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Pre-season run size forecasts for Fraser River Sockeye (*Oncorhynchus nerka*) and Pink (*O. gorbuscha*) Salmon in 2011

Prévisions présaison des remontes du saumon rouge (*Oncorhynchus nerka*) et du saumon rose (*O. gorbuscha*) du Fraser en 2011

Grant, S.C.H. and MacDonald, B.L.

Fisheries & Oceans Canada,
100 Annacis Parkway, Unit 3, Delta, BC, V3M 6A2

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ABSTRACT

Salmon forecasts remain highly uncertain due to stochastic (random) variability in annual survival rates. Fraser Sockeye survival has been particularly uncertain in recent years due to the systematic declines in productivity exhibited by most stocks, and the extremely variable productivity of the past two brood years (2005 and 2006 brood years corresponding, respectively, to the 2009 and 2010 returns for most Sockeye). To capture inter-annual random (stochastic) variability in Fraser Sockeye survival, forecasts are presented as standardized cumulative probabilities (10%, 25%, 50%, 75%, 90%). For example, at the 25% probability level there is a one in four chance that Sockeye returns will be at or below the forecasted value, given survival is within long-term or recent average historical observed ranges. Alternative assumptions of Sockeye productivity are presented as separate forecasts: 'Long-Term Average Productivity' and 'Recent Productivity (brood years: 1997-2004)'. The 'Recent Productivity' scenario is considered most plausible (CSAP Salmon Sub-Committee). The 'Long-Term Average Productivity' scenario is considered plausible but less likely. For Fraser Sockeye forecasts, under the assumption of 'Recent Productivity', there is a one in ten chance (10% probability) the Sockeye return will be at or below 1.0 million, and a nine in ten chance (90% probability) it will be at or below 12.1 million. The mid-point of this distribution (50% probability) is 3.2 million (there exists a one in two chance the return will be above or below this value assuming recent stock productivity). Under the assumption of 'Long-Term Average Productivity', there is a one in ten chance (10% probability) the return will be at or below 1.7 million, and a nine in ten chance (90% probability) it will be at or below 15.1 million. The 2011 forecast has a higher age-5 proportion (35-50% of age-4 + age-5 returns across stocks) than average (~20%), given the generally high brood year escapements for age-5 Sockeye, and the use of average (in the case of 'Recent Productivity' forecasts) to above average (for 'Long-Term Average Productivity' forecasts) 2010 age-4 productivities in forecasting the age-5 returns for some stocks. For Fraser Pink Salmon forecasts, based on the assumption of 'Long-Term Average Productivity', there is a one in ten chance (10% probability) the Pink return will be at or below 9.2 million and a nine in ten chance (90% probability) it will be at or below 37.5 million. The mid-point of this distribution (50% probability level) is 17.5 million. A recent productivity scenario was not produced for Pink Salmon, as they have not exhibited declines in productivity like Fraser Sockeye. The Fraser Pink forecast is highly uncertain because this forecast required extrapolation outside the range of observed data, given the record high fry abundance in 2010.

RÉSUMÉ

Les prévisions concernant le saumon demeurent très incertaines en raison de la variabilité stochastique (aléatoire) observée dans les taux de survie annuels. La survie chez le saumon rouge du Fraser est particulièrement incertaine ces dernières années en raison des déclins systématiques dans la productivité observés dans la plupart des stocks ainsi que de la productivité qui a été extrêmement variable au cours des deux dernières années d'éclosion (les années d'éclosion 2005 et 2006 correspondant respectivement aux retours de 2009 et de 2010 pour la plupart des saumons rouges). Afin de rendre compte de la variabilité stochastique interannuelle dans la survie du saumon rouge du Fraser, les prévisions sont présentées en tant que probabilités cumulatives normalisées (10 %, 25 %, 50 %, 75 % et 90 %). Par exemple, la probabilité que les retours de saumon rouge soient inférieurs ou égaux à la valeur de la prévision est de un sur quatre (25 %), compte tenu que la survie se situe dans la fourchette des moyennes à long terme ou récentes des données historiques observées. Différentes hypothèses concernant la productivité du saumon rouge sont présentées en tant que prévisions distinctes : « productivité moyenne à long terme » et « productivité récente (années d'éclosion 1997-2004) ». On considère que le scénario de la « productivité récente » est le plus plausible (sous-comité sur le saumon du CASP). On considère également que le scénario de la « productivité moyenne à long terme » est plausible, mais moins probable. Pour les prévisions concernant le saumon rouge du Fraser établies selon l'hypothèse de la « productivité récente », la probabilité que les retours de saumons rouges soient inférieurs ou égaux à 1,0 million est de un sur dix (10 %) et la probabilité qu'ils soient inférieurs ou égaux à 12,1 millions est de neuf sur dix (90 %). La valeur médiane de cette distribution (probabilité de 50 %) est de 3,2 millions (la probabilité que les retours soient supérieurs ou inférieurs à cette valeur est de un sur deux, selon la productivité récente du stock). Selon l'hypothèse d'une « productivité moyenne à long terme », la probabilité que les retours soient inférieurs ou égaux à 1,7 million est de un sur dix (10 %) et la probabilité qu'ils soient inférieurs ou égaux à 15,1 millions, de neuf sur dix (90 %). Dans les prévisions de 2011, la proportion d'individus d'âge 5 est supérieure (35-50 % de retours d'âge 4 + âge 5 dans l'ensemble des stocks) à la moyenne (~20 %) en raison des échappées des années d'éclosion généralement élevées pour les saumons d'âge 5 et de l'utilisation de la productivité des individus d'âge 4 de 2010 dans la moyenne (prévisions selon la « productivité récente ») et au-dessus de la moyenne (prévisions selon la « productivité moyenne à long terme ») pour la prévision des retours des individus d'âge 5 pour certains stocks. Pour les prévisions concernant le saumon rose du Fraser établies selon l'hypothèse d'une « productivité moyenne à long terme », la probabilité que les retours de saumons roses soient inférieurs ou égaux à 9,2 millions est de un sur dix (10 %) et la probabilité qu'ils soient inférieurs ou égaux à 37,5 millions, de neuf sur dix (90 %). La valeur médiane de cette distribution (probabilité de 50 %) est de 17,5 millions. Aucun scénario de productivité récente n'a été produit pour le saumon rose, car cette espèce n'affiche aucun déclin dans la productivité, contrairement au saumon rouge du Fraser. Les prévisions concernant le saumon rose du Fraser sont très incertaines car elles doivent être établies en fonction d'extrapolations qui ne cadrent pas avec les données observées étant donné que l'abondance des alevins la plus élevée a été observée en 2010.

INTRODUCTION

HISTORICAL ADULT RETURNS

Fraser Sockeye return abundances have historically varied, due to the four-year pattern of Sockeye abundance (cyclic dominance) observed for many stocks, and variability in annual survival rates (see Figure 5 in Grant et al. 2011). In recent years in particular, Fraser Sockeye have exhibited extremely large variations in returns, ranging from one of the lowest returns (2009 return year) to one of the highest returns (2010 return year) observed over the past century (see Figure 5 in Grant et al. 2011).

To provide context for the 2011 Fraser River adult Sockeye Salmon return forecasts, the cycle average returns are presented in Tables 1 & 4 (column I). On the 2011 cycle, the average Fraser Sockeye return (1953-2009) across all 19 forecasted stocks combined was ~ 5.3 million. Chilko (Summer Run) and Late Shuswap (Late Run) have historically been the main drivers of return abundances on the 2011 cycle line, each accounting for ~30% of the average total return. Stellako and Birkenhead have also contributed relatively high returns to the cycle average, at ~11% and 7% respectively. Stocks that have each comprised greater than 2% of the 2011 average cycle return include Early Stuart, Seymour, Quesnel and Weaver.

ESCAPEMENT IN THE 2006 AND 2007 BROOD YEARS

The abundance of adult returns in any given year is influenced by three main factors: the abundance of their parental spawners (brood year escapement, used as an index of egg deposition), the survival rate of the resulting offspring (egg to adult stages), and the age composition of each cohort that survives to adulthood. Since most Fraser Sockeye return at age-4 after spending two winters in freshwater and two winters in the marine environment (Gilbert-Rich aging convention: 4_2), the majority of Sockeye returning in 2011 are recruited from eggs spawned by adults in 2007 (brood year). Most of these returning fish would have emerged from the gravel in 2008, and migrated to the ocean in 2009.

For the 2007 brood year, the abundance of either effective female spawners (EFS) or smolts (Chilko & Cultus) for 10 of the 19 forecasted Fraser Sockeye stocks was close to, or above, their time series cycle average (1951-2003 for most stocks), including Fennell, Pitt, Raft, Scotch, Chilko, Late Stuart, Quesnel, Harrison, Weaver and Birkenhead. The greatest contributors to the 2007 brood year total EFS were Chilko (37% of the total EFS), Harrison (13%), Birkenhead (13%), Quesnel (8%), and Late Shuswap (8%), while several other stocks (Stellako, Pitt, Weaver) contributed ~4% each. The remaining 11 forecasted stocks each contributed less than 2% to the total 2007 brood year EFS. Nine stocks, in particular, had 2007 brood year EFS abundances that were well below average (Early Stuart, Bowron, Gates, Nadina, Seymour, Stellako, Cultus, Late Shuswap and Portage).

Most Fraser Sockeye stocks also have an age-5 (52) component that contributes, on average, 20% to their total recruitment. For the majority of these stocks, the number of EFS contributing to the 2011 age-5 returns (2006 brood year) was close to, or above, their cycle average (most time series: 1948-2002), with the exception of three stocks (Bowron, Cultus and Weaver), which were below average. Given the higher escapements observed for a number of stocks in the 2006 brood year, relative to the 2007 brood year, the age-5 component may contribute more than 20% to the total return in 2011. Pitt returns are typically comprised of a larger proportion of age-5 Sockeye relative to age-4 Sockeye, therefore, the 2006 brood year, which was above average, will contribute more to the total returns than the 2007 brood year. Harrison has an age-3 (3_1) component, which contributes variable proportions to the total Harrison recruitment. The brood year EFS abundance for Harrison in 2008 was average.

SURVIVAL RATES (PRODUCTIVITY)

Productivity trends across all Fraser Sockeye stocks have generally declined, though individual trends vary between stocks (Grant et al. 2010; Grant et al. 2011; Peterman & Dorner 2011). Overall, total

Fraser Sockeye productivity (driven by Summer Run stocks) has declined since the 1990's, coinciding with increases in total escapement. One notable exception is Harrison Sockeye, which have increased in productivity in recent years. Harrison Sockeye have a unique age-structure and life-history compared to all other stocks. Harrison Sockeye migrate to the ocean shortly after gravel emergence (most other Sockeye rear in lakes for one to two years prior to ocean migration) and return as age-3 & age-4 fish (most other Sockeye return at age-4 & age-5).

Productivity has been extremely variable in the last two brood years. The 2005 brood year productivities (2009 return year for most of these Sockeye) were amongst the lowest on record for most Fraser Sockeye stocks, including Harrison Sockeye. In contrast, 2006 brood year productivities (2010 return year for most of these Sockeye) were average for most stocks including Harrison, with the exceptions of Late Shuswap, Scotch and Seymour, which exhibited well above average productivities.

Marine survival ($\log_e$(Recruits/Smolt)) for Chilko and Cultus Sockeye has declined since the mid-1980's (Figure 1; Grant et al. 2010; Grant et al. 2011). Chilko and Cultus are the only two stocks with smolt data, which can be used to partition freshwater and marine survival (note: marine survival includes the period of smolt downstream migration from their rearing lakes to the Strait of Georgia).

METHODS

OVERVIEW

The 2011 Fraser Sockeye forecast approach is adapted from methods described in previous forecasts (Cass et al. 2006; DFO 2006; DFO 2007; DFO 2009; Grant et al. 2010). Similar to the 2010 forecast, the 2011 Fraser River Sockeye Salmon forecast includes two separate forecast approaches. The 'Long-Term Average Productivity' approach assumes that long term productivity trends (brood years 1948 to 2004 for most stocks) will persist through to 2011, while the 'Recent Productivity' approach assumes that recent productivity trends (brood years 1997 to 2004) will persist through to 2011. For most stocks, recent productivity has been below average, with the notable exception of Harrison Sockeye, which have exhibited higher than average productivity in recent years.

The '**Long-Term Average Productivity'** forecast approach uses methods that are similar to those described in previous forecasts (Cass et al. 2006; DFO 2006; DFO 2007; DFO 2009; Grant et al. 2010) and are summarized below:

- Candidate forecast models are described in Table 9.
- Retrospective analysis (see proceeding sections for details) was used to generate a suite of forecasts for the second half of the stock-recruitment time series for each model by stock. Subsequently, various performance measures were used to rank all candidate models relative to one another by comparing the retrospective forecasts to the observed returns. This analysis was updated in the current paper (Appendix 1), from its last update in 2009 (DFO 2009).
- Forecasts were generated for the top three ranked models, and a model evaluation process was conducted to select a single forecast model for each stock (see proceeding sections).
- For Scotch, Seymour and Late Shuswap, the above long-term average productivity associated with the 2006 brood year (2010 returns for most Sockeye) and the 2006 cycle line age-5 proportions (given the lower age-5 proportions on this cycle) were used to estimate the 2011 age-5 recruits. This approach used to estimate age-5 return forecasts for particular stocks was a recommendation from the CSAS process, and therefore, due to time constraints, was only updated in the final forecast Table (Table 1).

- Miscellaneous stocks were forecast using the product of their brood year escapements and the long-term average productivity for spatially and temporally similar stocks with stock recruitment data, as identified in Table 1 (footnotes e, f, g, h, i, m).

The '**Recent Productivity'** forecast approach uses methods that are similar to those described in Grant et al. (2010) and are summarized below:

- Candidate models used in the 'Recent Productivity' scenario were identical to the 'Long-Term Average Productivity' scenario (Table 9).
- Retrospective analysis (see proceeding sections for details) was used to generate a suite of forecasts for the second half of the stock-recruitment time series for each model by stock. In contrast to the 'Long-Term Average Productivity' scenario, the 'Recent Productivity' scenario methods used only the last eight brood years (brood years 1997 to 2004) of the retrospective forecasts and actual returns to calculate performance measures and rank models. Therefore, model selection for the 'Recent Productivity' forecasts focused on models that performed best in the recent productivity period. This analysis was not updated in the current paper given that it was last updated in 2010 (see Appendix 5 in Grant et al. 2010). See proceeding sections for details.
- Forecasts were generated for the top three ranked models, and a model evaluation process was conducted to select a single forecast model for each stock (see proceeding sections).
- For stocks where the selected forecast models (Table 4) incorporated recent (low) productivity (Early Stuart, Bowron, Scotch, Seymour, Chilko, Late Stuart, Late Shuswap and Portage), the productivity from the 2006 brood year (2010 returns for most Sockeye), which was average to above average across stocks, was used to estimate the age-5 returns. It was assumed that five year old fish returning in 2011 would experience similar high productivity to age-4 fish that returned in 2010, given that they came from the same brood year (2006) and, therefore, likely experienced similar survival conditions. In addition, the 2006 cycle line age-5 proportions were used for Scotch, Seymour and Late Shuswap, rather than the all cycle age-5 proportions used for other forecasts, since these stocks have much lower proportions of age-5 recruits on this cycle versus other cycles. This approach used to estimate age-5 return forecasts for particular stocks was a recommendation from the CSAS process, and therefore, due to time constraints, was only updated in the final forecast Table (Table 4).
- Miscellaneous stocks were forecast using brood year escapements for these stocks multiplied by average recent (brood years 1997 to 2004) productivity for spatially and temporally similar stocks with stock recruitment data, as identified in Table 1 (footnotes e, f, g, h, i, m).

The 2006 brood year productivities, used to forecast age-5 recruits for stocks identified in the previous 'Long-Term Average Productivity' and 'Recent Productivity' overview sections, are preliminary and incomplete, since the 2010 return data were not finalized at the time of this publication. In a number of cases, age-4 return data were not available at the individual stock level and, therefore, near-final Sockeye escapement proportions were used to partition returns from larger stock aggregates to individual stocks. Additionally, the 2006 brood year productivity does not include age-5 returns in 2011. For Scotch, Seymour and Late Shuswap, the age-5 recruit proportions on the 2006 cycle line were used to forecast age-5 recruits, given the much lower proportions on this cycle versus other cycles.

DATA

Biological Data

Annual estimates of Sockeye spawning escapement, fry or smolt abundance (if and when available), and recruits (sum of catch, escapement, and en-route loss) by stock are the primary data used to forecast Fraser Sockeye returns for the 19 forecasted stocks. For miscellaneous stocks, only escapement data are available. Escapement data used in the forecast are in the form of effective female spawners (EFS): the product of female spawners and the proportion of successfully spawned eggs (0%, 50%, or 100%), based on spawning ground carcass surveys. For most stocks with spawner and recruitment data, the time series by brood year extends from 1948 to 2004, with the following exceptions: Fennell (1967-2004), Gates (1968-2004), Nadina (1973-2004), Scotch (1980-2004), Portage (1953 to 2004) and Weaver (1966-2004). For these stocks, earlier data were omitted due to gaps in the time series (Fennell, Scotch, Portage) or due to the effect of spawning channels, which began operation in the late 1960's (Gates, Weaver) or late 1970's (Nadina). The last brood year for which full recruitment data (age-4 and age-5) are available is 2004. Final Age-5 recruitment data by stock from the 2005 brood year (returned in 2010), and age-4 and age-5 recruitment data from the 2006 brood year (returned in, respectively, 2010 and 2011) were not finalized at the time of publication. However, age-4 data from the 2005 brood year (age-4 recruits in 2009) were used in the age-4 productivity time-series. Age-4 productivity is calculated as the age-4 recruitment from each brood year divided by the brood year EFS (i.e. for 2005, the age-4 productivity is the age-4 returns in 2009 divided by the EFS in 2005).

