Fisheries and Oceans Canada — Pêches et Océans Canada
Science — Sciences
Pacific Region
Canadian Science Advisory Secretariat
Science Advisory Report 2006/043

# PRE-SEASON RUN SIZE FORECASTS FOR FRASER RIVER SOCKEYE AND PINK SALMON IN 2007

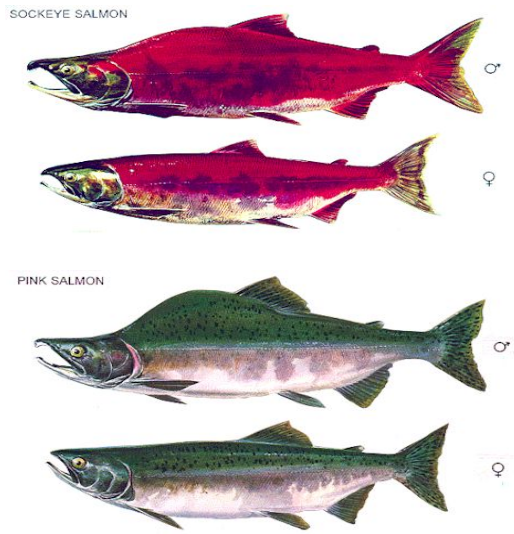


*Figure 1. Sockeye and pink salmon adult spawning phase. DFO website.*

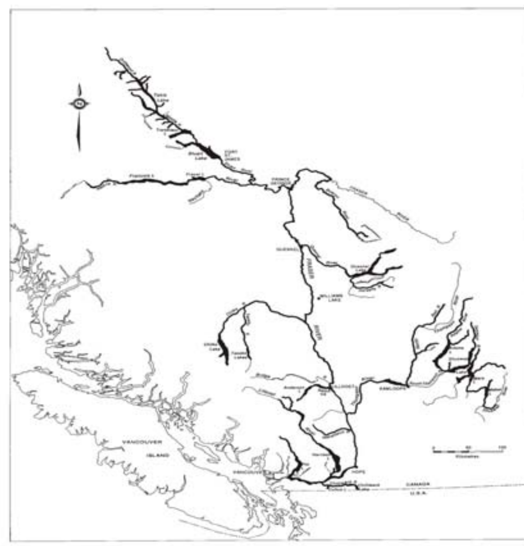

*Figure 2: Sockeye spawning locations in South Western BC.*

## Context

*Pre-season abundance forecasts of returning adult sockeye and pink salmon in 2007 were requested by DFO Fisheries management. They 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% level for all 19 stocks combined is 6.2 million fish (45,000 Early Stuart, 690,000 Early Summer, 3.4 million Summer and 2.1 million Late).
- This 50% level forecast is greater than the average for this cycle of 5.3 million fish (1948-2003). The Summer Run forecast accounts for 54% of the total forecast with Chilko and Quesnel in nearly equal proportions at 1.7 million and 1.2 million respectively. The remainder is largely Late run sockeye (34% of the total forecast) with the Late Shuswap and Birkenhead forecast of, respectively, 1.0 million and 0.5 million sockeye accounting for 71% of the Late run component.
- The Fraser pink salmon forecast at the 50% level is 19.6 million fish and is almost double the average return of 12 million (1961 to 2003).

- Forecasts at the 50% probability level (i.e. median value) for the Early Stuart and Summer sockeye timing groups have over-estimated returns in many years during the last decade due to recent declines in productivity. Forecast errors for Early Summer and Late timed stocks are smaller and without a persistent positive or negative trend.
- The cause(s) of the recent declines in sockeye productivity is not known. Recent changes in oceanographic conditions potentially affecting salmon that spawn in southern BC may have contributed to lower ocean survival. Recent high escapement levels for some stocks may have reduced survival through density dependent processes in freshwater rearing environments.
- 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.

