecast, for the Chilko stock, is based on March data so is typically released mid-April. The second forecast, for the Early Stuart stock, is based on May data so typically released mid-June. Blackbourn (1987) documents the early explorations into run timing forecasts of Fraser Sockeye. Unpublished research has since then pointed to specific oceanographic indicators that improved on forecast model performance.*

*During the last decade the run timing forecast for each stock has been produced using a statistical methodology known as linear regression, which mathematically relates an independent variable (i.e. "cause") to a dependent variable ("effect"). In the current approach we rely on two independent variables (ocean currents, sea surface temperature [SST]) to predict the dependent variable of median return timing date. The statistical 'fitting' between cause and effect relies on historical data (typically 1982 onwards) and is updated with each ensuing year.*

*Staff of the Pacific Salmon Commission supply DFO with their post-season estimates of median timing dates for each of the two stocks (Jim Cave PSC, Pers. Comm.). The sea current index has been estimated by Dr. Jim Ingraham[1], (NOAA retired scientist) using results from the OSCURS computer model. OSCURS is a computer simulation model that predicts the likely direction and magnitude of oceanographic currents at a given date and location in the North Pacific (*Ingraham & Miyahara,1988; Ingraham,1997*). Predictions of the average eastward sea current velocity during March 1st-31st at latitude 57.5°N, longitude 145°W are applied to the Chilko timing model, while predictions during May 1st-31st at latitude 45°N, longitude 140°W are applied to the Early Stuart timing forecast (Figure 1).*

[1] Dr. W. James (Jim) Ingraham, Jr.
DRIFTBUSTERS
720 Camano View Road
Camano Island, WA 98282, USA

This is Exhibit "A" referred to in the affidavit of Michael Folkes sworn before me at Nanaimo in the Province of British Columbia, this 14th day of Dec 2010

A Commissioner for taking Affidavits within the Province

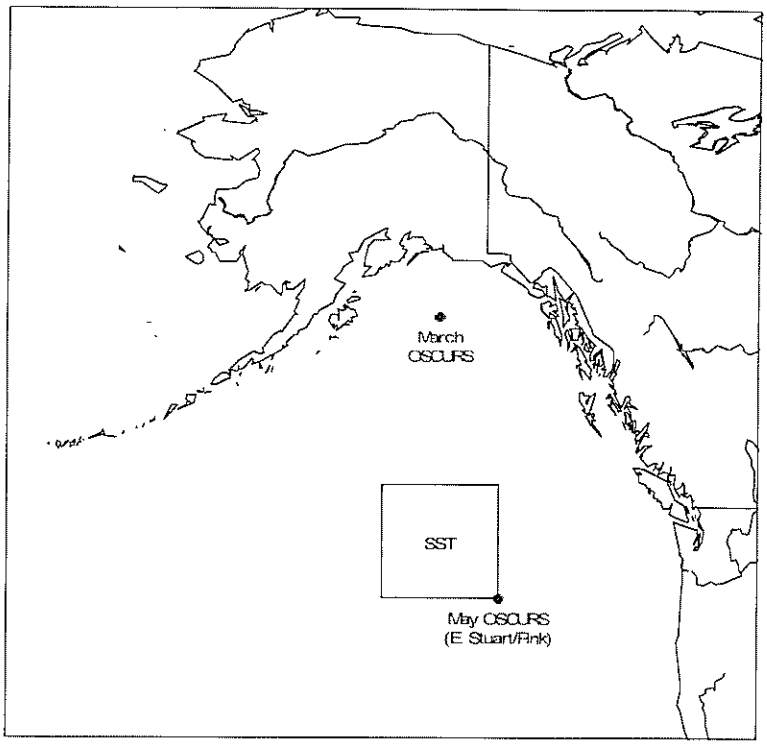


Figure 1: Mapped locations of environmental data used within both the Early Stuart and Early Stuart timing forecasts.