Forecasts that use juvenile data as a predictor variable were included in the evaluation for the following four stocks: Chilko (smolt), Cultus (smolt), Weaver (fry), and Nadina (fry). Gates (fry) and Early Stuart (fry) juvenile data were not used in the forecast process, as juvenile estimates for these stocks represent highly uncertain indices of abundance only. Quesnel (fall fry) and Late Shuswap (fall fry) juvenile data were also not used in the 2011 forecast process, because field surveys were not conducted to estimate fry production from the 2007 brood year. For Cultus, smolt data were used as the sole predictor variable in biological models, as Cultus Sockeye have been enhanced (fry & smolts) through hatchery production since the 2000 brood year. Cultus smolt data includes the total number of smolts (wild + hatchery produced smolts are included post-2000) migrating through the Sweltzer Creek enumeration fence, plus (post-2000 brood year) hatchery produced smolts released downstream of the fence. The Cultus smolt time-series is intermittent, and begins in 1950. Fry data for Weaver (brood years 1968-present) and Nadina (brood years 1972-present) include production from both within and outside the spawning channels. In recent years when fry assessments were not conducted outside the channels in these two systems, non-channel fry were estimated by multiplying the brood year EFS by the overall average number of fry produced-per-EFS outside the channel for each system.

To provide a visual overview of the biological data input for the forecast models, biological values such as brood year EFS and age-4 productivity ($\log_e$(age-4 R/EFS) or $\log_e$(age-4 R/smolt)) are represented in Tables 1 & 4 as colours, depicting below, above, or near average values. The cycle average and standard deviation of each EFS time-series was calculated using brood years 1948-2004. The time-series cycle average minus half the cycle standard deviation was used to set the lower bound (any value falling below this lower bound is coded red: below average), and the time series cycle average plus half the cycle standard deviation was used to set the upper bound (any value falling above this upper bound is coded green: above average) (Trudel, M., DFO Research Scientist, pers. comm.). Values falling within the upper and lower bounds are coded yellow: average. A similar colour-coding is used for the forecasted returns and for age-4 productivity. However, for age-4 productivity the data were log-transformed, and geometric means for the most recent four and eight year periods were colour-coded with reference to the geometric average and standard deviation for 1980-2005 (across all cycles). Again, age-4 data from the 2005 brood year (age-4 recruits in 2009) were used in the age-4 productivity time-series

Escapement and wild smolt (Cultus and Chilko) data were provided by DFO Fraser Stock Assessment (DFO, Keri.Benner@dfo-mpo.gc.ca), channel fry data (Nadina and Weaver) were provided by DFO Oceans, Habitat & Enhancement Branch (DFO, Roberta.Cook@dfo-mpo.gc.ca), data for Cultus hatchery smolt numbers (released downstream of the Sweltzer Creek enumeration fence) were obtained by DFO Oceans, Habitat and Enhancement Branch (Stuart.Barnetson@dfo-mpo.gc.ca), and recruitment data were provided by the Pacific Salmon Commission (PSC) (Lapointe@psc.org).

Environmental Data

In additional to biological data, several biological models incorporate environmental data, listed below:

Pacific Decadal Oscillation (PDO): winter PDO (November to March months, inclusive, immediately prior to smolt outmigration) was used as a broad index of sea surface temperature (SST) in the North Pacific (Mantua et al. 1997); http://jisao.washington.edu/pdo/PDO.latest

Sea-Surface-Temperature (SST): SST data from two lighthouses were used, as these sites are thought to best represent conditions experienced by juvenile Fraser Sockeye during their initial stages of migration in the marine environment. The two lighthouse locations are Entrance Island (Strait of Georgia, proximate to Nanaimo) and Pine Island (NE corner of Vancouver Island: http://www.pac.dfo-mpo.gc.ca/sci/OSAP/data/SearchTools/Searchlighthouse_e.htm

a) Entrance Island: average SST data (April to June) in the Strait of Georgia where juvenile Fraser Sockeye first enter the marine environment (see web link above).

b) Pine Island: average SST data (April to July) on the northern tip of Vancouver Island (see web link above).

Fraser discharge (peak and average April to June mean discharge):
http://www.wsc.ec.gc.ca/applications/H2O/index-eng.cfm

MODELS

Non-Parametric Models

Non-parametric models forecast future returns using the historical time series, and do not require parameter estimation. Four non-parametric models (R1C, R2C, RAC, TSA) do not include spawner (or juvenile) abundance as a predictor variable, but instead use total return data to generate forecasts (Table 9) (Cass et al. 2006; Haeseker et al. 2008). An additional six non-parametric models (RS1, RS2, RS4yr, RS8yr, MRS, RSC) forecast returns using the product of spawner (or juvenile) abundance and recruits-per-spawner averaged over different time periods (Table 9). Forecast distributions for non-parametric models were estimated as the residual error (forecast minus actual return) for each model determined using jack-knife re-sampling.

Miscellaneous stocks do not have associated recruitment data and, therefore, were forecast using non-parametric models only. Forecasts for miscellaneous stocks were generated using the product of their brood year EFS and the R/EFS for index stocks (stocks with paired stock-recruitment data that are in the same run timing group and occupy a similar geographic area as the miscellaneous stocks). Specifically, index stocks included Scotch and Seymour for the South Thompson miscellaneous stocks; Raft and Fennell for the North Thompson miscellaneous stocks; the aggregate Early Summer run timing stocks (8 non-miscellaneous stocks in Tables 1 & 4) for the Nahatlach and Chilliwack miscellaneous stocks; and Birkenhead for the Non-Shuswap (Harrison Lake rearing) miscellaneous stocks. Forecast distributions are estimated using the $\log_e$ mean and standard deviation of the stock-recruitment time series for associated index stocks. See Grant et al. (2010) for all non-parametric model equations.

Biological Models

Biological models (e.g., Ricker, power, or Larkin) forecast returns based on the relationship between spawners (or juveniles) and recruits, and they require parameter estimation (Table 9; see Grant et al. 2010 for all biological model equations). Only stock-recruitment models include environmental variables as covariates. Bayes posterior parameter distributions for the biological models were estimated using WinBUGS (Bayesian software Using Gibbs Sampling) (WinBUGS is available on the following website: http://www.mrc-bsu.cam.ac.uk/bugs/welcome.shtml). The R statistical software and the BRugs library were used to automate the analysis (R is available on the following website: http://www.biostat.umn.edu/~brad/software/BRugs/). In each trial, the MCMC burn-in length was set to 20,000 samples from the posterior distribution. A further 30,000 MCMC samples were taken to approximate the posterior probability distributions of the model parameters and associated forecast.

Return Estimation: Age Proportions

Most Fraser Sockeye stocks are comprised of age-4 (4_2) and age-5 (5_2) fish, therefore, the total number of returning recruits in 2011 is the sum of the forecasted number of age-4 recruits produced by spawners in the 2007 brood year, and the age-5 recruits produced by spawners in the 2006 brood year. In order to generate a forecast of age-4 recruits, the total number of recruits (age-4 + age-5) produced by spawners from the 2007 brood year was multiplied by the average stock-specific proportion of age-4 recruits since 1980 (see Grant et al. 2010, Appendix 3). In order to generate a forecast of age-5 recruits, with the exception of Scotch, Seymour, and Late Shuswap, the total number of recruits produced by spawners from the 2006 brood year was multiplied by the average stock-specific proportion of age-5 recruits since 1980. Age proportions for all stocks (generally the proportion of age-4 to age-5 year olds) were estimated using a truncated period of spawner data (1980-2004). This change was added to the methods because age at maturity has increased for most stocks post-1980 (Grant et al. 2010; Holt & Peterman 2004). For Scotch, Seymour and Late Shuswap, the 2006 cycle line age-5 recruit proportions were used to forecast age-5 recruits, given the much lower proportions on this cycle versus all other cycles.

MODEL EVALUATION

Retrospective Analysis

Retrospective analysis was used to produce forecasts by each model and stock for the second half of the stock-recruitment time series. Using retrospective analysis, models were initialized with only data from the first half of the stock-recruitment time series. Forecasts were generated sequentially for each year in the second half of the time series using updated data inputs for each year, which included data that would have been available in each forecast year (i.e all data up to that year)(Cass et al. 2006; Haeseker et al. 2007 & 2008; Grant et al. 2010). The retrospective analysis was re-run in 2011 for the 'Long-Term Average Productivity' forecasts, as these were not updated for the 2010 forecast (Grant et al. 2010). For the 'Long-Term Average Productivity' retrospective analysis, performance measures were calculated over the entire retrospective time series (Appendix 1). Retrospective analysis results for the 'Recent Productivity' scenario were updated in the 2010 forecast (see Appendix 5 in Grant et al. 2010) and, therefore, were not updated in the current paper.

Four performance measures (PM's): mean raw error (MRE), mean proportional error (MPE), mean absolute error (MAE) and root mean square error (RMSE) were used in combination with the retrospective analysis results to rank each model's performance (Cass et al. 2006; Haeseker et al. 2007 & 2008; Grant et al. 2010). Each performance measure evaluates a different component of a model's forecasting ability. Specifically, MRE evaluates model bias (i.e. does a model, on average, consistently over or under forecast true returns), MAE evaluates precision (i.e. on average, how close is a model's forecast to true returns), MPE evaluates relative precision (i.e. on average, how close is a model's forecast to true returns, standardized by true return size), and RMSE (i.e. evaluates variance in the difference between the forecasts and true returns). For each of these performance measures, the smaller the calculated value, the better the model's performance (see Grant et al. 2010, Appendix 4 for equations).

Model Selection Methods

Performance measures were estimated for each stock and model for both productivity scenarios ('Long-Term Average Productivity' versus 'Recent Productivity'), using paired retrospective analysis forecasts and observed returns. Each model was ranked relative to the other models separately for each performance measure (i.e. a model with rank=1 performs best relative to other models compared). Ranks across all of the four performance measures were averaged to generate an average rank for each model (see Appendix 1 for 'Long-Term Average Productivity' retrospective analysis results and Appendix 5 in Grant et al. 2010 for 'Recent Productivity' retrospective analysis results). Forecasts for 2011 were then run using the top three models for each stock (Tables 7 & 8), based on their average retrospective analysis rank. Three steps for final selection of the forecast model used for each stock are as follows:

1) For the 'Long-Term Average Productivity' forecasts, non-parametric models that consider recent productivity (RS1, RS2, R1C, R2C, RS4yr, RS8yr and KF) were excluded from the selection process (Table 7, rows highlighted dark grey). Therefore, for a number of stocks, first ranked models may not have been selected, if one of the recent productivity models ranked higher than other models in this scenario.

2) For both productivity scenarios, the 2007 brood year escapement (or juvenile abundances) for each stock was compared to its cycle average (Table 1 & 4, column C). If brood year escapements (or juvenile abundances) were above or below the cycle average (bounds on the average range were set the same as for the colour-coding, as described in the Biological Data section), only top ranked biological models, or non-parametric models that include escapement (or fry) as a predictor variable, were considered for the 2011 forecast.

3) For both productivity scenarios, final error checks included a comparison of the 2011 stock-specific forecasts across all top-ranked models (Tables 7 & 8) to understand similarities and differences in forecasts, described in proceeding individual stock results sections. In addition, the age-4 productivities associated with each forecast were compared to averages for each stock (Tables 2 & 5), to understand where productivities produced by the forecasts fall out in terms of observed recent and long-term stock productivities.

FORECAST RESULTS

OVERVIEW OF THE 2011 FRASER SOCKEYE RETURN

Alternative assumptions about future Sockeye productivity are presented as separate forecasts: 'Long-Term Average Productivity' (Figure 2; Tables 1 to 3) and 'Recent Productivity (brood years: 1997-2004)' (Figure 2; Tables 4 to 6). The 'Recent Productivity' scenario is considered most plausible (CSAP Salmon Sub-Committee), given the systematic changes in Fraser Sockeye productivity observed over time, and the particularly low productivity observed for most stocks in recent years. The 'Long-Term Average Productivity' scenario is considered plausible but less likely.

To capture inter-annual random (stochastic) variability in Fraser Sockeye survival, forecasts are presented as standardized cumulative probabilities (10%, 25%, 50%, 75%, 90%). For example, at the 25% probability level there is a one in four chance that Sockeye returns will be at or below the forecasted value, given that survival is within the range implied by the particular forecast model being used. Based on the assumption of 'Long-Term Average Productivity', there is a one in ten chance (10% probability) the Fraser Sockeye return will be at or below 1.7 million, and a nine in ten chance (90% probability) it will be at or below 15.1 million (Figure 2; Table 1). The mid-point of this distribution (50% probability level) is 4.6 million (one in two chance the return will be above or below this value assuming long-term average stock productivity). Productivities associated with these forecasts are presented in Table 2, and age-4 & age-5 components of these forecasts are presented in Table 3. Based on the assumption of 'Recent Productivity', there is a one in ten chance (10% probability) the return will be at or below 1.0 million, and a nine in ten chance (90% probability) it will be at or below 12.1 million (Figure 2; Table 4). The mid-point of this distribution (50% probability level) is 3.2 million (one in two chance the return will be above or below this value assuming recent stock productivity). Productivities associated with these forecasts are presented in Table 5, and age-4 & age-5 components of these forecasts are presented in Table 6.

Age-5 returns contribute greater than average proportions (age-5 Sockeye contribute on average 20% to total returns) to the total forecasts for both the 'Long-Term Average Productivity' (Table 3) and 'Recent Productivity' (Table 6) scenarios, ranging from 35% to 50%, depending on the stock. Higher age-5 proportions are attributed to the higher escapements observed for a number of stocks in the 2006 brood year (which contributes age-5 returns in 2011) compared to the 2007 brood year (which contributes age-4 returns in 2011). In addition, for the 'Long-Term Average Productivity' scenario, Scotch, Seymour and Late Shuswap age-5 returns were forecast using preliminary 2006 brood year productivities (which were above average) and 2006 cycle-line age-5 proportions. For the 'Recent Productivity' scenario, Early Stuart, Bowron, Scotch, Seymour, Chilko, Late Stuart, Late Shuswap and Portage age-5 returns were forecast using preliminary 2006 brood year productivities (which were average relative to the recent low productivites used to forecast age-4 returns in 2011 for these stocks). These changes to the age-5 forecast methods were made following CSAS Salmon Subcommittee recommendations and, given time constraints, were only made to the final total forecasts presented in Tables 1 & 4. As a result, final scenario forecasts (Tables 1 & 4) differ from the top ranked model forecast tables (respectively, Tables 7 & 8).

INDIVIDUAL STOCK FORECASTS

Early Stuart Run

The 2007 brood year is one of the three 'off cycle' years for the Early Stuart run, with 2005 being the dominant cycle. The 2007 escapement of 2,400 EFS for Early Stuart was less than 10% of the cycle average of 28,600 EFS (time-series: 1951-2003) (Tables 1 & 4, column C), and is the lowest EFS escapement on record for this cycle since 1963.

Physical conditions (water levels and temperature) on the Early Stuart spawning grounds were conducive to successful spawning despite higher than average water levels during the 2007 spawning season. Spawning success averaged 86% for the Early Stuart populations, falling below both the long-term cycle average (90%) and the brood year average (97%). However, the 2007 estimate may be biased low due to limited access to carcasses for the determination of spawning success in the mid to later portion of the spawning season. Juvenile fry data, used as an index of juvenile abundance, indicate that early freshwater survival in the 2007 brood year (500 fry/EFS) was below the cycle average (800 fry/EFS from brood years 1990-2006).

Average productivity (age-4 R/EFS) for Early Stuart has declined steadily since the mid-1960's (Grant et al. 2010). In both the last four (2001-2004; 2.4 R/EFS) and last eight brood years (1997-2004; 2.5 R/EFS) (Tables 2 & 5, columns E & D), average productivity for 4-year old fish has been approximately one quarter of the early time series average (brood years 1948-1979; 9.5 R/EFS) (Tables 2 & 5, column B).

The first-ranked model (Ricker-Pi), based on the full retrospective analysis for Early Stuart (Appendix 1), was used to generate the **'Long-Term Average Productivity'** 2011 return forecast for this stock (Tables 1 & 7). All three top-ranked models (Ricker-Pi, power & Ricker-PDO) produced similar forecasts, varying at most by 28% (calculated as the percent difference between the largest and smallest forecast at the 50% probability level) (Table 7). Under the assumption that long-term average productivity will persist through to the 2011 returns, this forecast ranges from 21,000 (3.8 age-4 R/EFS) to 100,000 (23.8 age-4 R/EFS) Sockeye at the 10% to 90% probability levels (Tables 1 & 2). The median (50% probability) forecast of 47,000 Sockeye (9.2 R/EFS) falls below (27% of) the long-term (1955-2007) cycle average return (172,000) (Tables 1 & 2).

