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Pacific Region

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PRE-SEASON RUN SIZE FORECASTS FOR FRASER RIVER SOCKEYE SALMON IN 2008

Figure 1. Sockeye salmon adult spawning phase. DFO website.

Figure 2: Sockeye spawning locations in South Western BC.

Context

Pre-season abundance forecasts of returning Fraser River adult sockeye 2008 were requested by DFO Fisheries Management. Fraser River pink salmon are an odd year run, therefore, a 2008 forecast is not required. Forecasts are used for pre-season planning purposes and for in-season management. They are most useful early in the summer fishing season before reliance on in-season run size estimates. Forecasts are produced by Fisheries and Oceans Canada (DFO) as agreed under the US-Canada Pacific Salmon Treaty. Detailed methods, model performance results, and "best" performing models are documented in Cass et al. 2006. Forecasts have been reviewed annually and a series of reports are publicly available: http://www.dfo-mpo.gc.ca/csas/csas/Publications/Pub_Index_e.htm.

SUMMARY

- The forecast of sockeye at the 50% probability level for all 19 stocks plus Early Summer and Late miscellaneous stocks combined is 2.9 million fish (35,000 Early Stuart, 349,000 Early Summer, 1.81 million Summer and 705,000 Late).
- This 50% probability level forecast (2.7 million excluding miscellaneous stocks) is below the long-term average for this cycle of 4.4 million fish (1980-2005). The Summer Run forecast (50% Chilko) accounts for 63% of the total forecast. Of the total forecast, the Late Run comprises 24%, the Early Summer run comprises 12% and Early Stuart sockeye comprises 1%.
- Forecasts at the 50% probability level (i.e. median value) for all run timing groups over-estimated returns in 2007. This overestimate is attributed to anomalously poor ocean survival conditions in 2005. To account for the effect of low marine survival in 2005 on the 2008 forecast, five year old forecasted returns in 2008 were multiplied by the

proportion of marine survival for Chilko in the 2003 brood year (i.e., 2005 smolt outmigration year) versus the long term survival average.

- Overall Pacific Ocean conditions in 2006 (when most sockeye returning in 2008 migrated to the ocean) were slightly cooler but had similar temperature regimes compared to 2005 (when most sockeye that returned in 2007 migrated to the ocean). In both years, water temperatures were near or above average from January to June (Pacific Decadal Oscillation Index (PDO): warm) and shifted to below average (PDO Index: cool) from July to December. Due to the lag in Strait of Georgia (SOG) temperatures from the North Pacific, SOG temperatures remained warm in 2006.
- Physical indicators of ocean productivity including vertical stratification, upwelling, and spring transition suggest productivity improved in 2006 relative to 2005. Biological indicators of ocean productivity and juvenile salmon survival (e.g. zooplankton composition and abundance, marine birds breeding success, coho growth rates and juvenile sockeye body sizes) are mixed in 2006 compared to uniformly poor in 2005.
- Given the mixed ocean productivity signals in 2006 relative to 2005, emphasis on more conservative forecast probability levels (>50%) is recommended.

INTRODUCTION

Total average sockeye returns for all stocks on the 2008 cycle were 4.4 million sockeye per year compared to the average returns for all stocks on all cycles of 9.7 million sockeye per year (1980-2005). Sockeye production from the 2008 cycle line has been dominated by returns to Chilko (summer run timing group). Chilko sockeye accounted for 40% of the total sockeye returns on the cycle since 1980. For the 2003 and 2004 brood years (respectively, age-5's and age-4's returning in 2008), Chilko, Late Stuart, Stellako, and Birkenhead each contributed on average 13% to the total number of effective female spawners (escapement) and Pitt River contributed 8%. Harrison River 2004 and 2005 brood years (respectively, age-4's and age-3's) contributed 20% to the total number of effective spawners given the extremely high escapement in this system in 2005 of ~200,000. Each of the other stocks contributed approximately 5% or less to the total escapement. The 2008 cycle line is the second off-cycle year for highly cyclic Early Stuart, Late Stuart and Quesnel sockeye. Forecasts are made for each of 19 individual sockeye stocks that have historical escapement and return data (Table 2). Together the 19 sockeye stocks accounted for 92% of the estimated escapement to the Fraser River in the 2008 brood years. Forecasts for the remaining 8%, for which only escapement data is available, are extrapolated based on mean recruits-per-spawner for combined stocks.