# INTRODUCTION

Sockeye production from the 2007 cycle line has been dominated by returns to Chilko and Late Shuswap. Average sockeye returns for all stocks on the 2007 cycle were 5.3 million sockeye per year compared to the average returns for all stocks on all cycles of 7.6 million sockeye per year (1948-2003). At nearly equal proportions, Chilko and Late Shuswap sockeye together accounted for 57% of the total sockeye returns on the cycle since 1948. For the 2007 brood year, Chilko, Late Shuswap, Birkenhead, and Quesnel respectively accounted for 33%,18%,15%, and 14% of the total escapement. Forecasts are made for each of 19 individual sockeye stocks and four run timing groups with historical escapement and return data (Table 3). Together the 19 sockeye stocks accounted for 99% of the estimated escapement to the Fraser River in brood year 2003. Forecasts for the remaining 1%, for which only escapement data is available, are extrapolated based on mean recruits-per-spawner for combined stocks.

Fraser pink salmon forecasts for all spawning populations combined are also provided. Outmigrating fry abundance is the primary predictor of pink returns. In 2005, fry abundance (600 million) was greater compared to average annual abundance from 1961-2005 (370 million).

Forecasts of salmon returns are typically made using a variety of models that include naïve and biological. Model selection for each stock depends on data availability and model performance using retrospective analysis (Cass *et al.* 2006). Uncertainty in sockeye and pink forecasts for 2007 is captured using Bayesian statistical inference. Sockeye and pink 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 provide 2007 forecasts.

# 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.

Estimates of Fraser pink escapements and returns are available for odd-number years (brood years 1957-97). Spawning escapement estimates are based on mark-recapture studies conducted by the International Pacific Salmon Fisheries Commission (1957-85) and DFO (1987-

2001). Pink fry abundance, the best current predictor of Fraser River pink salmon, is estimated at Mission during the downstream migration period. Current fry estimation procedures are consistent with procedures developed in 1962 (Vernon 1966).

## Forecast Models

Forecast model descriptions are presented in Table 2 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 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 assessment. 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 will over-forecast abundance. The two variants are biological models that extrapolate from brood year escapement data to forecasts 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 posterior 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.

## Retrospective Analysis

Since changes to the current sockeye forecast year (2007) data set were minor, previous year's retrospective analysis results were used to compare model performance and select the best model for each stock's forecast in 2007 (Cass *et al.* 2006). Performance measures (PM) used include the following: mean raw error (MRE), mean absolute error (MAE), root mean square error (RMSE).

For Fraser River pink salmon, retrospective analysis was not conducted in the previous forecast year (Cass *et al.* 2006) since this stock is an odd year run. Therefore, in the current forecast year (2007), retrospective analysis of naïve, fry-based and fry-SSS (sea-surface-salinity) models was conducted for pink salmon using methods described by Cass *et al.* (2006) for sockeye.

Forecasts for 2007 were generated for the top three ranking models based on retrospective error and overall rank. A further refinement was considered in this assessment based on the October 2006 PSARC review for stocks with very similar PMs and dissimilar forecasts. For those stocks, if top ranking forecasts deviated significantly then a pooled forecast was derived from the mean of each individual prediction weighted by the respective variance ($SE^2$) (Fried & Yuen 1987):

$$F = \sum_{n=1}^{2}\left[F_n * \frac{1}{SE_n^2}\right] / \sum_{n=1}^{2}\left[\frac{1}{SE_n^2}\right]$$

where $F_n$ = forecast of returns for model 1 to n (top ranking models).

$$SE = \sqrt{\frac{1}{n-2}\sum_{i=1}^{n}(R_t - \hat{R}_t)^2}$$ where $R_t$ is observed recruitment and $\hat{R}_t$ is forecasted recruitment

## Results

For most of the last decade, forecast error for the Early Stuart and Summer run timing groups at the 75% probability forecast level was smaller compared to the 50% probability level (Figures 3 & 4). At the 50% probability level for these groups, forecasts consistently overestimated recruitment. Conversely, for the Early Summer and Late run timing groups, error at the 50% probability level was smaller compared to the 75% probability level (Figures 3 & 4). At the 75% probability level for Early Summer and Late runs, forecast consistently underestimated recruitment.