*The sea surface temperature data represent the block mean within an area of the North Pacific defined by latitudes 45°N-50°N and longitudes 140°W-150°W during November and December of the year preceding forecast (Figure 1). The original time series is of mixed origin. For forecasts prior to 2010 the SST data series were amalgamated from three sources. Forecast years 1951-1997 are unpublished and produced by NMFS Monterey office (Dave Blackbourn, Pers. Comm.). These have the same derivation as the data used in Blackbourn (1987), but different months were utilized. Forecast years 1998-2002 relied on SST from the Reynolds data set. While forecast years 2003 to present have relied on data derived from the ARGO array and were processed by Howard Freeland at the Institute of Ocean Sciences. All three periods of SST data are estimates for the same geographic location. Commencing in 2010 the SST values were recalculated by the Thomson lab at IOS using just the Reynolds dataset.*

*Any sample statistic has an uncertainty and the timing forecast is derived from three statistics of the multiple regression, so it too possesses an uncertainty. The uncertainty associated with the forecast timing date is referred to as a prediction interval. This interval represents the range of dates that the median timing date could occur with a declared probability level. Inclusion of a prediction interval with the timing forecast serves to inform decision makers of the uncertainty around the forecast. In addition to the forecast date, the memos will include the historical time series median date, derived from the series of post season dates (again supplied by Jim Cave of the PSC). This allows for some comparison of how far off the historical 'average' the forecasted date may be. Large deviations from the historical median are almost certainly driven by abnormal environmental conditions. Uncertainty (i.e. the prediction interval) increases as the forecast value deviates away from the time series median. In other words, if the forecast is at the outer limits of what has been historically experienced (high or low) we will have less certainty in that forecast. The probability of erring increases relatively as forecasts move away from the historical median. Fundamentally, that is why prediction intervals play such an important role in any forecasting/predictive exercise, whether based on traditional, frequentist statistics or contemporary, Bayesian statistics.*

**b. Every year Chilko run-timing forecast is provided to the Fraser River Panel (the "FRP") around the end of April (see e.g. CAN013794 for 2007; CAN024343 for 2009). Why is only the run-timing for Chilko provided at this time?**

*This question is answered in Q2a. To reiterate, the Chilko forecast is based on oceanographic data from March, while Early Stuart is based on data from May. In the interest of expediency each forecast is released as a separate memo.*

**c. Are run-timing forecasts provided to the FRP for all stock management groups?**

*Run timing forecasts are released by DFO for just the Early Stuart and Chilko stocks. As the Early Stuart stock is the earliest of all four returning stock groups its timing is monitored as the first indicator for overall Fraser Sockeye return timing. There is a good historical record of Early Stuart run timing, which allows for more robust statistical relationship between timing and oceanographic indicators. The Chilko stock, part of the summer timing aggregate, has historically been numerically strong during each year of the four year Sockeye generation thus allowing for more data inclusion to the timing forecast model. This led to it being the stock of choice for timing evaluation. Comparatively, the Quesnel stocks and stocks of late run timing aggregate have shown cyclic dominance, resulting in two of the four year generation having very low return numbers. Consequently run timing estimates could be prepared for just half of those historical series, leading to greater uncertainty in forecasting.*

*In collaboration with PSC staff, the FRP technical committee has previously explored the relationship between timing of other Fraser Sockeye stocks and the more robust forecasts from Early Stuart and Chilko. I believe the relationship between variables was poor and so this analysis was never formally vetted through a peer-reviewed process. It may be that the FRP technical committee relies on this information to supplement the DFO timing forecast.*

**d. Please describe your involvement, if any, in updating run-timing estimates in-season.**

*I have no role with in-season updates to run timing estimates. This task lies with Pacific Salmon Commission biologist Jim Cave. His work is reported to the Fraser River Panel Technical Committee, who review the data and then report their findings to the Fraser River Panel. Though not an official member of the committee, I participated in most Technical Committee meetings during 2003-2005.*

**3. Forecasting: diversion rate**

**a. Please describe briefly (i.e. no more than 1-2 pages) how diversion rate forecasts are generated.**

*Historically the majority of returning adult Fraser Sockeye stocks migrated via the Strait of Juan de Fuca. Intermittent years would see returns via the northern route into Georgia Strait (i.e. via Johnstone Strait); thus the term "northern diversion" suggesting it was an anomaly from the norm. During the last two decades the majority of returns, by year, have swung equally between the northern and southern routes (Figure 2). Unlike timing, the diversion rate forecast is not stock specific but rather is a total estimate, accounting for all Fraser Sockeye returns. McKinnell et al. (1999) review the history and development of diversion forecasting. Two forecasts are produced annually. The first forecast is released in early June, the second in early July as additional environmental data become available. Staff at the Pacific Salmon Commission supply DFO with annual estimates of total Fraser Sockeye diversion rate.*

*Concerning migration routes into Georgia Strait, it is likely that returning adult Fraser Sockeye are responding to an environmental cue in the marine system, specifically temperature. McKinnell (1997) was able to show that diversion rates relate to late spring sea surface temperature (SST) recorded at*