Forecasts of salmon returns are typically made using a variety of methods that include naïve and biological models. Model selection for each stock depends on data availability and model performance using retrospective analysis (Cass *et al.* 2006). Uncertainty in sockeye forecasts for 2008 is captured using Bayesian statistical inference. Sockeye forecasts presented here are based on the same methods and data streams reported in Cass *et al.* (2006) except for the addition of recent years data required to generate 2008 forecasts. Exceptions are described below.

ASSESSMENT

Data Sources and Methods

Data sources and methods have been extensively reviewed by Pacific Scientific Advice Review Committee (PSARC) and are available on the Canadian Science Advisory Secretariat (CSAS) website: http://www.dfo-mpo.gc.ca/csas/csas/Publications/Pub_Index_e.htm. Methods are presented in Cass *et al.* 2006.

Forecast Models

Forecast model descriptions are presented in Table 1 with details provided in Cass *et al.* (2006): http://www.dfo-mpo.gc.ca/csas/Csas/Publications/ResDocs-DocRech/2006/2006_060_e.htm. One model not included in the 2006 analysis but used in the 2007 & 2008 analysis was the Larkin model to account for delay-density effects on recruitment of adjacent year classes (Walters and Staley 1987). In addition, two additional variants of stock-recruitment (R/S) models were also explored in this year's analysis. In recent years, productivity for some major stocks, based on recruits-per-spawner, has trended downward (Cass *et al.* 2006). If low productivity persists in the future, then models based on all-years of data may over-forecast abundance. The two variants are biological models that extrapolate from brood year escapement data to forecast returns using 1) the most recent R/S estimate in the brood year and 2) the 4-year geometric mean R/S for the most recent generation.

Bayes prior parameter distributions for the biological model formulation for each class of forecast model is presented in Cass *et al.* 2006 (Appendix 3). In each trial the MCMC burn-in length was set to 20,000 samples from the posterior distribution. This was adequate based on the Gelman Rubin statistical test. A further 30,000 posterior samples were then used for parameter estimation.

Forecasts for 2008 were generated for the top three ranking models based on retrospective error and overall rank. In the 2007 forecast, if the top three models deviated significantly then a pooled forecast was calculated from the mean of each individual prediction weighted by the respective variance (SE^2) (Fried & Yuen 1987). However in this year's 2008 forecast, given the low brood year escapements for 2008 returns, the best performing biological model was used if there were significant differences between the top performing models (generally naïve models produced higher forecasts relative to biological models).

To account for the effect of poor ocean survival conditions in 2005 on five year old returns in 2008, the proportion of Chilko marine survivals in the 2003 brood year (four year old returns in 2007) to the long term average marine survivals were applied to forecasted 5 year old returns for all stocks. Based on initial estimates of four year old returns in 2007, the marine survival for the 2003 Chilko brood year was 0.01 compared to the 1948 to 2002 brood year average of 0.09. Therefore, forecasted five year old return estimates for all stocks were multiplied by 0.11. This would affect the overall forecast only for stocks with a significant five year old component such as Pitt and to a lesser extent Birkenhead and Raft or stocks where the brood year escapement in 2003 was high relative to other cycles and/or years such as Chilko, Quesnel, and Late Shuswap.

Retrospective Analysis

Since changes to the current sockeye forecast year (2008) data set were minor, the 2006 retrospective analysis results were used to compare model performance and select the best model for each stock's forecast in 2008 (Cass *et al.* 2006). Performance measures (PM) used include the following: mean raw error (MRE), mean absolute error (MAE), root mean square error (RMSE).

Results

Forecasts based on the best candidate model are provided at various probability levels of achieving specified run sizes by stock and run-timing group (Table 2). The retrospective performance of the two additional sockeye models that forecast returns by multiplying brood year escapement by recent R/S data (see Forecast Models section) performed poorly. The inference is that changes in productivity, at least for most of the historical record, did not persist with sufficient regularity to improve forecast performance. Forecast models that include standard sea-surface-temperature data and Pacific Decadal Oscillation (PDO) indices have not helped reduce forecasting errors for most Fraser sockeye stocks (Cass et al. 2006).