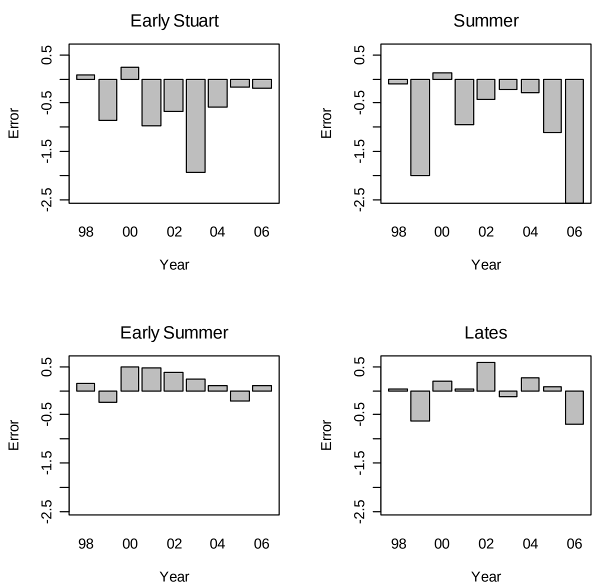


*Figure 3. Forecast performance (error: observed recruitment-forecast) from 1998-2006 at the 50% probability level.*

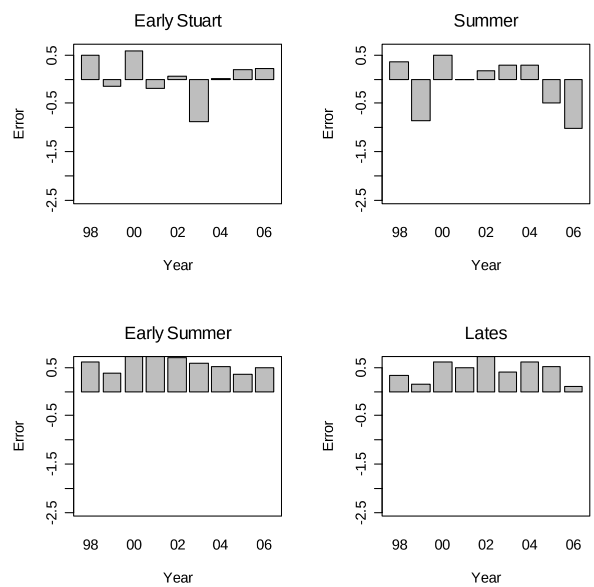


*Figure 4. Forecast performance at the 75% probability level.*

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 3). The retrospective performance of the two additional sockeye models used to extrapolate escapement based on recent R/S data only for the major stocks 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).

Forecasts for each stock were compared for the top three ranking models based on retrospective analysis reported in Cass *et al* 2006. Only Quesnel (Ricker-fry model and the naïve brood-year recruitment model) and Lower Shuswap (Larkin stock-recruit model and the naïve cycle line average recruitment model) produced significantly different results for the top performing models. As a result, for these populations the top-ranking models were pooled.

The 2007 forecast of sockeye at the 50% level for all stocks combined is 6.2 million fish (45,000 Early Stuart, 690,000 Early Summer, 3.4 million Summer and 2.1 million Late). This 50% level forecast is greater than the average for this cycle of 5.3 million fish (1948-2003). The Summer Run forecast accounts for 54% of the total forecast with Chilko and Quesnel in nearly equal proportions at 1.7 million and 1.2 million respectively. The remainder is largely Late run (34% of the total forecast) with the Late Shuswap and Birkenhead forecast of, respectively, 1.0 million and 0.5 million sockeye accounting for 71% of the Late run component. The Fraser pink salmon forecast at the 50% level is 19.6 million fish and is almost double the average return of 12 million (1961 to 2003).

## Early Stuart Sockeye

The 2007 cycle line is the first off cycle following the dominant (2005) and subdominant (2006) returns. The spawning escapement in the 2007 brood year was 6,932 effective females which is 25% of the long term average on this cycle. Spawning success in the brood year was higher than for previous years on this cycle (97% 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 in the 2007 brood year was 6.5 million which is 10% of the long term average on this cycle. The 2007 median (50%) forecast is 45,000. The forecast is below the long term average return for this cycle (~200,000). Based on the 2007 forecast distribution there is a 25% probability the return will exceed 104,000 sockeye and a 75% probability that the return will exceed 29,000 sockeye (Table 3).