*Kains Island lighthouse (NW Vancouver Island). While SST at this location is not likely the cue for Fraser Sockeye, it may be a proxy for the true environmental cue. For example SST at Kains Island may be reflective of temperatures that Fraser Sockeye respond to while migrating through critical locations of the North Pacific.*

*Since approximately year 2000 the Fraser Sockeye diversion rate has been forecasted by statistically relating historical diversion rate estimates to May, and later, May-June average SST at Kains Island. Additional analysis since that done by McKinnell et al. (1999) has shown that a statistical "fitting" calculated with a General Additive Model (GAM) gives more robust predictions than a simple linear regression. In simple terms the GAM and previously mentioned linear regression work in a similar manner by minimizing the amount of error between a fitted (predictive) line and the true historical data, but specific methodologies differ between techniques. Each approach is uniquely powerful and flexible, and depending on the shape of relationship between cause and effect, one method can perform superior to the other. Once a relationship between cause (SST) and effect (diversion rate) is estimated (e.g. "fitting the line"), that same fit is used to predict upcoming diversion given known ocean temperatures.*

*Commencing in 2009 the diversion forecast memorandum has included estimates of uncertainty around the forecast. These uncertainty estimates are derived from published deterministic methods associated with the statistical model, not from probabilistic methods (e.g. Monte Carlo simulation). Uncertainty is presented as prediction intervals around the forecast (i.e. the median or 50% probability level). Prediction intervals are stated with a probability level, for example "diversion forecast of 32%, with 50% probability the range is within 27%-42% and 95% probability the range is within 16%-59%". Due to the nature of the data distribution and how the GAM model fits a line to that data, the upper and lower prediction intervals are rarely symmetrical around the median of the forecast.*

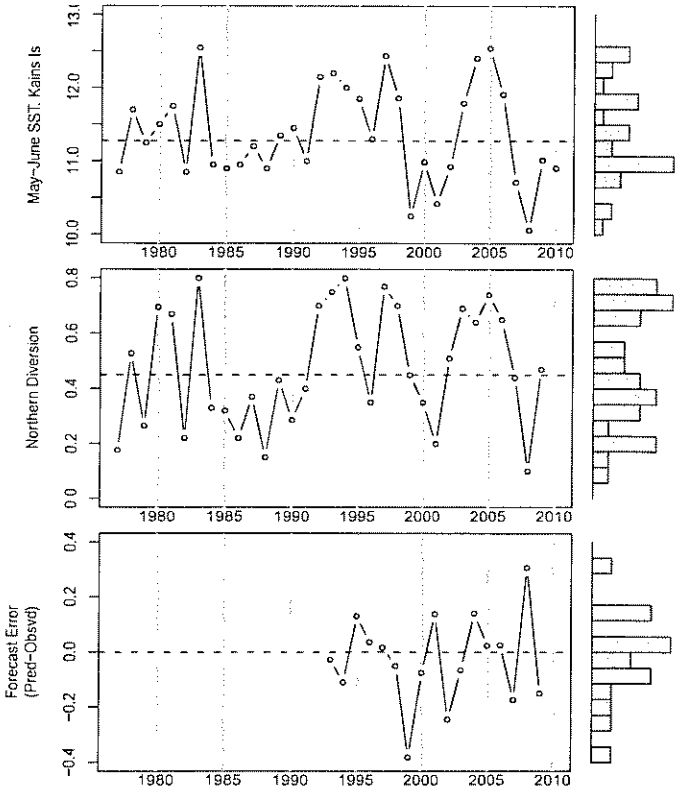


**Figure 2:** **Time series of environmental predictor (SST) and estimated northern diversion rate. Horizontal dashed lines represent series medians.**

**b. Please describe your involvement, if any, in updating diversion rate estimates in-season.**

*Annually, I submit to the PSC Fraser River Panel Canadian co-chair two forecasts of Fraser Sockeye northern diversion rate. The first is released in early June, the second in early July. Any in-season updates to the diversion rate estimate are prepared by the FRP technical committee. As indicated in question 2d, though not an official member of the committee, I participated in most Technical Committee meetings during 2003-2005.*

***Bibliography***


Blackbourn D. 1987. Sea surface temperature and the pre-season prediction of return timing in Fraser river Sockeye salmon (Oncorhynchus nerka). pp. 296-306 In Smith H, Margolis L & Wood CC (Eds.). Sockeye salmon (Oncorhynchus nerka) population biology and future management. Canadian Special Publication of Fisheries and Aquatic Sciences. 96.