The forecast of sockeye at the 50% probability level for all 19 stocks plus Early Summer and Late miscellaneous stocks combined is 2.9 million fish (35,000 Early Stuart, 349,000 Early Summer, 1.81 million Summer and 705,000 Late). This 50% probability level forecast (2.7 million excluding miscellaneous stocks) is below the long-term average for this cycle of 4.4 million fish (1980-2005). The Summer Run forecast (50% Chilko) accounts for 63% of the total forecast. Of the total forecast, the Late Run comprises 24%, the Early Summer run comprises 12% and Early Stuart sockeye comprises 1%.

Early Stuart Sockeye

The 2008 cycle line is the second off cycle following the dominant (2005) and subdominant (2006); the first off cycle was in 2007. Escapement in the 2004 brood year was 5,000 effective female spawners which is 15% of the long term average on this cycle (average: 34,000 from 1980-2005). Spawning success in the brood year was higher than for previous years on this cycle (98% versus 85%); physical conditions on the spawning grounds were conducive to successful spawning with water levels and temperature within an acceptable range. The estimated number of outmigrating fry for the 2004 brood year was 6 million which is 30% of the long term average on this cycle (average: 20 million from 1990-2005).

Egg-to-fry survival rates have been estimated annually since 1990 at two sites (Forfar and Gluske Creeks); Kynoch creek estimates were discontinued after brood year 2000. Survival rates of the 2004 brood year compared to the 1990-2005 mean were similar for Forfar creek (32% brood year survival versus 26% average) but greater for Gluske creek (28% brood yr survival versus 17% average). The ultimate impact of fry survival measured at these two spawning locations on overall adult Early Stuart recruitment is difficult to assess.

The 2008 median (50% probability level) forecast for the Early Stuart group is 35,000. Based on the 2008 forecast distribution there is a 25% probability the return will exceed 49,000 sockeye and a 75% probability that the return will exceed 24,000 sockeye (Table 2). The forecast at the 50% probability level is below the long term average return for this cycle (1980-2005: 182,000).

Early Summer Run Sockeye

The Early summer run mainly consists of several small stocks. Stocks in this timing group with individual forecasts include Bowron, Fennell, Gates, Nadina, Pitt, Raft, Scotch, and Seymour (Table 2). Escapement in the 2004 brood year was 59,000 effective female spawners for these eight stocks and total 83,000 when including the miscellaneous stocks. Pitt comprises 40% of this total escapement. For all stocks except Pitt and Nadina, the brood year escapement is on average 30% of the 1980-2005 cycle average; Pitt escapement was double the long-term average escapement on the 2007 & 2008 cycle line (Pitt is comprised of greater proportions of five year olds versus four year olds) and Nadina was similar to the long-term average escapement. For Pitt, given all escapement data points except for two years (1998 & 2001) were below the brood year escapement there is greater uncertainty associated with this forecast. Also since Pitt is comprised of 65% five year olds, a significant reduction in the forecast occurred due to the five year old survival correction applied to all stocks. For Nadina, the only fry-based model used for this run timing group forecast, fry numbers outmigrating in the 2008 brood year (16 million) were similar to the long-term cycle average of 15 million (1980-2005).

The escapement to Chilliwack Lake and Dolly Varden Creek (upper Chilliwack River) in the 2004 brood year (20,000 effective female spawners) was the largest escapement in the historic record. However, there is some evidence that the very large abundance of spawners may exceed the habitat capacity resulting in a very poor recruits per spawner. The only year of similar escapement, 2001, had 13,000 effective females and produced a total return of less than 3,000 4 yr olds. Thus, if Chilliwack Lake and Dolly Varden Creek stocks were forecast using average recruits per spawner similar to other miscellaneous stocks, the forecast would considerably overestimate returns. Therefore, Chilliwack Lake and Dolly Varden Creek were removed from the miscellaneous Early Summer group and their forecast was generated separately based on average escapements in past years.