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 2003 brood compared to the 1990-2003 mean were similar for Forfar creek (20% brood year survival versus 24% average) but greater for Gluske creek (30% 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.

## 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 3). The spawning escapement in the 2007 brood year was 81,000 effective females for these eight stocks and total 103,000 when including the miscellaneous stocks. The 2003 brood year represents the fourth largest Early Summer escapement observed on this cycle since surveys began in 1939; Pitt comprises 50% of this total escapement. Escapements for all stocks, except Pitt, fall within the historical escapement range; Pitt escapement was three times the long-term average escapement for this stock on the 2006 & 2007 cycle line (Pitt is comprised of similar proportions of four and five year olds). Escapements were lower than the 2007 cycle line average for Bowron (33%) and Nadina (12%), above the cycle line average for Pitt, Gates (two times) and Raft (two times) and similar to the cycle line average for Fennell, Scotch and Seymour. For Nadina, the only fry-based model used for this run timing group forecast, fry numbers outmigrating in the 2007 brood year (2 million) were 18% of the long term average. Spawning success in the brood year was higher than for previous years on this cycle (97% versus 91%). Drought conditions in the Thompson (north and south) restricted fish access to four and three spawning location. For North Thompson stocks, low water conditions improved visibility and increased survey effort. In part, this likely accounts for the high escapements in these systems.

The total forecast for the Early Summer group is 690,000 at the 50% level. The forecast is above the long term average return for this cycle (~580,000). Based on the 2007 forecast distribution there is a 25% probability the return will exceed 1,328,000 sockeye and a 75% probability that the return will exceed 389,000 sockeye (Table 3).

The egg-to-fry survival estimate for the 2003 brood at the Gates Creek spawning channel was lower (40% survival) than the long term mean (60%) (1973-2003). Survival of Nadina channel fry was greater at 83% versus the 50% long term mean survival (1973-2003).

## Summer Run Sockeye

Of the four Summer run stocks, Chilko and Quesnel sockeye account for 88% of the total Summer run forecast (Table 3). The spawning escapement for the Summer Run 2007 brood year was 543,533 effective females. The 2007 brood year represents the fourth largest Summer run escapement observed on this cycle since surveys began in 1939. The escapement in the 2007 brood year for Chilko (336,000) was almost double the long term cycle average (~200,000). For Chilko, the only juvenile-based model used for this run timing group, smolt numbers outmigrating in the 2007 brood year (23 million) were similar to the long term average. The brood year escapement for Quesnel (144,000) was five times greater than the long term cycle line average (~29,000) and the majority spawned in the Horesefly (57%) and Mitchell Rivers (31%). The 2007 brood year escapement for Late Stuart (19,200) was double the long term cycle average (~10,000). The Stellako brood year escapement of 44,000 was smaller than the long term cycle line average (~57,000). Fall-fry body weight for Quesnel for the 2007 brood was near average.

The total forecast for the Summer run group is 3,369,000 at the 50% level. The forecast is above the long term average return for this cycle (~2,400,000). Based on the 2007 forecast distribution there is a 25% probability the return will exceed 5,878,000 sockeye and a 75% probability that the return will exceed 1,971,000 sockeye (Table 3). The 50% level forecast for Chilko, Quesnel, Late Stuart, and Stellako was respectively 1,713,000, 1,242,000, 159,000 and 255,000. Other forecast levels are reported in Table 3.