Ingraham W. 1997. Getting to know OSCURS, REFM's ocean surface current simulator. Alaska Fisheries Science Center Quarterly Report (2) .

Ingraham W & Miyahara R. 1988. Ocean Surface Current Simulations in the North Pacific Ocean and the Bering Sea (OSCURS--Numerical model). NOAA Technical Memorandum NMFS F/NWC 130 155pp.

McKinnell S. 1997. Assessing the historical estimates of northern diversion of Fraser River sockeye salmon. Pacific Stock Assessment Review Committee Working paper () .

McKinnell S, Freeland HJ & Groulx SD. 1999. Assessing the northern diversion of sockeye salmon returning to the Fraser River, BC. Fisheries Oceanography 8 (2) pp. 104-114.

Michael Folkes

[redacted]

## EDUCATION

Sept. 1986 to May 1990 — **B.Sc. Hons. (Zoology) - The University of British Columbia, Vancouver**

Sept. 1992 to Oct. 1995 — **Graduate studies (Fish Biology) The University of British Columbia, Vancouver**
My work towards an M.Sc. was carried out under the direction of Dr. J.D. McPhail.

*This is Exhibit "B" referred to in the affidavit of Michael Folkes sworn before me at Nanaimo in the Province of British Columbia, this 14th day of Dec 2010*

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## ADVANCED COURSES

Fisheries Stock Assessment (Carl Walters)
Population Dynamics & Modeling (Carl Walters)
Biostatistics, UNIX systems operation, Technical writing. (All at UBC)

## EMPLOYMENT

June 2003 to present — **Dept. of Fisheries & Oceans (Pacific Biological Station)**
Salmon Stock Assessment Biologist.
- Science advice for implementing components of DFO's Wild Salmon Policy
- Modelling population biology of small stocks
- Legacy tasks from my participation in Fraser Sockeye science advice.

February 2003 to May 2003 — **Dept. of Fisheries & Oceans (Lower Fraser Area)**
Salmon Management Biologist (temporary deployment).
- Management strategy evaluation modeling of Fraser Sockeye (FRSSI).
- Public consultations.
- Cultus sockeye Recovery Team

February 2000 to January 2003 — **Dept. of Fisheries & Oceans (South Coast, Nanaimo)**
Salmon Stock Assessment Biologist.
- Management strategy evaluation modeling of Johnstone Strait Chum "Clockwork" fishery.
- Implementation of multi-year chum tagging operation
- Stakeholder consultations
- Analytical support to fishery managers during in-season assessment model.

July 1998 to February 2000 — **Inter-American Tropical Tuna Commission**
Associate Scientist.
- Manager of the tuna length frequency sampling program.

November 1995 to July 1998 — **Dept. of Fisheries & Oceans (Pacific Biological Station)**
Salmon Biologist.

| | |
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| 1989 to 1995 | **Dept. of Fisheries & Oceans:** Steelhead fishery data review<br>**UBC Zoology Fish Museum:** Research assistant<br>**UBC Fisheries Centre:** Technical writer<br>**R.L.& L. Consultants (Edmonton):** Field biologist<br>**D.A. Westworth & Associates (Edmonton):** Field biologist<br>**UBC Zoology:** Fish lab technician<br>**UBC Zoology:** Fisheries biology technician<br>**UBC Zoology/BC Min. of Ag., Food, And Fisheries:** Statistical data analyst<br>**UBC Animal Resource Ecology:** Technical writer |

**PUBLICATIONS**


Cass, A., M. Folkes, C. Parken, and C. Wood. 2006. Pre-season run size forecasts for Fraser River sockeye for 2006. DFO Can. Sci. Advis. Sec. Res. Doc. 2006/060

Folkes, M, B Ionson, and J Irvine. 2005. Scientific advice for input to the Allowable Harm Assessment for Interior Fraser Coho Salmon. DFO Can. Sci. Advis. Sec. Res. Doc. 2005/093

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Folkes, M. & I.A. Pearsall, 1995. A General Review of Steelhead Trout (*Oncorhynchus mykiss*) In The Fraser River System. Biology, Fishery, Interception, And Enhancement. Report to Dept. of Fish. & Oceans, Nanaimo.

Folkes, M., 1991. Marine Kelp Interaction Program - A Summary For Harvest Potential. B.C. Min. of Ag. and Fish. Data Report.

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