Most early summer run stocks were in good condition upon arrival to the spawning grounds. The exceptions include Gates and Nadina sockeye that were reported to be lethargic and stressed and had body lesions upon arrival to the spawning grounds. The 2004 brood year egg-to-fry survival (assuming average fecundity of 4,000 eggs/spawner) for Gates (37%) was below its long term average (1973-2006: 52%) and for Nadina (53%) was above its long term average (1968-2006: 36%).

The 2008 median (50% probability level) forecast for the Early Summer group is 349,000. Based on the 2008 forecast distribution there is a 25% probability the return will exceed 516,000 sockeye and a 75% probability that the return will exceed 205,000 sockeye (Table 2). The 2008 forecast excluding the miscellaneous group (50% probability forecast: 288,000) is below the long term average return for this cycle (1980-2005: 538,000).

Summer Run Sockeye

The summer run consists of four stocks: Chilko, Late Stuart, Quesnel and Stellako (Table 2). The spawning escapement in the 2004 brood year was 160,000 effective females for these four stocks. Chilko, Late Stuart and Stellako each comprised ~30% of this total escapement. Late Stuart and Quesnel 2004 brood year escapements are similar to their long term cycle escapement average (1980-2005). Stellako and Chilko brood year escapement were both below their long term cycle escapement average (1980-2005); respectively at 50% and 18% of their cycle average. For Chilko, the only juvenile (smolt)-based model used for this run timing group forecast, smolt numbers outmigrating in the 2004 brood year (11 million) were below the long-term cycle average of 18 million (1980-2005). Chilko smolt sizes were the largest on average observed for this population in the 2004 brood year (99.9 mm) versus the long term average (82.9 mm (± 5.69 stdev)); larger sized smolts can improve marine survival although given poorer marine conditions there is considerable uncertainty regarding smolt size effects on survival. Juvenile abundance (hydroacoustic estimates) for Quesnel sockeye was not estimated in 2006.

Summer run sockeye were exposed to extreme river migration conditions in 2004 (low flow rates and high water temperatures). These conditions impacted sockeye migration and survival in the Fraser River canyon area. However, Summer run sockeye were reported to be in good condition on their arrival to all spawning grounds. Body size of Quesnel fry could not be compared to the long term average due to the absence of assessment data in 2006.

The 2008 median (50% probability level) forecast for the Summer group is 1,810,000. Based on the 2008 forecast distribution there is a 25% probability the return will exceed 2,729,000 sockeye and a 75% probability that the return will exceed 1,182,000 sockeye (Table 2). The 2008 forecast at the 50% probability level is below the long term average return for this cycle (1980-2005: 2,882,000).

Late Run Sockeye

The late run consists of six stocks, Cultus, Harrison, Late Shuswap, Portage, Weaver, and Birkenhead (Table 2). The spawning escapement in the 2004 brood year was 36,000 effective females for these six stocks and total 47,000 when including the miscellaneous stocks. The spawning escapement for Harrison in recent years has been well above average and in the 2005 brood year (three year old returns in 2008) was approximately 200,000; Harrison is comprised of approximately 50% three year olds. Since this brood year escapement for Harrison is significantly above its long term escapement average of 4,300 (1980-2004) and exceeds the stock-recruitment data series, it was not possible to use biological models to forecast 2008 returns for this stock. Instead the best performing naïve model (time series average) was used to generate the forecast for Harrison. As a result, there is considerable uncertainty associated with the Harrison 2008 forecast.

For all stocks except Harrison, the brood year escapement is on average 50% of the 1980-2005 cycle average; Portage and Late Shuswap escapements were closest (~75%) to their cycle average. Cultus had a particularly low brood year escapement (33) that was 2% of the cycle average (4,000). However, a smolt-jack model was used to forecast returns for Cultus and due to hatchery supplementation of fry and smolts into the Cultus system, the number of outmigrating smolts (82,000) was above the long-term cycle average for this stock (50,000). Weaver was the other stock where a fry model was used to forecast returns. The brood year outmigrating fry (28,000,000) for Weaver were slightly below the long term cycle average of 36,000,000. Juvenile abundance (hydroacoustic estimates) for Late Shuswap sockeye was not estimated in 2006.