The first-ranked model (RS4yr), based on the truncated (1997-2004 brood years) retrospective analysis for Early Stuart (Appendix 5 in Grant et al. 2010), was used to generate the '**Recent Productivity**' 2011 age-4 recruitment forecast for this stock (Tables 4 & 8). All top-ranked models (RS4yr, RS8yr, KF & RS2) produced similar forecasts, varying at most by 36% (calculated as the percent difference between the largest and smallest forecast at the 50% probability level) (Table 8). The age-5 recruitment forecast was estimated using the preliminary 2006 brood year productivity for Early Stuart. Under the assumption that the recent average productivity will persist through to the 2011 returns, this forecast ranges from 6,000 (0.8 AGE-4 R/EFS) to 42,000 (6.3 age-4 R/EFS) Sockeye at the 10% to 90% probability levels (Tables 4 & 5). The median (50% probability level) forecast of 17,000 Sockeye (2.5 age-4 R/EFS) falls below (10% of) the long-term (1955-2007) cycle average return (172,000) (Tables 4 & 5).

Given that productivity has systematically declined for the Early Stuart stock since the 1960's (Figure 3A in Grant et al. 2010), and has been particularly low in recent years (brood years 1997-2004), the 'Recent Productivity' median (50% probability) forecast is only ~36% of the 'Long-Term Average Productivity' median forecast. In addition, since the below-average brood year EFS was used as a predictor variable in the selected models for both productivity scenarios, the resulting forecasts are both below the cycle average return.

Early Summer Run

The Early Summer Run consists of a number of small stocks relative to the more abundant Summer and Late Run stocks. Eight stocks in this timing group have individual forecasts: Bowron, Fennell, Gates, Nadina, Pitt, Raft, Scotch, and Seymour (Tables 1 & 4). Escapement for all of these stocks combined was 48,700 EFS in 2007, which was below the long term cycle average of 59,400 EFS. Four of the eight Early Summer stocks had brood year escapements (EFS) that were close to, or above, their cycle averages (Fennell, Pitt, Raft, Scotch), while the remaining four were below average (Bowron, Gates, Nadina, Seymour). The total EFS for the Early Summer Run, including the miscellaneous stocks (miscellaneous South Thompson, miscellaneous North Thompson, North Thompson River, Dolly Varden/Chilliwack Lake, and Nahatlatch) was 66,700.

Physical conditions (water levels and temperature) throughout the Early Summer Run aggregate spawning grounds were conducive to spawning in the 2007 brood year. Sockeye were reported to be in good condition upon their arrival to the spawning grounds, with no evidence of migration difficulties. Spawning success ranged from 76% to 100% across the Early Summer Run stocks and the average spawning success (97.4%) was above the long-term average of 91%. The upper Pitt stock, which has predominantly age-5 returns, experienced 99% spawning success during the 2006 brood year, despite near record lows in water levels during the spawning period.

Bowron

The 2007 brood year escapement for Bowron (1,100 EFS) was much lower than the long term cycle average of 9,100 EFS (1951-2003) (Tables 1 & 4, column C). In recent brood years (2001-2004), average productivity (2.1 age-4 R/EFS) has been about 25% of the early time series average prior to 1980 (brood years 1948-1979: 9.0 age-4 R/EFS) (Tables 2 & 5, columns E & B).

The first-ranked model (Ricker-PDO), based on the full retrospective analysis for Bowron (Appendix 1), was used to generate the **'Long-Term Average Productivity'** 2011 return forecast for this stock (Tables 1 & 7). The three top-ranked models (Ricker-PDO, Ricker-Pi & power) produced similar forecasts, varying at most by 15% (calculated as the percent difference between the largest and smallest forecast at the 50% probability level) (Table 7). Under the assumption that long-term average productivity will persist through to the 2011 returns, this forecast ranges from 5,000 (2.7 age-4 R/EFS) to 33,000 (28.2 age-4 R/EFS) Sockeye at the 10% to 90% probability levels (Tables 1 & 2). The median (50% probability) forecast of 12,000 (9.1 age-4 R/EFS) Sockeye falls below (15% of) the long-term (1955-2007) cycle average return (79,000) (Tables 1 & 2).

The first-ranked model (RS4yr), based on the truncated (1997-2004 brood years) retrospective analysis for Bowron (Appendix 5 in Grant et al. 2010), was used to generate the '**Recent Productivity**' 2011 age-4 recruitment forecast for this stock (Tables 4 & 8). The top-ranked models (RS4yr & KF) produced somewhat similar forecasts, varying by 49% (calculated as the percent difference between the largest and smallest forecast at the 50% probability level) (Table 8). The age-5 recruitment forecast was estimated using the preliminary 2006 brood year productivity for Bowron. Under the assumption that the recent average productivity will persist through to 2011 returns, the forecast ranges from 2,000 (0.9 age-4 R/EFS) to 22,000 (7.3 age-4 R/EFS) Sockeye at the 10% and 90% probability levels (Tables 4 & 5). The median (50% probability level) forecast of 5,000 Sockeye (1.8 age-4 R/EFS) falls below (6% of) the long-term (1955-2007) cycle average return (79,000) (Tables 4 & 5).

Given that productivity has systematically declined for the Bowron stock since the 1960's (Figure 3B in Grant et al. 2010), and has been particularly low in recent years (brood years 1997-2004), the 'Recent Productivity' forecast is only ~42% of the 'Long-Term Average Productivity' median (50% probability) forecast. In addition, since the below-average brood year EFS was used as a predictor variable in the selected models for both productivity scenarios, the resulting forecasts are both below the cycle average return.

Fennell

The 2007 brood year escapement for Fennell (6,800 EFS) was greater than the cycle average (4,900 EFS) from 1967-2003 (Tables 1 & 4, column C). Although productivity for Fennell has systematically declined since the mid-1970's, productivity in the last four (4.3 age-4 R/EFS) to eight (4.0 age-4 R/EFS) brood years is close to average for this stock (Tables 2 & 5, columns E, D, & C).

The second-ranked model (TSA), based on the full retrospective analysis for Fennell (Appendix 1), was used to generate the **'Long-Term Average Productivity'** 2011 return forecast for this stock (Tables 1 & 7). The first-ranked model (Ricker-Pi) produced a forecast that is roughly three times greater than those produced by the other top-ranked models (TSA & RAC) and the biological models (Ricker, power and Larkin), therefore the second-ranked (TSA) model was used to generate the forecast. The TSA, RAC and the lower-ranked biological models produced similar forecasts, varying at most by 50% (calculated as the percent difference between the largest and smallest forecast at the 50% probability level) (Table 7). Under the assumption that long-term average productivity will persist through to the 2011 returns, this forecast ranges from 7,000 (0.6 age-4 R/EFS) to 84,000 (10.3 age-4 R/EFS) Sockeye at the 10% to 90% probability levels (Tables 1 & 2). The median (50% probability) forecast of 25,000 (2.6 age-4 R/EFS) Sockeye is close to the long-term (1975-2007) cycle average return (33,000) (Tables 1 & 2).

The first-ranked model (power), based on the truncated (1997-2004 brood years) retrospective analysis for Fennell (Appendix 5 in Grant et al. 2010), was used to generate the '**Recent Productivity**' 2011 return forecast for this stock (Tables 4 & 8). All top-ranked models (power, RAC & TSA) produced similar forecasts, varying at most by 29% (calculated as the percent difference between the largest and smallest forecast at the 50% probability level) (Table 8). The 'Recent Productivity' forecast ranges from 14,000 (1.0 age-4 R/EFS) to 93,000 (11.5 age-4 R/EFS) Sockeye at the 10% and 90% probability levels (Tables 4 & 5). The median (50% probability level) forecast of 35,000 Sockeye (3.2 age-4 R/EFS) is close to the long-term (1975-2007) cycle average return (33,000) (Tables 4 & 5).

Although productivity has systematically declined for the Fennell stock since the mid-1970s (Figure 3C in Grant et al. 2010), in recent years productivity (brood years 1997-2004) has been average. As a result, the first-ranked model for the 'Recent Productivity' forecast (power) does not exclusively incorporate recent productivity and, therefore, the forecasts for both the 'Recent Productivity' and 'Long-Term Average Productivity' scenarios are similar. In addition, given that the brood year EFS for Fennell is used as a predictor variable in the selected models for both productivity scenarios, and this brood year EFS fell within the average range, the resulting forecasts are both close to the cycle average return.

Gates

The 2007 brood year escapement for Gates (1,100 EFS) was less than the cycle average (2,900 EFS) from 1971-2003 (Tables 1 & 4, column C). In recent years (brood years 2001-2004), average productivity (4.9 age-4 R/EFS) has been 25% of the early time series average prior to 1980 (brood years 1968-1979: 17.0 age-4 R/EFS) (Tables 2 & 5, columns E & B). Juvenile fry data, used as an index of juvenile abundance, indicate that early freshwater survival in the brood year (1,400 fry/EFS) was close to the cycle average (1,600 fry/EFS).

The first-ranked model (power), based on the full retrospective analysis for Gates (Appendix 1), was used to generate the **'Long-Term Average Productivity'** 2011 return forecast for this stock (Tables 1 & 7). The three top-ranked models (power, RAC & R2C models) produced similar forecasts, varying at most by 19% (calculated as the percent difference between the largest and smallest forecast at the 50% probability level) (Table 7). Under the assumption that long-term average productivity will persist through to the 2011 returns, this forecast ranges from 7,000 (3.6 age-4 R/EFS) to 47,000 (38.2 age-4 R/EFS) Sockeye at the 10% to 90% probability levels (Tables 1 & 2). The median (50% probability) forecast of 17,000 (12.7 age-4 R/EFS) Sockeye is below (71% of) the long-term (1975-2007) cycle average return (24,000) (Tables 1 & 2).

The first-ranked model (KF), based on the truncated (1997-2004 brood years) retrospective analysis for Gates (Appendix 5 in Grant et al. 2010), was used to generate the '**Recent Productivity**' 2011 return forecast for this stock (Tables 4 & 8). All top-ranked models (KF, RS8yr & RS4yr) produced similar forecasts, varying at most by 23% (calculated as the percent difference between the largest and smallest forecast at the 50% probability level) (Table 8). Under the assumption that recent average productivity will persist through to the 2011 returns, this forecast ranges from 2,000 (1.8 age-4 R/EFS) to 30,000 (18.2 age-4 R/EFS) Sockeye at the 10% and 90% probability levels (Tables 4 & 5). The median (50% probability level) forecast of 8,000 Sockeye (5.5 age-4 R/EFS) is below (33% of) the long-term (1975-2007) cycle average return (24,000) (Tables 4 & 5).

Given that productivity has systematically declined for the Gates stock since the late-1960's (Figure 3D in Grant et al. 2010), and has been particularly low in recent years (brood years 2001-2004), the 'Recent Productivity' forecast is only ~50% of the 'Long-Term Average Productivity' median (50% probability) forecast. In addition, given that the below-average brood year EFS for Gates is used as a predictor variable in the top-ranked models for both productivity scenarios, both resulting forecasts are below the cycle average return.

<u>Nadina</u>

The 2007 brood year escapement for Nadina (1,000 EFS) was less than one tenth of the cycle average (13,500 EFS) from 1975-2003 (Tables 1 & 4, column C). Juvenile fry data, used as an index of juvenile abundance, indicate that early freshwater survival in the brood year (1,300 fry/EFS) was slightly above the cycle average (1,000 fry/EFS). Although productivity has systematically declined for Nadina since the mid-1960's, average total productivity in the last four brood years (4.6 age-4 R/EFS) has been closer to average (Tables 2 & 5, columns E & C).

The first-ranked model (power (juv)-Ei), based on the full retrospective analysis for Nadina (Appendix 1), was used to generate the **'Long-Term Average Productivity'** 2011 return forecast for this stock (Tables 1 & 7). The three top-ranked models (power (juv)-Ei, Ricker-Pi & power (juv)-FrDpeak) produced similar forecasts, varying at most by 27% (calculated as the percent difference between the largest and smallest forecast at the 50% probability level) (Table 7). Under the assumption that long-term average productivity will persist through to the 2011 returns, this forecast ranges from 6,000 (2.0 age-4 R/EFS) to 42,000 (21.0 age-4 R/EFS) Sockeye at the 10% to 90% probability levels (Tables 1 & 2). The median (50% probability) forecast of 15,000 (6.0 age-4 R/EFS) Sockeye is below (17% of) the long-term (1979-2007) cycle average return (87,000) (Tables 1 & 2).

The first-ranked model (Ricker-FrDmean), based on the truncated (1997-2004 brood years) retrospective analysis for Nadina (Appendix 5 in Grant et al. 2010), was used to generate the '**Recent Productivity**' 2011 return forecast for this stock (Tables 4 & 8). All top-ranked models (Ricker-FrDmean, Ricker-Ei & Ricker) produced similar forecasts, varying at most by 11% (calculated as the percent difference between the largest and smallest forecast at the 50% probability level) (Table 8). The 'Recent Productivity' forecast ranges from 4,000 (2.0 age-4 R/EFS) to 37,000 (22.0 age-4 R/EFS) returns at the 10% to 90% probability levels (Tables 4 & 5). The median (50% probability) forecast of 12,000 (6.0 age-4 R/EFS) Sockeye is below (14% of) the long-term (1979-2007) cycle average return (87,000) (Tables 4 & 5).

Although productivity has systematically declined for the Nadina stock since the mid-1970's (Figure 3E in Grant et al. 2010), the last four brood years fell within an average productivity range for this stock. As a result, the top-ranked models for the 'Recent Productivity' forecast scenario do not explicitly incorporate changes in productivity, and their forecasts do not differ significantly from the

‘Long-Term Average Productivity’ forecasts. In addition, given that the below-average brood year EFS for Nadina was used as a predictor variable in both productivity scenarios, both forecasts are below the cycle average.

Pitt

The brood year escapements for Pitt in 2006 (for age-5 Sockeye returning in 2011: 21,300 EFS) and 2007 (for age-4 Sockeye returning in 2011: 19,900 EFS) were above the average escapement from 1948-2009 (13,500 EFS) (Tables 1 & 4, columns D & C). Pitt has a greater proportion of age-5 recruits (~70%) relative to age-4 recruits, and as a result, escapements are compared to the entire time series instead of the cycle average, which is used for stocks that are comprised predominantly of age-4 returns. Pitt productivity was above average prior to 1980 (brood year average from 1948-1979: 2.6 age-4 R/EFS) and has subsequently declined (1980-2004 brood year average: 0.6 age-4 R/EFS) (Tables 2 & 5, columns B & C). Productivity has been particularly low in the last four (0.1 age-4 R/EFS) to eight brood years (0.4 age-4 R/EFS) relative to this earlier period (Tables 2 & 5, columns E & D), and has coincided with above average escapements.

The first-ranked model (Ricker-Pi), based on the full retrospective analysis for Pitt (Appendix 1), was used to generate the **‘Long-Term Average Productivity’** 2011 return forecast for this stock (Tables 1 & 7). This model produced a forecast that is similar to the Ricker-PDO model but almost four times greater than the third-ranked Larkin model (Table 7). Under the assumption that long-term average productivity will persist through to the 2011 returns, this forecast ranges from 41,000 (0.9 age-4 R/EFS) to 372,000 (2.9 age-4 R/EFS) Sockeye at the 10% to 90% probability levels (Tables 1 & 2). The median (50% probability) forecast of 118,000 (1.7 age-4 R/EFS) Sockeye is above (1.6 times greater than) the long-term (1953-2007) average return (72,000) (Tables 1 & 2).

The first-ranked model (Ricker), based on the truncated (1997-2004 brood years) retrospective analysis for Pitt (Appendix 5 in Grant et al. 2010), was used to generate the ‘**Recent Productivity**’ 2011 return forecast for this stock (Tables 4 & 8). All four top-ranked models (Ricker, Ricker-Pi & Ricker-FrDpeak, power) produced similar forecasts, varying at most by 47% (calculated as the percent difference between the largest and smallest forecast at the 50% probability level) (Table 8). The ‘Recent Productivity’ forecast ranges from 32,000 (0.7 age-4 R/EFS) to 236,000 (1.3 age-4 R/EFS) Sockeye at the 10% to 90% probability levels (Tables 4 & 5). The median (50% probability) forecast of 82,000 (1.2 age-4 R/EFS) Sockeye is slightly greater than the long-term (1953-2007) average return (72,000) (Tables 4 & 5).

Productivity for Pitt Sockeye has systematically oscillated from periods of low to high productivity throughout the time series (Figure 3F in Grant et al. 2010). As a result, the top-ranked models for the ‘Recent Productivity’ forecast scenario do not explicitly incorporate changes in productivity, and their forecasts do not differ significantly from the ‘Long-Term Average Productivity’ forecasts. In addition, since the brood year EFS abundance in Pitt was above average, both productivity scenarios produced above average return forecasts.

Raft

The 2007 brood year escapement for Raft (8,100 EFS) was almost four times greater than the cycle average (2,100 EFS) from 1951-2003 (Tables 1 & 4, column C). Productivity is variable throughout the time series and has exhibited no systematic trends (Tables 2 & 5, columns B to E).

The first-ranked model (power), based on the full retrospective analysis for Raft (Appendix 1), was used to generate the **‘Long-Term Average Productivity’** 2011 return forecast for this stock (Tables 1 & 7). This model produced a forecast that is similar to the Ricker model forecast (tied for second-ranked) and the lower-ranked Larkin model forecast (Table 7). Under the assumption that long-term average productivity will persist through to the 2011 returns, this forecast ranges from 19,000 (1.1

age-4 R/EFS) to 104,000 (11.4 age-4 R/EFS) Sockeye at the 10% to 90% probability levels (Tables 1 & 2). The median (50% probability) forecast of 44,000 (3.6 age-4 R/EFS) Sockeye is double the long-term (1955-2007) cycle average return (21,000) (Tables 1 & 2).