## Late Run Sockeye

The spawning escapement for late run stocks in the 2007 brood year was 380,000 effective females. This is slightly below the long term cycle average (~433,000). Late Shuswap and Birkenhead comprised the greatest proportion of this Late Run escapement (50% and 40% respectively). Cultus and Late Shuswap escapement was below the long term escapement for this group and cycle line. Escapement for Cultus (662) was the lowest escapement recorded on this cycle. Numbers of Cultus outmigrating smolts (wild plus wild equivalents (hatchery)) in the 2007 brood year were 90,000 (7% of the long term average). Late Shuswap escapement (188,000) was 70% of the long term average for this stock on the 2007 cycle line. Fall-fry body weight for the brood year was near average. Harrison (6,000) and Portage (3,000) brood year escapements were similar to their long term averages. Weaver (25,000) and Birkenhead (153,000) brood year escapements were greater than their long term average by approximately double and four times, respectively. Outmigrating smolts for Weaver in the brood year (46 million) were also approximately double the long term average.

Spawning success in the brood year was higher than for previous years on this cycle (96.2% versus 86.7%). From October 14-22 2003 extremely heavy rainfall and flooding was experienced in most areas of the watershed resulting in record breaking water levels in the Harrison-Lillooet, Pitt, and Chilliwack areas. The affect on egg to fry survival for these sockeye stocks is unknown but may have reduced the egg-to-fry survival in these watersheds.

The total forecast for Late run sockeye is 2,143,000 at the 50% level. This forecast is slightly greater than the long term average return for this cycle (~2,100,000). Based on the 2007 forecast distribution there is a 25% probability the return will exceed 3,986,000 sockeye and a 75% probability that the return will exceed 1,213,000 sockeye (Table 3). The 50% level forecast for Cultus, Harrison, Late Shuswap, Portage, Weaver and Birkenhead are respectively, 4,000, 22,000, 994,000, 39,000, 416,000, and 543,000 sockeye. Miscellaneous Shuswap and non-Shuswap are respectively, 55,000 and 70,000. Other forecast levels are reported in Table 3.

## Fraser River Pink Salmon

The juvenile power model that included salinity data performed the best of all models (Table 1). However, excluding salinity data did not decrease overall performance significantly. Forecasts at the 50% probability level were similar for these two models (19.6 million versus 17.7 million). The total number of outmigrating fry in the brood year for pink salmon was 615 million, this is double the long term average of 370 million (1961-2005).

The total forecast for the Fraser River pink salmon is 19.6 million at the 50% level. This is above the long term average of 12 million. Based on the 2007 forecast distribution there is a 25% probability the return will exceed 26.5 million pink and a 75% probability that the return will exceed 13.9 million pink (Table 1).

# 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. Improved forecast accuracy is unlikely without a better understanding of factors affecting survival. Near record high ocean 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 ). There is general recognition that warm ocean conditions can reduce the survival of cold water species such as salmon, and affect the quantity and quality of their food supply. Current forecast models that include ocean temperature data are more accurate for some stocks such as Barkley Sound sockeye but have generally not improved forecast performance of Fraser River sockeye. Nevertheless, as shown in Figure 3, pre-season forecasts of Fraser sockeye at the 50% probability level have overestimated returns in most years since 1998 in 2 of 4 timing groups.

Preliminary information from the 2006 return year indicates that survival for Summer and Late run sockeye was substantially below average. Returns in 2006 based on in-season information (October 11 2006) for Summer Run sockeye were outside the 90% prediction limits largely due to the failure of the Quesnel stock. Returns of Late run sockeye were near the 75% probability level. If low sockeye productivity persists then the 50% 2007 sockeye forecasts will overestimate returns. The two additional R/S models in the current analysis 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. Preliminary coastwide estimates of pink salmon returns in 2006 are much lower than expected and imply that large scale oceanographic factors reduced ocean survival. If oceanographic factors affecting survival of pink salmon persist in 2007 then the Fraser pink return forecast for 2007 may over-estimate actual returns. 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. Model performance for Fraser River pink salmon.*

| | MRE | MAE | MAE rank | RMSE | RMSE rank | Average rank |
|---|---|---|---|---|---|---|
| **TSA** | -3.954 | 6.954 | 3 | 8.06 | 3 | 3 |
| **R1C** | 0.486 | 7.972 | 4 | 9.314 | 4 | 4 |
| **R2C** | 0.153 | 8.29 | 5 | 9.417 | 5 | 5 |
| **RAC** | -3.954 | 6.954 | 3 | 8.06 | 3 | 3 |
| **MRS** | 16.017 | 19.004 | 8 | 25.153 | 8 | 8 |
| **RS1** | 8.039 | 13.745 | 7 | 18.34 | 7 | 7 |
| **RS2** | 8.344 | 12.655 | 6 | 16.458 | 6 | 6 |
| **RSC** | 16.017 | 19.004 | 8 | 25.153 | 8 | 8 |
| **fry + env** | -1.267 | 5.503 | 1 | 6.704 | 1 | 1 |
| **fry only** | -2.909 | 5.213 | 2 | 6.879 | 2 | 2 |