The 2008 median (50% probability level) forecast for the Late group is 705,000. Based on the 2008 forecast distribution there is a 25% probability the return will exceed 1,139,000 sockeye and a 75% probability that the return will exceed 432,000 sockeye (Table 2). The 2008 forecast excluding the miscellaneous groups (50% probability forecast: 610,000) is below the long term average return for this cycle (1980 to 2005: 788,000).

CONCLUSIONS

Forecasts are associated with high uncertainty. Although forecasts are presented as probability distributions, for most stocks they are based on models that assume average survival conditions. Ocean conditions were anomalously poor (below average) in 2005 (ocean entry year for most sockeye returning in 2007) resulting in poor juvenile sockeye survival and subsequent adult returns well below the 50% probability levels in 2007. Although ocean survival conditions appeared to have improved in 2006 (ocean entry year for most sockeye returning in 2008) relative to 2005, ocean productivity indicators remain mixed and, therefore, the 2008 sockeye return forecast will be particularly uncertain. Given these conditions, emphasis on more conservative forecast probability levels (>50% probability level) is recommended. Improved forecast accuracy is unlikely without a better understanding of factors affecting sockeye survival in their early life-history stages.

High surface water temperatures have persisted off Canada's Pacific coast since 2003 (DFO, 2006: http://www.pac.dfo-mpo.gc.ca/sci/psarc/OSRs/Ocean_SSR_e.htm). In 2006 when the majority of 2008 returning sockeye migrated to the ocean, water temperatures in the north Pacific were near or above average from January to June (Pacific Decadal Oscillation Index (PDO): warm) and shifted to below average (PDO Index: cool) from July to December. Storms in late 2006 also contributed to cooler water temperatures. In the Strait of Georgia where Fraser salmon first enter the ocean and, therefore, could be most vulnerable to factors affecting their survival, temperatures remained warm in 2006. Overall, sea-surface-temperature (cooling) improvements were minor in 2006 relative to 2005.

Physical indicators of ocean productivity including vertical stratification, upwelling, and spring transition suggest productivity improved in 2006 relative to 2005. Vertical stratification and upwelling both contribute to the amount of nutrients mixed into surface ocean waters from deeper waters and, therefore, affect productivity at the base of the food web (plankton production); the greater the vertical stratification and the weaker the upwelling, the fewer nutrients are available and the lower the productivity (food availability to juvenile salmon). In 2006 vertical stratification was weak and upwelling was strong (numerous storms contributed to high vertical mixing in 2006), converse to 2005, suggesting that food availability for juvenile salmon improved for sockeye that migrated to the ocean in 2006 (returning in 2008). Spring transition also improved in 2006 (average timing: early April) relative to 2005 (delayed timing: June). Spring transition is the switch from dominant winter wind (results in downwelling) to summer wind (results in upwelling) directions and represents the start of the productive summer season. Generally, if spring transition is delayed ocean productivity is reduced that year.

Biological indicators of ocean productivity and juvenile salmon survival (e.g. zooplankton composition and abundance, marine birds breeding success, coho growth rates and juvenile sockeye body sizes) are mixed in 2006 compared to uniformly poor in 2005. Zooplankton composition and abundance remained poor in 2006, similar to 2005. In both years, zooplankton composition was dominated by warm-water species typically found in Southern California. These species have a lower energy content (poorer food quality) compared to cold water species. Large cold water euphasiid abundance (a main food source for juvenile salmonids) was also poor in both 2005 and 2006. Other indicators that integrate the effect of several factors on juvenile salmon survival showed some improvements in 2006 relative to 2005. Marine bird breeding success was average in 2006 compared to being the lowest on record in 2005. Marine birds are a good indicator of food availability for salmon since, among other things, they feed on zooplankton. Growth rates and body sizes of juvenile salmon are also good indicators of survival since typically the faster a fish grows the less time they spend in smaller more vulnerable sizes resulting in improved survival. Growth rates for coho salmon on the West Coast of Vancouver Island (as an indicator of sockeye salmon survival) were average in 2006 compared to being the lowest on record in the 2005. Similarly, juvenile sockeye salmon size was the largest observed in the past 10 years in 2006.