The first-ranked model (Ricker-PDO), based on the truncated (1997-2004 brood years) retrospective analysis for Raft (Appendix 5 in Grant et al. 2010), was used to generate the '**Recent Productivity**' 2011 return forecast for this stock (Tables 4 & 8). Two of the three top-ranked models (Ricker-PDO and Ricker-Pi) produced similar forecasts, varying at most by 4% (calculated as the percent difference between the largest and smallest forecast at the 50% probability level). The Ricker-cyc model forecast (third-ranked model) is 46% lower (Table 8). The 'Recent Productivity' forecast ranges from 29,000 (2.0 age-4 R/EFS) to 171,000 (19.9 age-4 R/EFS) Sockeye at the 10% to 90% probability levels (Tables 4 & 5). The median (50% probability) forecast of 68,000 (6.5 age-4 R/EFS) Sockeye is triple the long-term (1955-2007) cycle average return (21,000) (Tables 4 & 5).

Given that productivity has not declined for Raft Sockeye (Figure 3G in Grant et al. 2010), the differences between the 'Long-Term Average Productivity' and 'Recent Productivity' forecasts were attributed to differences in model form between the top-ranked models (power vs. Ricker-PDO). Neither model specifically incorporates recent productivity into their forecast. In addition, since the Raft brood year EFS was above average, both productivity scenarios produced above cycle average return forecasts.

Scotch

The 2007 brood year escapement for Scotch (4,800 EFS) was above the cycle average (3,000 EFS) (Table 1 & 4, column C) from 1983-2003. The brood year escapement for Scotch Sockeye returning as age-5 returns in 2011 (2006 brood year) was the highest observed on record (72,700 EFS) (Table 1 & 4, column D). Recent brood year productivities (6.3 age-4 R/EFS from brood years 1997-2004) are similar to the long-term average (6.7 age-4 R/EFS from brood years 1980-2004) (Tables 2 & 5, columns C & D).

The second-ranked model (Ricker-PDO), based on the full retrospective analysis for Scotch (Appendix 1), was used to generate the **'Long-Term Average Productivity'** 2011 age-4 recruitment forecast for this stock (Tables 1 & 7). The age-5 recruitment forecast was estimated using the preliminary 2006 brood year productivity and the 2006 cycle line age-5 proportion for Scotch. Under the assumption that average productivity will persist through to the 2011 returns, this forecast ranges from 13,000 (1.7 age-4 R/EFS) to 274,000 (18.3 age-4 R/EFS) Sockeye at the 10% to 90% probability levels (Tables 1 & 2). The median (50% probability) forecast of 57,000 (5.4 age-4 R/EFS) is triple the long-term (1987-2003) cycle average return (19,000) (Tables 1 & 2).

The first-ranked model (KF), based on the truncated (1997-2004 brood years) retrospective analysis for Scotch (Appendix 5 in Grant et al. 2010), was used to generate the '**Recent Productivity**' 2011 age-4 recruitment forecast for this stock (Tables 4 & 8). Three of the four top-ranked models (KF, Ricker-PDO & RS4yr) produced relatively similar forecasts, while the remaining model (RS1) generated a higher forecast. The age-5 recruitment forecast was estimated using the preliminary 2006 brood year productivity and the 2006 cycle line age-5 proportion for Scotch. Under the assumption that recent average productivity will persist through to the 2011 returns, this forecast ranges from 14,000 (1.0 age-4 R/EFS) to 465,000 (29.0 age-4 R/EFS) Sockeye at the 10% to 90% probability levels (Tables 4 & 5). The median (50% probability) forecast of 80,000 (5.6 age-4 R/EFS) Sockeye is four times the long-term (1987-2007) cycle average return (19,000) (Tables 4 & 5).

Productivity has been variable for Scotch since 1980, with productivity in the last four to eight brood years being close to average (Tables 2 & 5, columns E, D & C). As a result, returns for both productivity scenarios were similar. Brood year EFS (2007) abundance for age-4 Sockeye returning in

2011 was above average, and brood year EFS (2006) abundance for age-5 Sockeye returning in 2011 was the highest EFS observed on record for this stock. As a result, both the 'Long-Term Average Productivity' and 'Recent Productivity' forecasts are above the cycle average.

Seymour

The 2007 brood year escapement for Seymour (5,900 EFS) was less than one third of the cycle average (20,600 EFS) from 1951-2003 (Tables 1 & 4, column C). Productivity has been variable throughout the time series for this stock, with a general declining trend from the earlier time series (1948-1979 average age-4 R/EFS: 10.9) to the more recent period (1980-2004 average: 5.1 age-4 R/EFS) (Tables 2 & 5, columns B & C). Productivity has been particularly low in the past four brood years (2001-2004 average: 3.8 age-4 R/EFS) (Tables 2 & 5, column E).

The first-ranked model (power), based on the full retrospective analysis for Seymour (Appendix 1), was used to generate the **'Long-Term Average Productivity'** 2011 age-4 recruitment forecast for this stock (Tables 1 & 7). The power model produced a forecast that is similar to the second-ranked model (Larkin) and lower-ranked Ricker model forecasts, but half that of the third-ranked model (RAC) forecast. The RAC model forecast is lower than all other top-ranked forecasts, because this non-parametric model does not incorporate Seymour's below-average brood year EFS as a predictor variable in the forecast (Table 7). The age-5 recruitment forecast was estimated using the preliminary 2006 brood year productivity and the 2006 cycle line age-5 proportion for Seymour. Under the assumption that long-term average productivity will persist through to the 2011 returns, this forecast ranges from 17,000 (2.2 age-4 R/EFS) to 245,000 (24.7 age-4 R/EFS) Sockeye at the 10% to 90% probability levels (Tables 1 & 2). The median (50% probability) forecast of 66,000 (7.8 age-4 R/EFS) is 40% of the long-term (1955-2007) cycle average return (163,000) (Tables 1 & 2).

The first-ranked model (RS4yr), based on the truncated (1997-2004 brood years) retrospective analysis for Seymour (Appendix 5 in Grant et al. 2010), was used to generate the '**Recent Productivity**' 2011 age-4 recruitment forecast for this stock (Tables 4 & 8). The first-ranked model forecast was half that of the second-ranked (RS2) and third-ranked model (MRS) forecasts. The RS2 model includes the relatively high (compared to the cycle average) brood year productivity from 1999 (18 R/EFS) in its forecast calculation, and the MRS model uses the time series average, whereas the first-ranked (RS4yr) model considers only the last four years of productivity, during which productivity has been half of the time series average. The top-ranked model (RS4yr) produced a similar forecast to the KF model, which also considers recent productivity in its forecast (Table 8). The age-5 recruitment forecast was estimated using the preliminary 2006 brood year productivity and the 2006 cycle line age-5 proportion for Seymour. Under the assumption that recent average productivity will persist through to the 2011 returns, this forecast ranges from 10,000 (1.0 age-4 R/EFS) to 178,000 (13.4 age-4 R/EFS) Sockeye at the 10% to 90% probability levels (Tables 4 & 5). The median (50% probability) forecast of 42,000 (3.7 age-4 R/EFS) Sockeye is 26% of the long-term (1955-2007) cycle average return (163,000) (Tables 4 & 5).

Productivity has systematically declined for Seymour Sockeye (see Figure 3I in Grant et al. 2010), therefore, the 'Recent Productivity' forecasted abundance is 64% of the 'Long-Term Productivity' forecasts. In addition, given that the brood year EFS abundance for Seymour was below average, both the 'Long-Term Average Productivity' and 'Recent Productivity' forecasts are below the cycle average.

Summer Run

The Summer Run consists of four stocks: Chilko, Late Stuart, Quesnel and Stellako (Tables 1 & 4). Escapement in the 2007 brood year for these four stocks (214,000 EFS) was below the long-term cycle average (317,000 EFS). Chilko comprised the largest percentage of this total escapement (73%), followed by Quesnel (16%), Stellako (9%), and Late Stuart (2%). Sockeye were reported to be in good condition upon their arrival on the spawning grounds. Spawning success across stocks (average: 97%) was above the cycle average (95%).

Chilko

The 2007 brood year escapement for Chilko (157,000 EFS) was 70% of the cycle average (220,000 EFS) from 1951-2003. Juvenile (smolt) abundance in the 2007 brood year (27.5 million age-1 smolts) was greater than the long-term (brood years 1951-2003) cycle average (19.9 million age-1 smolts) (Tables 1 & 4, column C), but was similar to the recent (brood years 1983-2003) cycle average (27.4 million smolts). Smolt abundance in the previous (2006) brood year, for the age-5 Sockeye returning in 2011, was amongst the highest on record at 71 million. Smolt body sizes in the 2006 (81.9 mm) and 2007 (83.0 mm) brood years have been close, or identical, to the long-term (brood years 1952-2007) average (83.0 mm).

Marine survival for Chilko has been particularly low in the last four to eight brood years (3% marine survival) relative to the post-1980 (brood years 1980-2004) and the long term (brood years 1949-2004) averages (Figure 1, Tables 2 & 5, columns D & C). Marine survival for Chilko observed in the 2009 returns was the lowest on record, coinciding with an unprecedented number of Chilko smolts in the 2005 brood year (77 million age-1 smolts).

The first-ranked model (power (juv)), based on the full retrospective analysis for Chilko (Appendix 1), was used to generate the **'Long-Term Average Productivity'** 2011 return forecast for this stock (Tables 1 & 7). The power (juv) model produced a forecast that is similar to all other top-ranked models (Ricker-Ei & Ricker-FrD-peak), varying at most by 17% (calculated as the percent difference between the largest and smallest forecast at the 50% probability level) (Table 7). Under the assumption that long-term average productivity will persist through to the 2011 returns, this forecast ranges from 809,000 (2% R/J) to 4,296,000 (14% R/J) Sockeye at the 10% to 90% probability levels (Tables 1 & 2). The median (50% probability) forecast of 1,733,000 (5% R/J) is above the long-term (1955-2007) cycle average return (1,556,000) (Tables 1 & 2).

The first-ranked model (RJ4yr), based on the truncated (1997-2004 brood years) retrospective analysis for Chilko (Appendix 5 in Grant et al. 2010), was used to generate the '**Recent Productivity**' 2011 age-4 recruitment forecast for this stock (Tables 4 & 8). The top-ranked models (RJ4yr & RJ8yr) produced similar forecasts, varying by 16% (calculated as the percent difference between the largest and smallest forecast at the 50% probability level) (Table 8). The age-5 recruitment forecast was estimated using the preliminary 2006 brood year productivity for Chilko. Under the assumption that recent average productivity will persist through to the 2011 returns, this forecast ranges from 513,000 (1% R/J) to 2,548,000 (6% R/J) Sockeye at the 10% to 90% probability levels (Tables 4 & 5). The median (50% probability) forecast of 1,141,000 (3% R/J) Sockeye is 73% of the long-term (1955-2007) cycle average return (1,556,000) (Tables 4 & 5).

Given that marine survival has systematically declined for Chilko since the late-1980s (Figure 3J in Grant et al. 2010), and has been particularly low in recent years (brood years 1997-2004), the 'Recent Productivity' forecast is ~66% the size of the 'Long-Term Average Productivity' median (50% probability) forecast. The 'Long-Term Average Productivity' scenario produced an above average forecast given that smolt abundances in the brood year were above average, and this forecast did not incorporate recent low productivity in its calculation.

Late Stuart

The 2007 brood year escapement for Late Stuart (4,100 EFS) was less than half of the cycle average (10,600 EFS) from 1951-2003 (Tables 1 & 4, column C), though it fell within 0.5 standard deviations from the average. The 2007 brood year is the second of three weaker cycles for this stock following the dominant cycle in 2005. Productivity was variable throughout the time series up to 1979 (average:

11.3 age-4 R/EFS) (Tables 2 & 5, column B), and has declined in recent years (1997-2004 average productivity: 2.7 age-4 R/EFS) (Tables 2 & 5, column D).

One of the two models that tied for third-ranked (power), based on the full retrospective analysis for Late Stuart (Appendix 1), was used to generate the **'Long-Term Average Productivity'** 2011 return forecast for this stock (Tables 1 & 7). Both third-ranked models (power & Ricker-cyc) produced similar forecasts, varying by 41% (calculated as the percent difference between the largest and smallest forecast at the 50% probability level) (Table 7). The top two ranked models were not selected as they are recent productivity models. Under the assumption that long-term average productivity will persist through to the 2011 returns, this forecast ranges from 24,000 (3.2 age-4 R/EFS) to 312,000 (65.6 age-4 R/EFS) Sockeye at the 10% to 90% probability levels (Tables 1 & 2). The median (50% probability) forecast of 82,000 (14.6 age-4 R/EFS) is nearly equal to the long-term (1955-2003) cycle average return (86,000) (Tables 1 & 2).

The third-ranked model (RS8yr), based on the truncated (1997-2004 brood years) retrospective analysis for Late Stuart (Appendix 5 in Grant et al. 2010), was used to generate the '**Recent Productivity**' 2011 age-4 recruitment forecast for this stock (Tables 4 & 8). The first-ranked model (LLY) was not available at the time of forecast. The age-5 recruitment forecast was estimated using the preliminary 2006 brood year productivity for Late Stuart. Under the assumption that recent average productivity will persist through to the 2011 returns, this forecast ranges from 5,000 (0.5 age-4 R/EFS) to 331,000 (18.3 age-4 R/EFS) Sockeye at the 10% to 90% probability levels (Tables 4 & 5). The median (50% probability) forecast of 41,000 (2.7 age-4 R/EFS) Sockeye is 48% of the long-term (1955-2007) cycle average return (86,000) (Tables 4 & 5).

Productivity has systematically declined for the Late Stuart stock since the late-1980s (Figure 3K in Grant et al. 2010), and has been particularly low in recent years (brood years 1997-2004). As a result, the 'Recent Productivity' forecast is 50% of the 'Long-Term Average Productivity' median (50% probability) forecast. The 'Recent Productivity' scenario forecast, in particular, falls below the cycle return average for this stock.

<u>Quesnel</u>

The 2007 brood year escapement for Quesnel (33,800 EFS) was greater than the cycle average (29,300 EFS) from 1951-2003 (Tables 1 & 4, column C). This brood year is the first weaker cycle following the dominant 2005 and sub-dominant 2006 brood year cycles. Fry assessments were not conducted for Quesnel in the 2007 brood year. Total 2011 cycle-line productivity for Quesnel has declined in the past eight brood years (1997-2004 brood years: 1.8 age-4 R/EFS) relative to the 1980-2004 brood year average (5.1 age-4 R/EFS) and the long term average (1948-1980 brood years: 15.1 age-4 R/EFS) (Tables 2 & 5, columns D & C).

All three top-ranked models (R1C, R2C & RAC) for the **'Long-Term Average Productivity'** forecast scenario (Table 7), ranked by the full retrospective analysis (Appendix 1), are non-parametric models that use previous returns to predict future returns. The resulting forecasts produced by these models vary significantly (by up to 75%, calculated as the percentage of the largest forecast at the 50% probability level), which can be attributed to variable but higher returns in recent years (R1C & R2C) relative to the time series average (RAC) (Table 7). The forth-ranked model (RS1) uses the below-average productivity of the previous cycle year in its forecast calculation, therefore, this forecast is particularly low relative to the top-ranked (non-parametric) models and other lower-ranked biological model forecasts. Since the higher ranked R1C, R2C & RS1 models were not selected as they are recent productivity models. All biological models that were compared produced similar forecasts. Given the variable returns and below-average productivity seen in Quesnel in recent years, the first-ranked biological model (Ricker-cyc) was used to generate the 2011 'Long-Term Average' return forecast. Under the assumption that long-term average productivity will persist through to the 2011 returns, Quesnel has a 10% probability of returning below 121,000 (2.3 age-4 R/EFS) and a 90%

probability of returning below 980,000 (27.6 age-4 R/EFS). The median (50% probability) forecast of 299,000 (7.6 age-4 R/EFS) is almost double the cycle average return (153,000).

The first-ranked model (RAC), based on the truncated (1997-2004 brood years) retrospective analysis for Quesnel (Appendix 5 in Grant et al. 2010), was used to generate the '**Recent Productivity**' 2011 return forecast for this stock (Tables 4 & 8). The Larkin model (ranked second) had the highest forecast of all models, while the third-ranked model (R1C) forecast was similar to the first-ranked. The truncated power and Ricker models, both of which only consider productivity post-1990, produced similar forecasts to the first-ranked model, while the KF, RS4yr and RS8yr models, which focus on very recent productivity, produced lower forecasts (Table 8). The RAC model forecast ranges from 50,000 (0.3 age-4 R/EFS) to 1,673,000 (40.9 age-4 R/EFS) Sockeye at the 10% and 90% probability levels. The median (50% probability) 'Recent Productivity' forecast for Quesnel of 239,000 (3.9 age-4 R/EFS) Sockeye is ~1.5 times the size of the cycle average (153,000).

Although productivity has systematically declined for Quesnel since the 1980s (Figure 3L in Grant et al. 2010), and has been particularly low in recent years (brood years 1997-2004), the 'Recent Productivity' forecast is ~80% of the 'Long-Term Average Productivity' median (50% probability) forecast. Since brood year EFS is above average, the 'Long-Term Average Productivity' median forecast is above average.