*Table 2. List of candidate models and data requirements.*

| 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<br>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 3. Pre-season forecasts for 2007 by stock/timing group and probability.*

| Sockeye stock/timing group | Forecast model[b] | Mean Run Size[c] all cycles | Mean Run Size[c] 2007 cycle | Probability of Achieving Specified Run Sizes[a] 0.1 | 0.25 | 0.5 | 0.75 | 0.9 |
|---|---|---|---|---|---|---|---|---|
| **Early Stuart** | fry | **330,000** | **192,000** | **100,000** | **65,000** | **45,000** | **29,000** | **19,000** |
| **Early Summer** | | **508,000** | **579,000** | **2,813,000** | **1,328,000** | **690,000** | **389,000** | **231,000** |
| Bowron | Ricker-pi | 44,000 | 89,000 | 54,000 | 37,000 | 25,000 | 17,000 | 12,000 |
| Fennell[f] | RAC | 24,000 | 32,000 | 796,000 | 165,000 | 29,000 | 5,000 | 1,000 |
| Gates | power | 58,000 | 25,000 | 142,000 | 87,000 | 51,000 | 30,000 | 19,000 |
| Nadina | fry | 87,000 | 127,000 | 51,000 | 31,000 | 18,000 | 11,000 | 6,000 |
| Pitt[g] | TSA | 71,000 | 82,000 | 228,000 | 131,000 | 71,000 | 38,000 | 22,000 |
| Raft | power | 31,000 | 20,000 | 101,000 | 68,000 | 45,000 | 29,000 | 18,000 |
| Scotch | R1C | 62,000 | 20,000 | 172,000 | 94,000 | 48,000 | 24,000 | 13,000 |
| Seymour | Ricker-cyc | 131,000 | 184,000 | 476,000 | 298,000 | 188,000 | 120,000 | 81,000 |
| Misc[d] | R/S | - | - | 793,000 | 417,000 | 215,000 | 115,000 | 59,000 |
| **Summer** | | **3,782,000** | **2,401,000** | **9,870,000** | **5,878,000** | **3,369,000** | **1,971,000** | **1,261,000** |
| Chilko | smolt | 1,373,000 | 1,574,000 | 3,649,000 | 2,588,000 | 1,713,000 | 1,119,000 | 783,000 |
| Late Stuart | R1C | 579,000 | 92,000 | 1,113,000 | 443,000 | 159,000 | 57,000 | 23,000 |
| Quesnel[h] | pooled[h] | 1,349,000 | 103,000 | 4,538,000 | 2,458,000 | 1,242,000 | 628,000 | 341,000 |
| Stellako | R1C | 481,000 | 632,000 | 570,000 | 389,000 | 255,000 | 167,000 | 114,000 |
| **Late** | | **2,936,000** | **2,166,000** | **6,923,000** | **3,986,000** | **2,143,000** | **1,213,000** | **731,500** |
| Cultus | smolt-jack | 41,000 | 93,000 | 14,000 | 8,000 | 4,000 | 1,000 | 500 |
| Harrison | Ricker-PDO | 41,000 | 66,000 | 62,000 | 39,000 | 22,000 | 14,000 | 12,000 |
| Late Shuswap[j] | pooled[j] | 2,081,000 | 1,482,000 | 3,753,000 | 2,011,000 | 994,000 | 504,000 | 276,000 |
| Portage | power | 39,000 | 24,000 | 170,000 | 85,000 | 39,000 | 20,000 | 11,000 |
| Weaver | fry | 375,000 | 173,000 | 1,081,000 | 668,000 | 416,000 | 269,000 | 188,000 |
| Birkenhead | power | 359,000 | 328,000 | 1,467,000 | 929,000 | 543,000 | 352,000 | 216,000 |
| Misc Shuswap[e] | R/S | - | - | 160,000 | 97,000 | 55,000 | 29,000 | 17,000 |
| Misc. non-Shuswap[e] | R/S | - | - | 216,000 | 149,000 | 70,000 | 24,000 | 11,000 |
| **TOTAL** | | **7,556,000** | **5,338,000** | **19,706,000** | **11,257,000** | **6,247,000** | **3,602,000** | **2,242,500** |
| **PINKS** | fry-salinity | **12,120,896** | - | **35,775,000** | **26,455,000** | **19,570,000** | **13,908,000** | **10,069,000** |