Preliminary information from the 2007 return year indicates that survival for most sockeye returns were substantially below average. Returns in 2007 based on in-season information (December 1 2007) for most stocks were around the 90% prediction limits. Preliminary marine survival estimates for Chilko in 2007 were 1% versus the long term average of 9%. If low sockeye productivity persists then the 50% 2008 sockeye forecasts will overestimate returns. Therefore, emphasis on a more conservative forecast probability levels (>50%) is recommended. The two additional R/S models (see Forecast Models section) that attempt to account for near-term changes in productivity performed poorly based on the retrospective analysis. This indicates that variation in survival is difficult to predict from the series of historical R/S data. Long-term anomalous trends in productivity due to climate change or persistent freshwater density effects due to high escapement levels will increase the uncertainty in future forecasts. In the long term, as more fisheries and oceanographic data is collected and assessed, the link between salmon production and factors affecting survival such as climate change may become more quantifiable.

Table 1. The range of models explored for forecasting future sockeye returns.

Model Name	Model Type	Model Method	Data Applied			
			Returns	**Escapement & Adult Recruitment**	**Juvenile Estimates**	**Environmental**
R1C	Naïve	Returns 4 years previous after accounting for series mean proportion at age	X			
R2C	Naïve	Average of returns 4 & 8 years previous after accounting for series mean proportion at age	X			
RAC	Naïve	Average returns on cycle line after accounting for series mean proportion at age	X			
TAC	Naïve	Time Series Average Return after accounting for series mean proportion at age	X			
Power	Biological	Power function combining all cycles		X		
Power-cyc	Biological	Power function based on 1 cycle line		X		
Larkin	Biological	Larkin function assuming delay-density dependence		X		
Ricker	Biological	Ricker function combining all cycles		X		
Ricker-cyc	Biological	Ricker function based on 1 cycle line		X		
Power-fry	Biological	Power (log-log) regression function			X	
Smolt-Jack	Biological	Bayesian			X	
Ricker-disc	Biological & Environmental	Multiple regression		X		Average spring Fraser discharge
Ricker-peak	Biological & Environmental	Multiple regression		X		Peak spring Fraser discharge
Ricker-ei Ricker-pi	Biological & Environmental	Multiple regression		X		Average spring-summer Lighthouse SST
Ricker-PDO	Biological & Environmental	Multiple regression		X		Winter Pacific Decadal Oscillation Index

Table 2. Pre-season forecasts for 2008 by stock/timing group and probability.