<u>Stellako</u>

The 2007 brood year escapement for Stellako (19,600 EFS) was below the cycle average (57,300 EFS) from 1951-2003 (Tables 1 & 4, column C). Stellako productivity has declined in recent years (average of 1997-2004 brood years: 2.5 age-4 R/EFS) relative to the productivity of earlier years (average of 1948-1979 brood years: 10.1 age-4 R/EFS) (Tables 2 & 5, columns D & B). In the last four brood years (2001-2004) Stellako has experienced particularly low productivity (average: 1.9 age-4 R/EFS) (Tables 2 & 5, column E).

The third-ranked model (Ricker-PDO), based on the full retrospective analysis for Stellako (Appendix 1), was used to generate the **'Long-Term Average Productivity'** 2011 return forecast for this stock (Tables 1 & 7). The first-ranked model (TSA) was not selected because it does not incorporate the below-average brood year escapement into its forecast. The second ranked model was not selected as it was a recent productivity model. The Ricker-PDO model produced a forecast that is similar to the lower-ranked Ricker, power and Larkin biological models (Table 7). Under the assumption that long-term average productivity will persist through to the 2011 returns, this forecast ranges from 113,000 (1.5 age-4 R/EFS) to 991,000 (29.4 age-4 R/EFS) Sockeye at the 10% to 90% probability levels (Tables 1 & 2). The median (50% probability) forecast of 350,000 (8.0 age-4 R/EFS) is 60% of the long-term (1955-2007) cycle average return (594,000) (Tables 1 & 2).

The first-ranked model (RS4yr), based on the truncated (1997-2004 brood years) retrospective analysis for Stellako (Appendix 5 in Grant et al. 2010), was used to generate the '**Recent Productivity**' 2011 return forecast for this stock (Tables 4 & 8). The RS4yr forecast fell between the second (R1C) and third-ranked (KF) model forecasts (Table 8). Under the assumption that recent average productivity will persist through to the 2011 returns, this forecast ranges from 22,000 (0.5 age-4 R/EFS) to 283,000 (6.5 age-4 R/EFS) Sockeye at the 10% to 90% probability levels (Tables 4 & 5). The median (50% probability) forecast of 79,000 (1.8 age-4 R/EFS) Sockeye is 13% of the long-term (1955-2007) cycle average return (594,000) (Tables 4 & 5).

Given that productivity has systematically declined for the Stellako stock since the late-1980s (Figure 3M in Grant et al. 2010), and has been particularly low in recent years (brood years 1997-2004), the 'Recent Productivity' forecast is only ~23% of the 'Long-Term Average Productivity' median (50%

probability) forecast. In addition, given that the brood year escapement for Stellako was below average, forecasts for both productivity scenarios are below average.

Late Run

The Late Run consists of six stocks: Cultus, Harrison, Late Shuswap, Portage, Weaver, and Birkenhead (Tables 1 & 4). Escapement of the Late Run stocks in the 2007 brood year was 161,000 EFS (excluding Cultus), which was well below the cycle average of 258,000 EFS (Tables 1 & 4). Harrison Sockeye EFS in the 2007 (57,400 EFS) brood year was above the historical time series average; however the 2008 brood year (4,400 EFS) (Harrison is comprised of age-4 (4_1) and age-3 (3_1) Sockeye) was below historical escapements. The miscellaneous Late Run stocks (Harrison Lake rearing) brood year EFS was 3,000 (Tables 1 & 4).

Early arrival of Late Run stocks was not observed on the terminal spawning grounds of most stocks in 2007; however, elevated levels of en-route and pre-spawn mortality, previously associated with this behavior, were observed in several stocks (Cultus, Birkenhead, Weaver, Late Shuswap). Despite higher than average water levels in several areas of the spawning grounds during the Late Run spawning period in 2007, conditions appeared conducive to spawning. Late Run spawning success in 2007 averaged at 95%, surpassing the 1987-2003 cycle average of 92% (this average includes the 75% spawning success rate recorded in 1999; one of the lowest on record). Cultus Sockeye exhibited early migration, as it has since the mid-1990's, and spawning success (47%) was below the 1987-2003 cycle average (69%). Conditions in the Harrison system in 2008 (age 3 (3_1) returns) were similar to 2007, with elevated levels of pre-spawn mortality; however spawning success in this system was 100%.

Cultus

Although Cultus escapement was particularly low in the 2007 brood year (442 effective total spawners (ETS)) relative to the cycle average (1927-2003 brood year average: 24,000), hatchery supplementation of both fry into Cultus Lake and smolts into Sweltzer Creek (downstream of Cultus Lake) has increased the number of outmigrating smolts since the program commenced in the 2000 brood year. However, despite hatchery supplementation, the number of smolts in the 2007 brood year (341,000; of which 80% were hatchery origin) was much lower than the long-term cycle average (1.2 million) (Tables 1 & 4). Marine survival for Cultus has been particularly low in the last eight brood years (2% marine survival), relative to the 1980-2004 average (4%) (Figure 1, Tables 2 & 5, columns D & C). Preliminary jack returns (age-3 recruits) for the 2007 brood year (2010 returns: 628) were high relative to the time series average. For comparison, both smolt and jack abundances from the 2007 brood year were similar to those of the 2006 brood year, which produced approximately 16,000 age-4 returns in 2010 (based on preliminary return data at the time of publication).

The first-ranked model (power (juv)-FrDpeak), based on the full retrospective analysis for Cultus (Appendix 1), was used to generate the **'Long-Term Average Productivity'** 2011 return forecast for this stock (Tables 1 & 7). All three top-ranked models (power(juv)-FrD-peak, Smolt-Jack model using full marine survival time series from 1951-2004, & power(juv)-PDO) produced similar forecasts, varying by 29% (calculated as the percent difference between the largest and smallest forecast at the 50% probability level) (Table 7). Under the assumption that long-term average productivity will persist through to the 2011 returns, this forecast ranges from 5,000 (1% R/J) to 60,000 (15% R/J) Sockeye at the 10% to 90% probability levels (Tables 1 & 2). The median (50% probability) forecast of 15,000 (4% R/J) is 17% of the long-term (1955-2007) cycle average return (86,000) (Tables 1 & 2).

The Smolt-Jack model with a truncated marine survival time series (1999-2004) was used to generate the 2011 '**Recent Productivity**' forecast for Cultus, similar to the 2010 forecast (Table 8). All three top-ranked model forecasts (Smolt-Jack (trunc), KF(smolt) & power(juv)-FrDpeak) were similar, varying at most by 25% (calculated as the percent difference between the largest and smallest forecast at the 50% probability level). Under the assumption that recent productivity will persist through to the 2011 returns, this forecast ranges from 4,000 (1% R/J) to 17,000 (4% R/J) Sockeye at the 10% to 90% probability levels (Tables 4 & 5). The median (50% probability) forecast of 9,000 (2% R/J) Sockeye is 10% of the long-term (1955-2007) cycle average return (86,000) (Tables 4 & 5).

Given that productivity has systematically declined for the Cultus stock since the late-1980s, and has been particularly low in recent years (brood years 1997-2004), the 'Recent Productivity' forecast is only ~60% of the 'Long-Term Average Productivity' median (50% probability) forecast. In addition, given that the Cultus brood year smolt abundance is below average, both productivity scenarios produced below average forecasts.

<u>Harrison</u>

Escapement of the Harrison stock was 57,400 EFS in the 2007 brood year (age-4 recruits in 2011) and 4,400 EFS in the 2008 brood year (age-3 recruits in 2011), respectively falling above and below the long term time series average (1948-2009 average: 13,500 EFS). Escapements for Harrison Sockeye are compared to the entire time series instead of the cycle average, which is used for stocks that are comprised predominantly of age-4 returns (Tables 1 & 4, columns C & D). Harrison Sockeye have a unique life history in that they do not rear in lakes for one to two years after gravel emergence, but instead migrate to the ocean as fry sometime after gravel emergence. Additionally, their proportional age-at-return as 4_1 or 3_1 fish varies inter-annually (4_1 proportions range from 10% to 90% of the total returns). In contrast to most other Fraser Sockeye stocks, productivity for Harrison has generally increased, from the early time-series average of 2.3 age-4 R/EFS (1948-1979) to an average of 16.1 age-4 R/EFS in the last 8 brood years (1997-2004) (Tables 2 & 5, column B & D), with the exception of the 2005 brood year, which exhibited the lowest productivity on record for this stock (Grant et al. 2010).

Harrison Sockeye have been extremely challenging to forecast in recent years, given the large increases in escapements and variable recent productivity. Historically (up to the 2004 brood year), average escapements were 7,000 EFS, average productivity was 15 age-4 R/EFS, and this stock exhibited density dependence at high spawner abundances. However, for the 2004 brood year, productivity increased to a time series maximum of 140 age-4 R/EFS (140,000 recruits divided by 1,000 spawners), and subsequently declined for the 2005 brood year to a minimum of 0.07 age-4 R/EFS (14,000 recruits divided by 200,000 spawners). The most recent brood year productivity (2006) was average (15 recruits per EFS) despite a well above-average brood year escapement (90,000), which would be expected to result in lower productivity due to density-dependence (based on historical data). Age proportions are also extremely variable throughout the time series, with age-4 proportions varying from 3% to 98%, and higher age-4 proportions occurring in odd versus even years. Due to this variability in age proportions, sibling relationships that use age-3 Harrison Sockeye recruits to predict age-4 recruits are extremely weak. Therefore, despite the large return of age-3's in 2010 (257,000), this information was not used to forecast age-4 returns in 2011.

The first-ranked model (Ricker-FrDpeak), based on the full retrospective analysis for Harrison (Appendix 1), was used to generate the **'Long-Term Average Productivity'** 2011 return forecast for this stock (Tables 1 & 7). The second and third-ranked models (Ricker-FrDmean & Ricker-Pi) produced very similar forecasts to each other, varying by 0% at the 50% probability level (calculated as the percent difference between the largest and smallest forecast). However, the first-ranked model forecast differed from these lower-ranked models, varying by 76% at the 50% probability level (Table 7). Under the assumption that long-term average productivity will persist through to the 2011 returns, this forecast ranges from 37,000 to 2,637,000 Sockeye at the 10% to 90% probability levels (Tables 1 & 2). The median (50% probability) forecast of 380,000 is 6.3 times greater than the long-term (1953-2009) average return (60,000) (Tables 1 & 2).

The first-ranked model (Ricker-FrDmean), based on the truncated (1997-2004 brood years) retrospective analysis for Harrison (Appendix 5 in Grant et al. 2010), was used to generate the '**Recent Productivity**' 2011 return forecast for this stock (Tables 4 & 8). This forecast differs from both the second (Ricker-FrDpeak) and third-ranked (KF) model forecasts, producing a higher forecast, that varies by as much as 73% from these lower-ranked model forecasts (calculated as the percent difference between the largest and smallest forecast at the 50% probability level). The 'Recent Productivity' forecast ranges from 37,000 to 2,630,000 Sockeye at the 10% to 90% probability levels (Tables 4 & 5). The median (50% probability) forecast of 372,000 Sockeye is 6.2 times greater than the long-term (1953-2009) average return (60,000) (Tables 4 & 5).

As a result of high inter-annual variability in the age-4 to age-3 proportions, the Harrison forecast is more uncertain than stocks with more consistent age proportions (most stocks are consistently comprised of ~95% age-4 fish). Even with consideration for the higher age-4 proportion in odd (Pink) brood years, age-proportions can still vary considerably across years. Uncertainty in Harrison forecasts is further increased by enumeration methods. Despite the large brood year escapement observed on this system in 2007, escapement enumeration was conducted with a relatively low precision visual survey (helicopter) method. Since productivity has increased for Harrison Sockeye in recent years, and brood year escapements have fallen both above (2007 brood year) and below average (2008 brood year), both productivity scenarios produced well above average forecasts. The difference between the productivity scenario forecasts was attributed to the structure of their top-ranked models (Ricker-FrDpeak vs. Ricker-FrDmean).

<u>Late Shuswap</u>

The 2007 brood year escapement for Late Shuswap (32,300 EFS) was less than one fifth of the cycle average (191,400 EFS) from 1951-2003 (Tables 1 & 4, column C). The 2006 brood year EFS (dominant cycle for this highly cyclic stock) was very high (1.2 million EFS) relative to the 2007 brood year. Fry assessments were not conducted for Late Shuswap in the 2007 brood year. Average productivity on the 2011 cycle has dropped in recent years, relative to the pre-1980 reference period (1948-1979 average: 8.1 age-4 R/EFS), to 4.1 age-4 R/EFS (1997-2004 brood years) (Tables 2 & 5, columns C, D & E).

The first-ranked model (Larkin), based on the full retrospective analysis for Late Shuswap (Appendix 1), was used to generate the **'Long-Term Average Productivity'** 2011 age-4 recruitment forecast for this stock (Tables 1 & 7). Three of the four top-ranked models (Larkin, Ricker & Ricker-FrDpeak) produced similar forecasts, varying by 9% (calculated as the percent difference between the largest and smallest forecast at the 50% probability level). The remaining third-ranked model (R1C) produced a much lower forecast, as the previous return on this cycle was very low compared to the cycle average (Table 7). The age-5 recruitment forecast was estimated using the preliminary 2006 brood year productivity and the 2006 cycle line age-5 proportion for Late Shuswap. Under the assumption that long-term average productivity will persist through to the 2011 returns, this forecast ranges from 43,000 (0.7 /EFS) to 1,192,000 (17.9 age-4 R/EFS) Sockeye at the 10% to 90% probability levels (Tables 1 & 2). The median (50% probability) forecast of 251,000 (4.4 age-4 R/EFS) is 18% of the long-term (1955-2007) cycle average return (1,427,000) (Tables 1 & 2).

The second-ranked model (Ricker-Pi), based on the truncated (1997-2004 brood years) retrospective analysis for Late Shuswap (Appendix 5 in Grant et al. 2010), was used to generate the '**Recent Productivity**' 2011 age-4 recruitment forecast for this stock (Tables 4 & 8). This forecast is larger than the other top-ranked models (Ricker-cyc & Ricker-Ei), and those that consider recent productivity (KF & RS4yr) (Table 8). The Ricker-cyc forecast produces a lower forecast compared to total forecasts produced for other biological models (not presented in Table 8), as the age-5 proportion on the 2006 cycle (used to estimate age-5 recruits from the 2006 brood year for the Ricker-cyc model) is extremely low (~1%), therefore contributing a small number of age-5 recruits to this forecast despite the large 2006 brood year escapement. The age-5 recruitment forecast was estimated using the preliminary 2006 brood year productivity and the 2006 cycle line age-5 proportion for Late Shuswap. The 'Recent Productivity' forecast ranges from 60,000 (1.3 age-4 R/EFS) to 1,555,000 (29.2 age-4 R/EFS) Sockeye at the 10% to 90% probability levels (Tables 4 & 5). The median (50% probability) forecast of 355,000 (7.6 age-4 R/EFS) Sockeye is 25% of the long-term (1955-2007) cycle average return (1,427,000) (Tables 4 & 5).

Although productivity for Late Shuswap Sockeye (Figure 3O in Grant et al. 2010) has been below average in recent years, overall productivity for this stock has not systematically declined. Therefore, the 'Recent Productivity' forecast is larger (by a factor of 1.4) than the 'Long-Term Average Productivity' forecast. However, since the Late Shuswap brood year EFS was below average, both productivity scenarios produced below-cycle-average return forecasts.

<u>Portage</u>

The 2007 brood year escapement for Portage (800 EFS) was less than half of the cycle average (2,500 EFS) from 1955-2003 (Tables 1 & 4, column C). Productivity was particularly high in the first part of the time series with an average of 20.9 age-4 R/EFS over the brood years 1953-1979 (Tables 2 & 5, column B). Subsequently, between 1980 and 2004, productivity has been consistently lower (average of 8.8 age-4 R/EFS) (Tables 2 & 5, column C). The most recent four brood years (2001-2004) had particularly low productivity for this stock (5.1 age-4 R/EFS) (Tables 2 & 5, column E).

The first-ranked model (power), based on the full retrospective analysis for Portage (Appendix 1), was used to generate the **'Long-Term Average Productivity'** 2011 return forecast for this stock (Tables 1 & 7). All three top-ranked model (power, Ricker & Ricker-FrDpeak) forecasts were similar, varying by 14% (calculated as the percent difference between the largest and smallest forecast at the 50% probability level) (Table 7). Under the assumption that long-term average productivity will persist through to the 2011 returns, this forecast ranges from 4,000 (3.8 age-4 R/EFS) to 68,000 (66.3 age-4 R/EFS) Sockeye at the 10% to 90% probability levels (Tables 1 & 2). The median (50% probability) forecast of 19,000 (16.3 age-4 R/EFS) is 70% of the long-term (1959-2007) cycle average return (27,000) (Tables 1 & 2).

The second-ranked model (KF), based on the truncated (1997-2004 brood years) retrospective analysis for Portage (Appendix 5 in Grant et al. 2010), was used to generate the '**Recent Productivity**' 2011 age-4 recruitment forecast for this stock (Tables 4 & 8). The first-ranked (LLY) model forecast could not be generated, since data for 2010 were not available at the time of this forecast. The second (KF) and third-ranked (Ricker-FrDmean) models produced very similar forecasts, varying by 0% at the 50% probability level (calculated as the percent difference between the largest and smallest forecast) (Table 8). The age-5 recruitment forecast was estimated using the preliminary 2006 brood year productivity for Portage. Under the assumption that recent average productivity will persist through to the 2011 returns, this forecast ranges from 4,000 (2.5 age-4 R/EFS) to 98,000 (60.0 age-4 R/EFS) Sockeye at the 10% to 90% probability levels (Tables 4 & 5). The median (50% probability) forecast of 21,000 (12.5 age-4 R/EFS) Sockeye is 78% of the long-term (1959-2007) cycle average return (27,000) (Tables 4 & 5).