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

[b] see Table 2 and Cass *et al.* 2006 for model descriptions

[c] sockeye: 1948-2003; pink: 1961-2003

[d] unforecasted miscellaneous Early Summer stocks

[e] unforecasted miscellaneous Late stocks

[f] Fennell performance measures of TSA and RAC models were nearly indistinguishable. Brood effective females (5,200) were close to the cycle line average (5,000), as a result the cycle line average model (RAC) was used.

[g] Pitt brood year escapement exceeds the historical range. Use of any escapement based model would be invalid. The best ranking naive model (TSA) was used to forecast Pitt returns.

[h] Quesnel top ranking forecasts (Ricker-fry and R1C) were pooled (weighted average based on SE calculated from retrospective analysis).

[j] L. Shuswap top ranking forecasts (Larkin and RAC) were pooled (weighted average based on SE calculated from retrospective analysis).

**Model definitions:** fry or smolt (juvenile-based power function); Ricker-pi (Ricker function with Pine Island SST covariate); RAC (average recruitment on the cycle line); power (power function); TSA (time series average of recruitment); R1C (recruitment like last generation); Ricker-cyc (Ricker function using cycle line data only); smolt-jack (multiple linear relation between smolt production, jack escapement, and recruitment); Ricker-PDO (Ricker function with Pacific Decadal Oscillation Index).

## SOURCES OF INFORMATION

Cass, A.J., Folkes, M., Parken, C.K., and Wood, C.C. 2006. Pre-season run size forecasts for Fraser River sockeye for 2006. Pacific Stock Assessment Review Committee, Working Paper S2005-04.

DFO, 2006. State of the Pacific Ocean 2005. DFO. Sci. Oceans Status Report. 2006/001.

Fried, S.M. and H.J. Yuen. 1987. Forecasting sockeye salmon (*Oncorhynchus nerka*) returns to Bristol Bay, Alaska: a review and critique of methods, p. 273-279. *In* H.D. Smith, L. Margolis, and C.C. Wood [ed.] Sockeye management. Can. Spec. Publ. Fish. Aquat. Sci: 96: 486.

Haeseker, S.L., R.M. Peterman, Z.Su and C.C. Wood. 2005. Retrospective evaluation of pre-season forecasting models for pink salmon. North Am. J. Fish Manag. 25: 897-918.

Vernon, E.H. 1966. Enumeration of migrant pink salmon fry in the Fraser River estuary. Internat. Pacific Salmon. Fish. Comm. Bull. XIX, 83 p.

Walters, C.J. and M.J. Staley 1987. Evidence against the existence of cycle dominance in Fraser River sockeye (*Oncorhychus nerka*). P 375-384. *In* H.D. Smith, L. Margolis, and C. C. Wood [ed.] Sockeye salmon (*Oncorhychus nerka*) population biology and future management. Can. Spec. Publ. Fish. Aquat. Sci. 96.

## FOR MORE INFORMATION

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

ISSN 1480-4913 (Printed)


*La version française est disponible à l'adresse ci-dessus.*

## CORRECT CITATION FOR THIS PUBLICATION

DFO, 2006. Pre-season run size forecasts for Fraser River sockeye and pink salmon in 2007. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2006/043.