Sockeye stock/timing group	Forecast model[b]	Mean Run Size[c] all cycles	Mean Run Size[c] 2008 cycle	Probability of Achieving Specified Run Sizes[a] 0.1	0.25	0.5	0.75	0.9
Early Stuart	fry	**335,000**	**182,000**	**73,000**	**49,000**	**35,000**	**24,000**	**17,000**
Early Summer		-	-	**932,000**	**563,000**	**349,000**	**216,000**	**136,000**
(total exlcuding miscellaneous)		***(499,000)***	***(538,000)***	***(702,000)***	***(444,000)***	***(288,000)***	***(185,000)***	***(120,000)***
Bowron	Ricker-pi	23,000	26,000	8,000	6,000	5,000	3,000	2,000
Fennell	power	28,000	41,000	37,000	25,000	17,000	11,000	7,000
Gates	power	65,000	149,000	148,000	97,000	63,000	38,000	25,000
Nadina	fry	80,000	129,000	288,000	168,000	103,000	59,000	35,000
Pitt	power	61,000	65,000	91,000	73,000	59,000	52,000	39,000
Raft	power	32,000	64,000	91,000	51,000	27,000	14,000	8,000
Scotch	power	63,000	16,000	19,000	10,000	5,000	3,000	1,000
Seymour	Ricker-cyc	147,000	48,000	20,000	14,000	9,000	5,000	3,000
Misc[d]	R/S	-	-	136,000	72,000	37,000	20,000	10,000
Misc[e]	R/S	-	-	50,000	26,000	14,000	7,000	4,000
Misc[f]	avg escp	-	-	44,000	21,000	10,000	4,000	2,000
Summer		**5,677,000**	**2,882,000**	**4,324,000**	**2,729,000**	**1,810,000**	**1,182,000**	**822,000**
Chilko	smolt	1,760,000	1,804,000	1,783,000	1,230,000	885,000	596,000	433,000
Late Stuart	power	834,000	323,000	1,450,000	714,000	355,000	177,000	95,000
Quesnel	power	2,556,000	90,000	255,000	163,000	93,000	48,000	27,000
Stellako	Ricker	527,000	665,000	836,000	622,000	477,000	361,000	267,000
Late		-	-	**1,728,000**	**1,139,000**	**705,000**	**432,000**	**283,000**
(total exlcuding miscellaneous)		***(3,172,000)***	***(788,000)***	***(1,435,000)***	***(938,000)***	***(610,000)***	***(400,000)***	***(268,000)***
Cultus	smolt-jack	19,000	6,000	14,000	9,000	5,000	3,000	2,000
Harrison[h]	TSA	47,000	19,000	233,000	110,000	47,000	21,000	10,000
Late Shuswap	Larkin	2,133,000	39,000	49,000	26,000	15,000	7,000	3,000
Portage	power	58,000	24,000	49,000	27,000	15,000	7,000	4,000
Weaver	fry	432,000	405,000	629,000	434,000	290,000	193,000	126,000
Birkenhead	power	483,000	295,000	461,000	332,000	238,000	169,000	123,000
Misc. Shuswap[g]	R/S	-	-	6,000	3,000	2,000	1,000	1,000
Misc. non-Shuswap[g]	R/S	-	-	287,000	198,000	93,000	31,000	14,000
TOTAL		-	-	**7,057,000**	**4,480,000**	**2,899,000**	**1,854,000**	**1,258,000**
(TOTAL excluding miscellaneous)		***(9,683,000)***	***(4,390,000)***	***(6,534,000)***	***(4,160,000)***	***(2,743,000)***	***(1,791,000)***	***(1,227,000)***

[a] probability that the actual run size will exceed the specified projection

[b] see Cass *et al.* 2006 for model descriptions

[c] sockeye: 1980-2005 (excluding miscellaneous stocks)

[d] unforecasted miscellaneous Early Summer stocks (Early Shuswap stocks and N.Thompson mainstem); return timing most similar to Scotch & Seymour).

[e] unforecasted miscellaneous Early Summer stocks (N. Thomson tributaries, Nahatlatch, etc.; return timing most similar to Fennell/Bowron/Nadina).

[f] Chilliwack Lake and Dolly Varden Creek; return timing most similar to Early Stuart.

[g] unforecasted miscellaneous Late stocks; note that the true late component made up a very small component of the Misc. non-Shu (<200 at 50% probability level)

[h] Harrison River brood year escapement (three year olds) in 2005 was ~200,000. Given this is considerably greater than the long term average (1980-2002: 4,300) and exceeds the SR data series, the best performing naïve models was used (TSA).

Model definitions: R1C (recruitment like last generation); TSA (time series average); Ricker-pi (Ricker function with Pine Island SST covariate); Ricker-cyc (Ricker function using cycle line data only).

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FOR MORE INFORMATION

Contacts:	Sue Grant Fraser River Stock Assessment Fisheries and Oceans Canada 100 Annacis Parkway, Unit 3 Delta, BC V3M 6A2	Al Cass Pacific Biological Station Fisheries and Oceans Canada 3190 Hammond Bay Road Nanaimo, BC V9T 6N7
Tel:	604-666-7270	250-756-7142
Fax:	604-666-7112	250-756-7209
E-Mail:	Grants@pac.dfo-mpo.gc.ca	Cassa@pac.dfo-mpo.gc.ca

Pacific Scientific Advice Review Committee
Pacific Region
Fisheries and Oceans Canada
Pacific Biological Station
Nanaimo, BC V9T 6N7

Telephone: (250) 756-7208
Fax: (250) 756-7209
E-Mail: psarc@pac.dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas

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