Despite systematic declines in productivity since the 1960's, and particularly low productivity seen in Portage in recent years, the 'Recent Productivity' forecast for this stock is slightly larger than the 'Long-Term Average Productivity' forecast. This difference is attributed to differences in model forms, and differences in the approach used to estimate the age-5 forecasts in the two forecast scenarios. In addition, the below-average brood year EFS for Portage was used as a predictor variable in both the 'Long-Term Average Productivity' and 'Recent Productivity' scenarios, producing forecasts that are both below cycle average.

Weaver

The 2007 brood year escapement for Weaver (15,800 EFS) was close to the cycle average (18,000 EFS) from 1967-2003 (Tables 1 & 4, column C). Juvenile production in the 2007 brood year (1,900 fry/EFS) was greater than the cycle average (1,600 fry/EFS). Productivity has been relatively consistent over the time series (Tables 2 & 5, columns B-E).

The first-ranked model (power(juv)-PDO), based on the full retrospective analysis for Weaver (Appendix 1), was used to generate the **'Long-Term Average Productivity'** 2011 return forecast for this stock (Tables 1 & 7). The power (juv)-PDO forecast is similar to the Ricker-PDO model forecast, both of which use EFS as a predictor variable. However, this model forecast is approximately 1.6 times greater than that of the second-ranked RJC model and other lower-ranked biological models that do not include environmental variables as covariates (Table 7). Under the assumption that long-term average productivity will persist through to the 2011 returns, this forecast ranges from 185,000 (7.7 age-4 R/EFS) to 1,142,000 (66.8 age-4 R/EFS) Sockeye at the 10% to 90% probability levels (Tables 1 & 2). The median (50% probability) forecast of 440,000 (21.0 age-4 R/EFS) is 2.1 times larger than the long-term (1971-2007) cycle average return (209,000) (Tables 1 & 2).

The first-ranked model (Ricker-FrDpeak), based on the truncated (1997-2004 brood years) retrospective analysis for Weaver (Appendix 5 in Grant et al. 2010), was used to generate the '**Recent Productivity**' 2011 return forecast for this stock (Tables 4 & 8). This model produced a forecast that is similar that of the second-ranked (Ricker-FrDmean) model, but half the size of the third-ranked (Ricker-PDO) model forecast (Table 8). The 'Recent Productivity' forecast ranges from 90,000 (2.8 age-4 R/EFS) to 761,000 (42.4 age-4 R/EFS) Sockeye at the 10% to 90% probability levels (Tables 4 & 5). The median (50% probability) forecast of 253,000 (11.4 age-4 R/EFS) Sockeye is 1.2 times larger than the long-term (1971-2007) cycle average return (209,000) (Tables 4 & 5).

Given that productivity has not systematically declined for the Weaver stock (Figure 3Q in Grant et al. 2010), the differences between the 'Long-Term Average Productivity' and 'Recent Productivity' forecasts were attributed to the structure of their top-ranked models (power (juv)-PDO vs. Ricker-FrDmean), neither of which specifically incorporates recent productivity into their forecast. In addition, since the Weaver brood year EFS was average, the 'Recent Productivity' scenario produced an average return forecast. The 'Long-Term Average Productivity' forecast is double the average size, as it is being driven by the environmental variable used as a covariate in the forecast model.

Birkenhead

The 2007 brood year escapement for Birkenhead (54,300 EFS) was similar to the cycle average (43,000 EFS) from 1951-2003 (Tables 1 & 4, column C). Productivity in recent years (1997 to 2004 average: 1.5 age-4 R/EFS) has been relatively low compared to brood years 1948 to 1979 (average of 9.4 age-4 R/EFS) for this stock (Tables 2 & 5, columns B & D).

The first-ranked model (Ricker-PDO), based on the full retrospective analysis for Birkenhead (Appendix 1), was used to generate the **'Long-Term Average Productivity'** 2011 return forecast for this stock (Tables 1 & 7). All top-ranked models (Ricker-PDO, power & Ricker) produced similar forecasts, varying at most by 19% (calculated as the percent difference between the largest and smallest forecast at the 50% probability level) (Table 7). Under the assumption that long-term average productivity will persist through to the 2011 returns, this forecast ranges from 163,000 (0.9 age-4 R/EFS) to 1,410,000 (14.6 age-4 R/EFS) Sockeye at the 10% to 90% probability levels (Tables 1 & 2). The median (50% probability) forecast of 456,000 (3.7 age-4 R/EFS) is 1.2 times greater than the long-term (1955-2007) cycle average return (376,000) (Tables 1 & 2).

The first-ranked model (KF), based on the truncated (1997-2004 brood years) retrospective analysis for Birkenhead (Appendix 5 in Grant et al. 2010), was used to generate the '**Recent Productivity**' 2011 return forecast for this stock (Tables 4 & 8). This model produced a lower forecast than all other top-ranked models (Ricker & RS1), since it incorporates the recent low productivity into the forecast (Table 8). Under the assumption that recent average productivity will persist through to the 2011 returns, this forecast ranges from 59,000 (0.7 age-4 R/EFS) to 551,000 (3.9 age-4 R/EFS) Sockeye at the 10% to 90% probability levels (Tables 4 & 5). The median (50% probability) forecast of 178,000 (1.7 age-4 R/EFS) Sockeye is 47% of the long-term (1955-2007) cycle average return (376,000) (Tables 4 & 5).

Given that productivity has declined for the Birkenhead stock since the late-1980s (Figure 3R in Grant et al. 2010), and has been relatively low in recent years (brood years 1997-2004), the 'Recent Productivity' forecast is only 39% of the 'Long-Term Average Productivity' median (50% probability) forecast.

Pink Salmon

The first-ranked power model with an environmental covariate (specifically, average sea-surface salinity from July to September at the Race Rocks and Amphitrite Point lighthouse stations), ranked by a previously-run retrospective analysis (DFO 2006) was used to generate the 2011 Fraser Pink return forecast. The 2011 Pink forecast ranges from 9.2 million to 37.5 million fish at the 10% to 90% probability levels (Table 1). The median (50% probability) forecast of 17.5 million Pink Salmon is 1.5 times greater than the long-term (1959-2007) cycle average return (11.8 million) (Table 1). This forecast was 34% smaller than that of the power model excluding an environmental covariate (median probability forecast of 26.9 million) (Table 7).

The 2011 Pink forecast is highly uncertain for a number of reasons. First, the estimated brood year (2010) Fraser Pink fry abundance (1 billion) is the largest abundance of outmigrating fry on record (the second highest occurred in 1997 at 697 million fry), and is more than double the long-term (brood years 1961-2007) average of 376 million fry. As a result, the Pink forecast model is extrapolating beyond the range of observed stock-recruitment data when using this record fry abundance as a predictor variable. Second, the 2010 fry estimate was interpolated between the dates of April 23 to May 1 (the interpolation comprised 30% or 296 million of the total estimated abundance), during which the survey vessel was out of commission and four surveys were missed (J.Tadey, DFO, pers. comm.). The gap in the time series occurred during the historical peak migration period and coincided with the 2010 peak observed abundance. The un-interpolated (the period during normal vessel operation) fry abundance was 766 million fry, which alone represents the largest Pink fry abundance observed. Finally, estimation methods for Pink recruitment have changed significantly over the years, and in recent year's recruitment is estimated with lower precision methods (test fisheries), due to the absence of spawning ground enumerations for Pink salmon.

ENVIRONMENTAL CONDITIONS

Fraser Sockeye forecasts are highly uncertain. Understanding the factors that contribute to Fraser Sockeye survival is complex, given their broad distribution in both freshwater and marine environments throughout their life-history (typically two years in freshwater followed by two years in the marine environment). A number of hypotheses that potentially explain the long-term declines in productivity have recently been presented (Peterman et al. 2010), and environmental indictors of Fraser Sockeye survival are the subject of on-going investigation.

In contrast to the situation for Fraser Sockeye salmon, environmental indicator data are routinely incorporated into survival forecasts for juvenile Coho and Chinook Salmon in Oregon and Washington (http://www.nwfsc.noaa.gov/research/divisions/fed/oeip/a-ecinhome.cfm). For these salmon, survival rates are generally higher when the ocean is cool, and lower when the ocean is warm. American researchers use various physical, biological, and oceanographic indicators to predict salmon returns 1-2 years in advance of their return.

In Canada, our understanding of the environmental factors that control salmon survival is less well-developed than in the US Pacific Northwest. For salmon returning to the Fraser River in 2011, marine conditions in 2009 would be expected to most strongly influence returns of Sockeye, while conditions in 2010 would influence 2011 returns of Pink salmon. Several approaches that incorporate environmental indicator data to forecast salmon survival have been documented in recent State of the Pacific Ocean reports (Crawford & Irvine, 2010), and this is an area of active investigation.

DISCUSSION

Fraser Sockeye forecasts in 2011 are associated with relatively high uncertainty, consistent with previous Fraser Sockeye forecasts (Cass et al. 2006; Grant et al. 2010) and recent research conducted on coast-wide salmon stocks (Haeseker et al. 2007 & 2009). Fraser Sockeye forecasts have been especially uncertain in recent years given the decreasing trends in productivity observed for most stocks in recent decades and, in particular, the large variability in annual survival observed in the past few years. Information to predict future Fraser Sockeye survival including environmental indicators and sibling relationships should help to decrease this uncertainty in the forecasts. However, environmental covariates (e.g. sea-surface temperature, Fraser discharge, etc.) currently included within the forecast models do not consistently or significantly improve model performance when compared retrospectively. Efforts are being made to develop a suite of environmental indicators for Fraser Sockeye to assist with future forecasts. Sibling (jack) models provide some information on returning age-4 recruits but these predictions are generally more uncertain than the models currently being used to forecast Fraser Sockeye returns. Sibling (jack) models are also limited by recent smaller stock sizes and the trend towards increased age-at-maturity, which have resulted in smaller numbers of jacks returning for most Fraser Sockeye stocks in any given year.

In the absence of leading quantitative or qualitative indicators of Fraser Sockeye survival, both stochastic (random) uncertainty and uncertainty regarding future survival (productivity) associated with the 2011 Fraser Sockeye forecast are presented in this paper. Uncertainty that is attributed to stochastic (random) variability in annual survival rates is presented through a series of forecasted values that correspond to standardized cumulative probabilities (10%, 25%, 50%, 75%, and 90%). Uncertainty about future Fraser Sockeye survival is presented in two forecast scenarios that vary in their survival assumptions. The 'Long-Term Average Productivity' forecast assumes that long term productivity will persist through to 2011 and ranges from 1,700,000 to 15,056,0000 at the 10% to 90% probability levels. The 'Recent Productivity' forecast evaluates the performance of all models in the recent productivity period, and ranges from 1,006,000 to 12,083,000 at the 10% to 90% probability level. Given the recent low productivity trends and systematic declines in productivity observed for most stocks in recent decades, the 'Recent Productivity' scenario is considered most plausible (CSAP Salmon Sub-Committee recommendation). The 'Long-Term Average Productivity' scenario is considered plausible but less likely.

The smaller total 'Recent Productivity' scenario forecast relative to the 'Long-Term Average Productivity' forecast is attributed to the 11 out of 19 (58%) stocks that were forecast using models that specifically consider recent (generally low) productivity (e.g. RS4yr, RS8yr, KF, or, in the case of Cultus Sockeye, a recent marine survival smolt-jack model) in the 'Recent Productivity' scenario. In contrast, only models that assume long-term average productivity were used for the 'Long-Term Average Productivity' scenario. In addition, since miscellaneous stocks were forecast using the recent (low productivity) time series in the 'Recent Productivity' scenario, these forecasts were also generally lower than in the 'Long-Term Productivity' scenario. However, in the 'Recent Productivity' scenario eight out of the 19 stocks (42%) were not forecast using models that specifically consider recent low productivity. Differences between the scenario forecasts for these stocks were attributed to differences in model form as opposed to differences in productivity considerations. For these eight stocks, long-term models outperformed models that specifically considered recent productivity, even in the most recent low productivity years. Therefore, when interpreting returns in 2011, the model form specific to each stock should be considered when making inferences regarding the productivity associated with stock-specific returns.

For the total 2011 Fraser Sockeye forecasts, age-5 proportions for both forecast scenarios (~30%) were higher than average (~20%), excluding the Harrison Sockeye, which are age-3 and age-4 fish. For individual stocks in the 'Long-Term Average Productivity' scenario, these age-5 proportions range from 14% (Quesnel) to 72% (Pitt). For individual stocks in the 'Recent Productivity' scenario, these age-5 proportions range from 22% (Cultus) to 73% (Late Stuart). Higher age-5 proportions were generally attributed to the combination of higher brood year escapements for age-5 Sockeye in 2006 (compared to age-4 Sockeye brood year escapements in 2007), and the use of the average to above average 2010 age-4 productivities in forecasting the age-5 returns for particular stocks. Though, in the case of Pitt Sockeye, the age-5 proportion is typically higher (70%) compared to all other stocks. Also, Harrison Sockeye were comprised of ~90% age-4 Sockeye for both scenarios, largely attributed to their much larger abundances in the age-4 (2007) versus the age-3 (2008) brood year.

Fraser Pink Salmon have not exhibited similar declines in productivity to Fraser Sockeye. Therefore, only one forecast scenario, based on 'Long-Term Average Productivity', was considered. The Fraser Pink forecast is highly uncertain because predictions were made outside the observed range of data, given the record high fry abundance in 2010. Additional factors also contribute to the increased forecast uncertainty (e.g. absence of spawning ground enumerations for Pink salmon in recent years and interpolation of Pink fry abundance between April 23 – May 1 when the survey vessel was inoperable).

RECOMMENDATIONS

Salmon forecasts remain highly uncertain, in large part due to variability in annual salmon survival rates. Fraser Sockeye survival has been particularly uncertain in recent years, due to the systematic declines in productivity exhibited by most stocks, and the extremely variable productivity of the past two brood years (2005 and 2006 brood years corresponding, respectively, to 2009 and 2010 returns for most Sockeye). In attempts to improve the predictability of Fraser Sockeye survival, return forecasts have incorporated environmental variables, both quantitatively into forecast models (Grant et al. 2010), and qualitatively into forecast advice (DFO 2009). However, to date, the inclusion of environmental variables has not significantly reduced forecast uncertainty (i.e. it has not significantly explained annual survival rates). On-going research and workshops should continue to explore environmental variables that could be used to explain the inter-annual variability in Fraser Sockeye recruitment.

Future forecasts may also benefit from changes to the methods used to rank forecast models. In the current paper, models were ranked using retrospective analysis (Cass et al. 2006; Haseker et al. 2007 & 2009). However, ranking models using retrospective analysis is quite sensitive to the performance measures used, and the time period over which they are evaluated. Alternative methods of ranking forecast models that should be explored include cross validation approaches (Adkison & Peterman 1999), jackknife approaches, or simulation modelling to assess model performance over varying productivity regimes.

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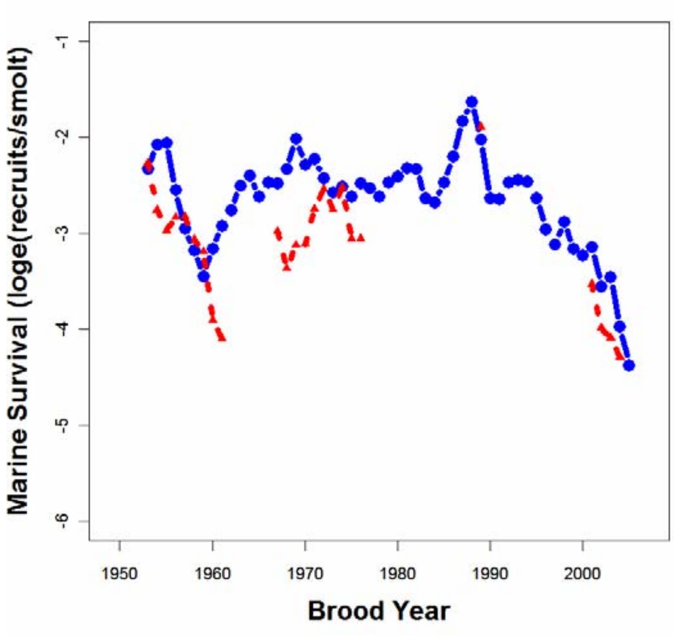

Figure 1. Chilko (blue solid line with circles) & Cultus (red dashed line with triangles) marine survival (log_e recruits/smolt) from the 1951-2005 brood years. Note: the 2004 and 2005 brood year marine survival data include preliminary 2009 and 2010 age-4 and age-5 return data (these years are currently in the process of being finalized). Re-printed from Grant et al. (2010).

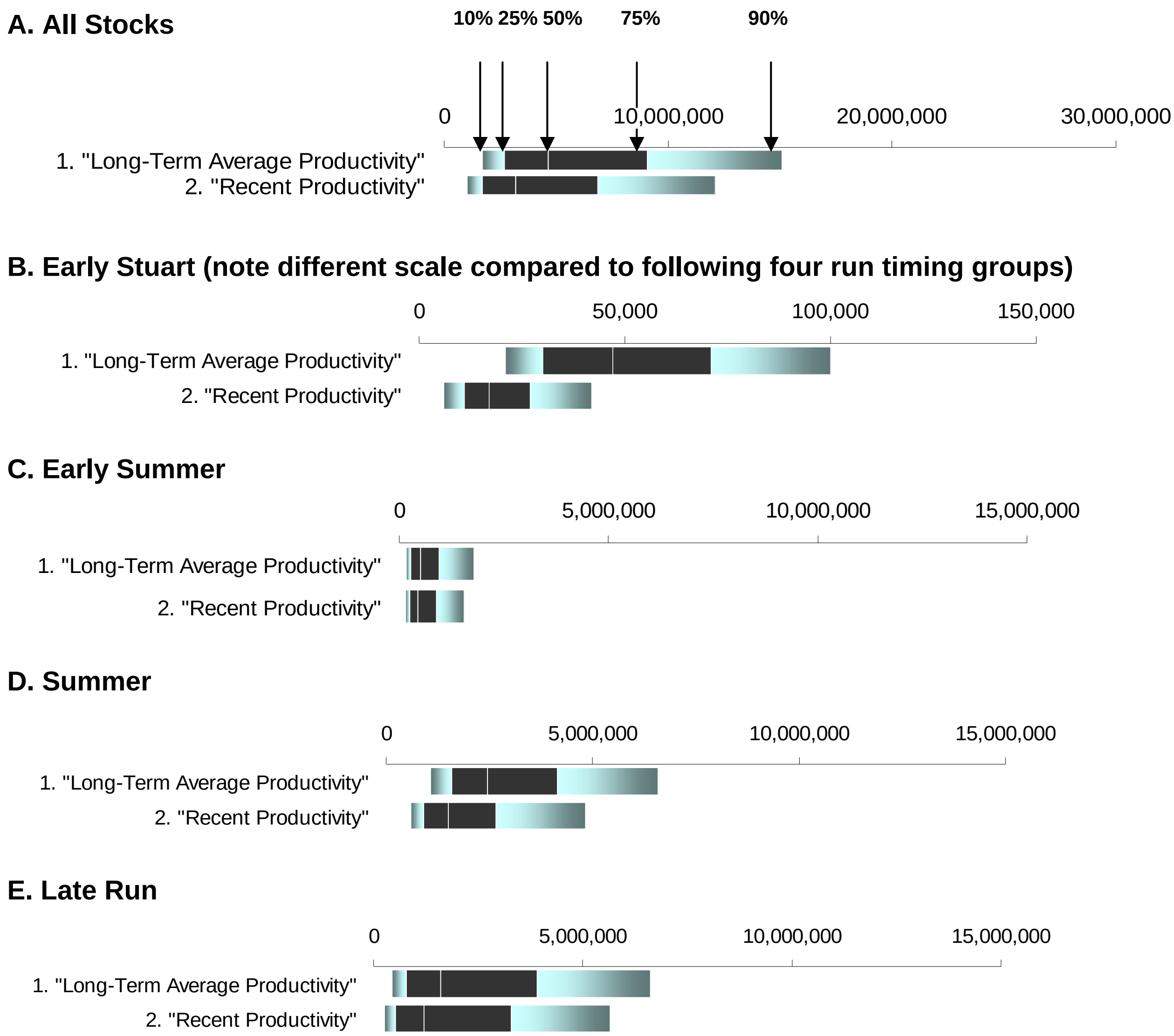

Figure 2. Fraser Sockeye 2011 forecast probability distributions for A. All Stocks; B. Early Stuart; C. Early Summer; D. Summer and E. Late Run timing groups for the two forecast scenarios: 1. 'Long-Term Average Productivity'; 2. 'Recent Productivity'. These figures describe both the stochastic (random) uncertainty in forecasts (probability distributions) and the uncertainty associated with future Fraser Sockeye survival (represented by the two different survival scenarios). Colors on the horizontal bars represent the 10% to 90% probability levels (see first example that links, using arrows, the probability level to the bar color as a key for all subsequent figures).

Table 1. The ***'Long-Term Average Productivity'*** *2011 forecasts (from the 10% to 90% probability levels) are presented by stock and timing group (columns A and J to N). The selected models for these forecasts are presented in column B by stock. Average run sizes are presented across all cycles (H) and for the 2011 cycle (I). Brood year escapements (smolts for Chilko and Cultus) for age-4 (2007) and age-5 (2006) Sockeye returning in 2011 (columns C & D) are presented and colour coded relative to their 1950-2009 cycle average. Forecasted returns (column G) that correspond to the 50% probability level (column L), and productivity in the last eight brood years (column E) and last four brood years (column F) are also colour coded relative to their cycle average. Colour codes represent the following: red (< average), yellow (average) and green (> average).*

A	B	C	D	E	F	G	H	I	J	K	L	M	N
Run timing group		BY (07)	BY (06)	Prod.	Prod.	Ret	Mean Run Size		Probability that Return will be at/or Below Specified Run Size [a]				
Stocks	**Forecast Model [b]**	(EFS)	(EFS)	(-8yr)	(-4yr)	2011	all cycles[c]	2011 cycle[d]	10%	25%	50%	75%	90%
Early Stuart	*Ricker-Pi*	2,400	15,900	2.5	2.4	[red]	311,000	172,000	**21,000**	**30,000**	**47,000**	**71,000**	**100,000**
Early Summer							**510,000**	**497,000**	**164,000**	**284,000**	**518,000**	**958,000**	**1,785,000**
(total excluding miscellaneous)							***510,000***	***497,000***	**115,000**	**194,000**	**354,000**	**650,000**	**1,201,000**
Bowron	*Ricker-PDO*	1,100	600	2.4	2.1	[red]	39,000	79,000	5,000	7,000	12,000	20,000	33,000
Fennell	*TSA*	6,800	8,000	4.0	4.3	[yellow]	25,000	33,000	7,000	13,000	25,000	47,000	84,000
Gates	*Power*	1,100	1,500	5.3	4.9	[red]	53,000	24,000	7,000	10,000	17,000	28,000	47,000
Nadina	*Power(juv)-Ei*	1,000	4,500	3.0	4.6	[red]	80,000	87,000	6,000	9,000	15,000	25,000	42,000
Pitt	*Ricker-Pi*	19,900	21,300	0.4	0.1	[green]	72,000	71,000	41,000	67,000	118,000	197,000	372,000
Raft	*Power*	8,100	3,400	3.7	2.9	[green]	32,000	21,000	19,000	28,000	44,000	69,000	104,000
Scotch	*Ricker-PDO*	4,800	72,700	6.3	5.3	[green]	78,000	19,000	13,000	26,000	57,000	128,000	274,000
Seymour	*Power*	5,900	57,300	5.2	3.8	[red]	131,000	163,000	17,000	34,000	66,000	136,000	245,000
Misc [e]	*RS (Sc/Se)*	4,000	20,000				--	--	11,000	19,000	41,000	64,000	93,000
Misc [f]	*RS (Ra/Fe)*	1,000	3,000				--	--	4,000	6,000	11,000	23,000	46,000
Misc [g]	*RS (Ra/Fe)*	10,000	12,000				--	--	28,000	51,000	87,000	178,000	362,000
Misc [h]	*RS (Esum)*	1,000	1,000				--	--	2,000	5,000	9,000	15,000	29,000
Misc [i]	*RS (Esum)*	2,000	1,000				--	--	4,000	9,000	16,000	28,000	54,000
Summer							**3,730,000**	**2,389,000**	**1,067,000**	**1,598,000**	**2,464,000**	**4,138,000**	**6,579,000**
Chilko [j]	*Power(juv)*	27.5M	71M	0.03	0.03	[yellow]	1,350,000	1,556,000	809,000	1,170,000	1,733,000	2,854,000	4,296,000
Late Stuart	*Power*	4,100	14,300	2.7	2.9	[yellow]	560,000	86,000	24,000	46,000	82,000	161,000	312,000
Quesnel	*Ricker-cyc*	33,800	90,400	1.8	0.8	[yellow]	1,358,000	153,000	121,000	182,000	299,000	552,000	980,000
Stellako	*Ricker-PDO*	19,600	79,800	2.5	1.9	[red]	462,000	594,000	113,000	200,000	350,000	571,000	991,000
Late							**3,020,000**	**2,196,000**	**448,000**	**781,000**	**1,598,000**	**3,907,000**	**6,622,000**
(total exlcuding miscellaneous)							***3,020,000***	***2,196,000***	***437,000***	***760,000***	***1,561,000***	***3,842,000***	***6,509,000***
Cultus [j & k]	*Power(juv)-FrD-peak*	341,000	389,200	0.02	0.02	[red]	39,000	86,000	5,000	8,000	15,000	31,000	60,000
Harrison [l]	*Ricker-FrD (peak)*	57,400	4,400	16.1	19.7	[green]	60,000	71,000	37,000	99,000	380,000	1,660,000	2,637,000
Late Shuswap	*Larkin*	32,300	1.2M	4.1	1.4	[red]	2,152,000	1,427,000	43,000	109,000	251,000	587,000	1,192,000
Portage	*Power*	800	11,000	5.3	5.1	[red]	40,000	27,000	4,000	9,000	19,000	37,000	68,000
Weaver	*Power(juv)-PDO*	15,800	13,600	11.8	6.9	[green]	363,000	209,000	185,000	281,000	440,000	717,000	1,142,000
Birkenhead	*Ricker-PDO*	54,300	137,400	1.5	1.2	[yellow]	366,000	376,000	163,000	254,000	456,000	810,000	1,410,000
Misc. non-Shuswap [m]	*RS (Birkenhead)*	3,000	11,000				--	--	11,000	21,000	37,000	65,000	113,000
TOTAL SOCKEYE SALMON							-	-	**1,700,000**	**2,693,000**	**4,627,000**	**9,074,000**	**15,086,000**
(TOTAL excluding miscellaneous)							***(7,571,000)***	***(5,254,000)***	***(1,640,000)***	***(2,582,000)***	***(4,426,000)***	***(8,701,000)***	***(14,389,000)***
PINK SALMON	*Power-SSS*	**2009 Brood Year Fry** 1 billion					**11,800,000**	**11,800,000**	**9,156,000**	**12,648,000**	**17,495,000**	**25,125,000**	**37,496,000**

a. Probability that return will be at, or below, specified projection.
b. See Table 5 for model descriptions
c. Sockeye: 1953-2009 (depending on start of time series)
d. Sockeye: 1955-2007 (depending on start of time series)
e. Unforecasted miscellaneous Early Summer Stocks (Early Shuwap stocks: S.Thompson; used Scotch/Seymour R/EFS)
f. Unforecasted miscellaneous Early Summer stocks (N. Thomson tributaries; used Raft/Fennell R/EFS).
g. North Thompson River (used Raft/Fennell R/EFS)
h. Chilliwack Lake and Dolly Varden Creek (used Early Summer R/EFS)
i. Nahatlach River & Lake (used Early Summer R/EFS)
j. Brood year smolts in columns C & D (not effective females)
k. For Cultus, this 'Long-Term Average Productivity' smolt-jack forecast uses the full marine survival time series.
l. Harrison are age-4 (column C) and age-3 (column D).
m. Unforecasted miscellaneous Late Run stocks (Harrison Lake down stream migrants including Big Silver, Cogburn, etc.); used Birkenhead R/EFS

Definitions: BY: Brood year; BY05: brood year 2005; BY06: brood year 2006; EFS: effective female spawners; Prod. 8yr, Prod. 4yr, Prod BY05, or Prod BY06: Productivity in $\log_e$ recruits-per-effective females in the last 8 yrs, last 4 yrs, 2005 brood year or 2006 brood year (preliminary data); Pi (Pine Island SST covariate); Ei (Entrance Island SST covariate); FrD (Fraser discharge); PDO (Pacific Decadal Oscillation covariate); R/S (used for stocks with no recruit data: product of R/S for stocks indicated and EFS), SSS (Sea Surface Salinity covariate).

*Table 2. For each of the 19 forecasted stocks (column A), average age-4 productivities (recruits-per-effective female spawner: R/EFS) are presented for the first part of the time series (up to and including 1979) (column B), the last eight brood years (1996-2004) (column D), and the last four brood years (2000-2004) (column E) relative to the average over the 1980-2004 brood years (column C). The age-4 productivities associated with the **'Long-Term Average Productivity'** 2011 forecasts (**based on Table 1 forecasts and escapements)** are presented from the 10% to 90% probability levels in columns (F) to (J). Log_e (R/EFS) was used to determine colour codes for columns (B) to (E) (see methods in Grant et al. 2010), however, productivities in the below table are presented in R/EFS. Colour codes represent the following: Red (< average), yellow (average) and green (> average).*

A	B	C	D	E	F	G	H	I	J
Run timing group / Stocks	**Early Time Series** Avg R/EFS (up to 1979)	**Reference Period** Avg R/EFS (1980-2004)	**Last 8 yrs** Avg R/EFS (1997-2004)	**Last 4 yrs** Avg R/EFS (2001-2004)	**"Long-Term Average" 2011 forecast productivities (R/EFS) for each probability level in Table 3 by stock**				
					10%	**25%**	**50%**	**75%**	**90%**
Early Stuart	9.5	3.9	2.5	2.4	**3.8**	**5.4**	**9.2**	**15.0**	**23.8**
Early Summer									
Bowron	9.0	4.8	2.4	2.1	2.7	4.5	9.1	16.4	28.2
Fennell	20.0	4.2	4.0	4.3	0.6	1.2	2.6	5.4	10.3
Gates	17.0	7.3	5.3	4.9	3.6	7.3	12.7	22.7	38.2
Nadina	10.1	5.3	3.0	4.6	2.0	3.0	6.0	11.0	21.0
Pitt	2.6	0.6	0.4	0.1	0.9	1.2	1.7	2.1	2.9
Raft	7.9	4.5	3.7	2.9	1.1	2.0	3.6	6.5	11.4
Scotch	NA	6.7	6.3	5.3	1.7	2.9	5.4	10.0	18.3
Seymour	10.9	5.1	5.2	3.8	2.2	4.2	7.8	15.3	24.7
Summer									
Chilko[a]	0.08	0.06	0.03	0.03	0.02	0.03	0.05	0.09	0.14
Late Stuart	11.3	7.3	2.7	2.9	3.2	6.3	14.6	31.5	65.6
Quesnel[b]	15.1	5.1	1.8	0.8	2.3	4.0	7.6	15.0	27.6
Stellako	10.1	4.5	2.5	1.9	1.5	3.8	8.0	16.8	29.4
Late									
Cultus[a]	0.05	0.04	0.02	0.02	0.01	0.02	0.04	0.08	0.15
Harrison[c]	2.3	4.9	16.1	19.7	NA	NA	NA	NA	NA
Late Shuswap[b]	8.1	5.2	4.1	1.4	0.7	2.0	4.4	9.8	17.9
Portage	20.9	8.8	5.3	5.1	3.8	6.3	16.3	35.0	66.3
Weaver	15.2	10.2	11.8	6.9	7.7	12.5	21.0	36.9	66.8
Birkenhead	9.4	3.0	1.5	1.2	0.9	1.8	3.7	8.0	14.6

a. Chilko and Cultus are marine survival (recruits per smolt).

b. Quesnel and Late Shuswap are cycle averages.

c. Harrison forecasts cannot be assessed for productivity due to their variable age proportions; making comparisons to columns B to E productivities nc

*Table 3. The **'Long-Term Average Productivity'** 2011 four year old, five year old and total forecasts (from the 10% to 90% probability levels) are presented by stock and timing group.*

Sockeye stock/timing group	FOUR YEAR OLDS Probability that actual return will be at or below specified run size					FIVE YEAR OLDS Probability that actual return will be at or below specified run size					TOTAL Probability that actual return will be at or below specified run size				
	10%	25%	50%	75%	90%	10%	25%	50%	75%	90%	10%	25%	50%	75%	90%
Early Stuart[a]	**9,000**	**13,000**	**22,000**	**36,000**	**57,000**	**12,000**	**17,000**	**25,000**	**35,000**	**43,000**	**21,000**	**30,000**	**47,000**	**71,000**	**100,000**
Early Summer	**96,000**	**168,000**	**302,000**	**544,000**	**959,000**	**67,700**	**116,000**	**216,000**	**414,000**	**826,000**	**164,000**	**284,000**	**518,000**	**958,000**	**1,785,000**
Bowron[a]	3,000	5,000	10,000	18,000	31,000	2,000	2,000	2,000	2,000	2,000	5,000	7,000	12,000	20,000	33,000
Fennell	4,000	8,000	18,000	37,000	70,000	3,000	5,000	7,000	10,000	14,000	7,000	13,000	25,000	47,000	84,000
Gates	4,000	8,000	14,000	25,000	42,000	2,700	2,000	3,000	3,000	5,000	7,000	10,000	17,000	28,000	47,000
Nadina	2,000	3,000	6,000	11,000	21,000	4,000	6,000	9,000	14,000	21,000	6,000	9,000	15,000	25,000	42,000
Pitt	17,000	24,000	33,000	41,000	58,000	24,000	43,000	85,000	156,000	314,000	41,000	67,000	118,000	197,000	372,000
Raft	9,000	16,000	29,000	53,000	92,000	10,000	12,000	15,000	16,000	12,000	19,000	28,000	44,000	69,000	104,000
Scotch[a]	8,000	14,000	26,000	48,000	88,000	5,000	12,000	31,000	80,000	186,000	13,000	26,000	57,000	128,000	274,000
Seymour[a]	13,000	25,000	46,000	90,000	146,000	4,000	9,000	20,000	46,000	99,000	17,000	34,000	66,000	136,000	245,000
Misc[e]	9,000	16,000	35,000	55,000	78,000	2,000	3,000	6,000	9,000	15,000	11,000	19,000	41,000	64,000	93,000
Misc[f]	2,000	3,000	5,000	10,000	20,000	2,000	3,000	6,000	13,000	26,000	4,000	6,000	11,000	23,000	46,000
Misc[g]	19,000	34,000	57,000	117,000	238,000	9,000	17,000	30,000	61,000	124,000	28,000	51,000	87,000	178,000	362,000
Misc[h]	2,000	4,000	8,000	14,000	26,000	0	1,000	1,000	1,000	3,000	2,000	5,000	9,000	15,000	29,000
Misc[i]	4,000	8,000	15,000	25,000	49,000	0	1,000	1,000	3,000	5,000	4,000	9,000	16,000	28,000	54,000
Summer	**682,000**	**1,095,000**	**1,843,000**	**3,336,000**	**5,510,000**	**385,000**	**503,000**	**621,000**	**802,000**	**1,069,000**	**1,067,000**	**1,598,000**	**2,464,000**	**4,138,000**	**6,579,000**
Chilko[a]	563,000	859,000	1,371,000	2,371,000	3,730,000	246,000	311,000	362,000	483,000	566,000	809,000	1,170,000	1,733,000	2,854,000	4,296,000
Late Stuart[a]	13,000	26,000	60,000	129,000	269,000	11,000	20,000	22,000	32,000	43,000	24,000	46,000	82,000	161,000	312,000
Quesnel	77,000	136,000	256,000	506,000	934,000	44,000	46,000	43,000	46,000	46,000	121,000	182,000	299,000	552,000	980,000
Stellako	29,000	74,000	156,000	330,000	577,000	84,000	126,000	194,000	241,000	414,000	113,000	200,000	350,000	571,000	991,000
Late	**225,000**	**455,000**	**1,061,000**	**3,046,000**	**5,192,000**	**223,000**	**326,000**	**537,000**	**861,000**	**1,430,000**	**448,000**	**781,000**	**1,598,000**	**3,907,000**	**6,622,000**
Cultus	4,000	7,000	12,000	27,000	52,000	1,000	1,000	3,000	4,000	8,000	5,000	8,000	15,000	31,000	60,000
Harrison[b]	18,000	72,000	341,000	1,621,000	2,594,000	19,000	27,000	39,000	39,000	43,000	37,000	99,000	380,000	1,660,000	2,637,000
Late Shuswap[a]	24,000	66,000	143,000	317,000	579,000	19,000	43,000	108,000	270,000	613,000	43,000	109,000	251,000	587,000	1,192,000
Portage[a]	3,000	5,000	13,000	28,000	53,000	1,000	4,000	6,000	9,000	15,000	4,000	9,000	19,000	37,000	68,000
Weaver	121,000	197,000	332,000	583,000	1,056,000	64,000	84,000	108,000	134,000	86,000	185,000	281,000	440,000	717,000	1,142,000
Birkenhead	49,000	96,000	199,000	433,000	794,000	114,000	158,000	257,000	377,000	616,000	163,000	254,000	456,000	810,000	1,410,000
Misc. non-Shuswap[l]	6,000	12,000	21,000	37,000	64,000	5,000	9,000	16,000	28,000	49,000	11,000	21,000	37,000	65,000	113,000
Total	**1,012,000**	**1,731,000**	**3,228,000**	**6,962,000**	**11,718,000**	**687,700**	**962,000**	**1,399,000**	**2,112,000**	**3,368,000**	**1,700,000**	**2,693,000**	**4,627,000**	**9,074,000**	**15,086,000**

a. Age-5 forecasts generated using preliminary age-4 productivity from the 2006 brood year (2010 returns)
b. Harrison are age-4 (in four year old columns) and age-3 (in five year old columns) forecasts

Below subscripts line up with same subscripts in Tables 1 & 2

e. Unforecasted mis. Early Summer Stocks (Early Shuwap stocks: S.Thompson); return timing most similar to Scotch/Seymour (Sc/Se)
f. Unforecasted misc. Early Summer stocks (N. Thomson tributaries; return timing most similar to Raft/Fennell (Ra/Fe)).
g. North Thompson River
h. Chilliwack Lake and Dolly Varden Creek (Esum)
i. Nahatlach River & Lake (Esum)
l. Unforecasted miscellaneous Late Run stocks (Harrison L.)

Table 4. The 'Recent Productivity' 2011 forecasts (from the 10% to 90% probability levels) are presented by stock and timing group (columns A and J to N). The selected models for these forecasts are presented in column B by stock. Average run sizes are presented across all cycles (H) and for the 2011 cycle (I). Brood year escapements (smolts for Chilko and Cultus) for age-4 (2007) and age-5 (2006) Sockeye returning in 2011 (columns C & D) are presented and colour coded relative to their 1950-2009 cycle average. Forecasted returns (column G) that correspond to the 50% probability level (column L), and productivity in the last eight brood years (column E) and last four brood years (column F) are also colour coded relative to their cycle average. Colour codes represent the following: Red (< average), yellow (average) and green (> average).

A	B	C	D	E	F	H	I	J	K	L	M	N	O
Run timing group		BY (07)	BY (06)	Prod.	Prod.	Ret	Mean Run Size		Probability that Return will be at/or Below Specified Run Size [a]				
Stocks	Forecast Model [b]	(EFS)	(EFS)	(-8yr)	(-4yr)	2011	all cycles[c]	2011 cycle[d]	10%	25%	50%	75%	90%
Early Stuart	*RS4yr*	2,400	15,900	2.5	2.4		311,000	172,000	**6,000**	**11,000**	**17,000**	**27,000**	**42,000**
Early Summer							**510,000**	**497,000**	**153,000**	**257,000**	**453,000**	**894,000**	**1,558,000**
(total excluding miscellaneous)							***510,000***	***497,000***	**107,000**	**181,000**	**332,000**	**648,000**	**1,232,000**
Bowron	*RS4yr*	1,100	600	2.4	2.1		39,000	79,000	2,000	2,000	5,000	12,000	22,000
Fennell	*Power*	6,800	8,000	4.0	4.3		25,000	33,000	14,000	21,000	35,000	60,000	93,000
Gates	*KF*	1,100	1,500	5.3	4.9		53,000	24,000	2,000	4,000	8,000	16,000	30,000
Nadina	*Ricker-FrD (mean)*	1,000	4,500	3.0	4.6		80,000	87,000	4,000	7,000	12,000	21,000	37,000
Pitt	*Ricker*	19,900	21,300	0.4	0.1		72,000	71,000	32,000	51,000	82,000	140,000	236,000
Raft	*Ricker-PDO*	8,100	3,400	3.7	2.9		32,000	21,000	29,000	44,000	68,000	108,000	171,000
Scotch	*KF*	4,800	72,700	6.3	5.3		78,000	19,000	14,000	32,000	80,000	201,000	465,000
Seymour	*RS4yr*	5,900	57,300	5.2	3.8		131,000	163,000	10,000	20,000	42,000	90,000	178,000
Misc [e]	*RS (Sc/Se)*	4,000	20,000			--	--	--	11,000	23,000	40,000	54,000	77,000
Misc [f]	*RS (Ra/Fe)*	1,000	3,000			--	--	--	3,000	5,000	7,000	17,000	23,000
Misc [g]	*RS (Ra/Fe)*	10,000	12,000			--	--	--	27,000	40,000	57,000	138,000	180,000
Misc [h]	*RS (Esum)*	1,000	1,000			--	--	--	2,000	3,000	6,000	13,000	16,000
Misc [i]	*RS (Esum)*	2,000	1,000			--	--	--	3,000	5,000	11,000	24,000	30,000
Summer							**3,730,000**	**2,389,000**	**590,000**	**903,000**	**1,500,000**	**2,657,000**	**4,835,000**
Chilko [j]	*RJ4yr (smolt)*	27.5M	71M	0.03	0.03		1,350,000	1,556,000	513,000	749,000	1,141,000	1,740,000	2,548,000
Late Stuart	*RS8yr*	4,100	14,300	2.7	2.9		560,000	86,000	5,000	14,000	41,000	123,000	331,000
Quesnel	*RAC*	33,800	90,400	1.8	0.8		1,358,000	153,000	50,000	99,000	239,000	639,000	1,673,000
Stellako	*RS4yr*	19,600	79,800	2.5	1.9		462,000	594,000	22,000	41,000	79,000	155,000	283,000
Late							**3,020,000**	**2,196,000**	**257,000**	**516,000**	**1,207,000**	**3,288,000**	**5,648,000**
(total exlcuding miscellaneous)							***3,020,000***	***2,196,000***	***254,000***	***502,000***	***1,188,000***	***3,261,000***	***5,612,000***
Cultus [j & k]	*Smolt-Jack*	341,000	389,200	0.02	0.02		39,000	86,000	4,000	6,000	9,000	13,000	17,000
Harrison[l]	*Ricker-FrD (mean)*	57,400	4,400	16.1	19.7		60,000	71,000	37,000	96,000	372,000	1,656,000	2,630,000
Late Shuswap	*Ricker-Pi*	32,300	1.2M	4.1	1.4		2,152,000	1,427,000	60,000	152,000	355,000	780,000	1,555,000
Portage	*KF*	800	11,000	5.3	5.1		40,000	27,000	4,000	9,000	21,000	47,000	98,000
Weaver	*Ricker-FrD (peak)*	15,800	13,600	11.8	6.9		363,000	209,000	90,000	143,000	253,000	444,000	761,000
Birkenhead	*KF*	54,300	137,400	1.5	1.2		366,000	376,000	59,000	96,000	178,000	321,000	551,000
Misc. non-Shuswap[m]	*RS (Birkenhead)*	3,000	11,000	--	--	--	--	--	3,000	14,000	19,000	27,000	36,000
TOTAL							-	-	**1,006,000**	**1,687,000**	**3,177,000**	**6,866,000**	**12,083,000**
(TOTAL excluding miscellaneous)							***(7,571,000)***	***(5,254,000)***	***(957,000)***	***(1,597,000)***	***(3,037,000)***	***(6,593,000)***	***(11,721,000)***

a. Probability that return will be at, or below, specified projection.
b. See Table 5 for model descriptions
c. Sockeye: 1953-2009 (depending on start of time series)
d. Sockeye: 1955-2007 (depending on start of time series)
e. Unforecasted miscellaneous Early Summer Stocks (Early Shuwap stocks: S.Thompson; used Scotch/Seymour R/EFS)
f. Unforecasted miscellaneous Early Summer stocks (N. Thomson tributaries; used Raft/Fennell R/EFS).
g. North Thompson River (used Raft/Fennell R/EFS)
h. Chilliwack Lake and Dolly Varden Creek (used Early Summer R/EFS)
i. Nahatlach River & Lake (used Early Summer R/EFS)
j. Brood year smolts in columns C & D (not effective females)
k. For Cultus, this 'Recent Productivity' smolt-jack forecast uses a truncated (brood years 1997-2004) marine survival time series.
l. Harrison are age-4 (column C) and age-3 (column D).
m. Unforecasted miscellaneous Late Run stocks (Harrison Lake down stream migrants including Big Silver, Cogburn, etc.); used Birkenhead R/EF & Weaver age proporitons

Definitions: BY: Brood year; BY07: brood year 2007; BY06: brood year 2006; EFS: effective female spawners; Prod. (8yr), Prod. (4yr): Productivity in recruits-per-effective female spawners in the last 8 yrs or last 4 yrs; Pi (Pine Island sea-surface-temperature covariate); PDO (Pacific Decadal Oscillation covariate); TSA (time series average model); Ei (Entrance Island sea-surface-temperature covariate); R/S (used for stocks with no recruit data--product of R/S for stocks indicated and EFS), cyc (cycle line data only used); FrD-peak (peak Fraser discharge covariate); SSS (sea surface salinity covariate)

Table 5. For each of the 19 forecasted stocks (column A), average age-4 productivities (recruits-per-effective female spawner: R/EFS) are presented for the first part of the time series (up to and including 1979) (column B), the last eight brood years (1996-2004) (column D), and the last four brood years (2000-2004) (column E) relative to the average over the 1980-2004 brood years (column C). Age-4 productivities associated with the 'Recent Productivity' 2011 forecasts (based on Table 4 forecasts and escapements) are presented from the 10% to 90% probability levels in columns (F) to (J). Loge (R/EFS) was used to determine colour codes for columns (B) to (E) (see methods in Grant et al. 2010), however, productivities in the below table are presented in R/EFS. Colour codes represent the following: Red (< average), yellow (average) and green (> average).

A	B	C	D	E	F	G	H	I	J
Run timing group / Stocks	Early Time Series Avg R/EFS (up to 1979)	Ref. Period Avg R/EFS (1980-2004)	Last 8 yrs Avg R/EFS (1997-2004)	Last 4 yrs Avg R/EFS (2001-2004)	"Recent Productivity" 2011 forecast productivities (R/EFS) for each probability level in Table 3 by stock				
					10%	25%	50%	75%	90%
Early Stuart	9.5	3.9	2.5	2.4	**0.8**	**1.7**	**2.5**	**4.2**	**6.3**
Early Summer									
Bowron	9.0	4.8	2.4	2.1	0.9	0.9	1.8	4.5	7.3
Fennell	20.0	4.2	4.0	4.3	1.0	1.9	3.2	6.5	11.5
Gates	17.0	7.3	5.3	4.9	1.8	2.7	5.5	10.9	18.2
Nadina	10.1	5.3	3.0	4.6	2.0	3.0	6.0	11.0	22.0
Pitt	2.6	0.6	0.4	0.1	0.7	1.0	1.2	1.3	1.3
Raft	7.9	4.5	3.7	2.9	2.0	3.7	6.5	11.6	19.9
Scotch	NA	6.7	6.3	5.3	1.0	2.5	5.6	13.3	29.0
Seymour	10.9	5.1	5.2	3.8	1.0	1.9	3.7	7.5	13.4
Summer									
Chilko[a]	0.08	0.06	0.03	0.03	0.01	0.02	0.03	0.04	0.06
Late Stuart	11.3	7.3	2.7	2.9	0.5	1.0	2.7	7.3	18.3
Quesnel[b]	15.1	5.1	1.8	0.8	0.3	1.0	3.9	13.5	40.9
Stellako	10.1	4.5	2.5	1.9	0.5	0.9	1.8	3.6	6.5
Late									
Cultus[a]	0.05	0.04	0.02	0.02	0.01	0.02	0.02	0.03	0.04
Harrison[c]	2.3	4.9	16.1	19.7	NA	NA	NA	NA	NA
Late Shuswap[b]	8.1	5.2	4.1	1.4	1.3	3.4	7.6	15.8	29.2
Portage	20.9	8.8	5.3	5.1	2.5	5.0	12.5	28.8	60.0
Weaver	15.2	10.2	11.8	6.9	2.8	5.4	11.4	22.4	42.4
Birkenhead	9.4	3.0	1.5	1.2	0.7	1.0	1.7	2.6	3.9

a. Chilko and Cultus are marine survival (recruits per smolt).

b. Quesnel and Late Shuswap are cycle averages.

c. Harrison forecasts cannot be assessed for productivity due to their variable age proporitions; making comparisons to columns B to E productivities not valic

Table 6. The ***'Recent Productivity'*** *2011 four year old, five year old and total forecasts (from the 10% to 90% probability levels) are presented by stock and timing group.*

Sockeye stock/timing group	FOUR YEAR OLDS Probability that actual return will be at or below specified run size					FIVE YEAR OLDS Probability that actual return will be at or below specified run size					TOTAL Probability that actual return will be at or below specified run size				
	10%	**25%**	**50%**	**75%**	**90%**	**10%**	**25%**	**50%**	**75%**	**90%**	**10%**	**25%**	**50%**	**75%**	**90%**
Early Stuart[a]	**2,000**	**4,000**	**6,000**	**10,000**	**15,000**	**4,000**	**7,000**	**11,000**	**17,000**	**27,000**	**6,000**	**11,000**	**17,000**	**27,000**	**42,000**
Early Summer	**86,000**	**146,000**	**252,000**	**476,000**	**764,000** 0	**67,300**	**110,900**	**201,000**	**418,000**	**794,000**	**153,000**	**257,000**	**453,000**	**894,000**	**1,558,000**
Bowron[a]	1,000	1,000	2,000	5,000	8,000	1,000	1,000	3,000	7,000	14,000	2,000	2,000	5,000	12,000	22,000
Fennell	7,000	13,000	22,000	44,000	78,000	7,000	8,000	13,000	16,000	15,000	14,000	21,000	35,000	60,000	93,000
Gates	2,000	3,000	6,000	12,000	20,000	0	1,000	2,000	4,000	10,000	2,000	4,000	8,000	16,000	30,000
Nadina	2,000	3,000	6,000	11,000	22,000	2,300	3,900	6,000	10,000	15,000	4,000	7,000	12,000	21,000	37,000
Pitt	13,000	19,000	24,000	26,000	25,000	19,000	32,000	58,000	114,000	211,000	32,000	51,000	82,000	140,000	236,000
Raft	16,000	30,000	53,000	94,000	161,000	13,000	14,000	15,000	14,000	10,000	29,000	44,000	68,000	108,000	171,000
Scotch[a]	5,000	12,000	27,000	64,000	139,000	9,000	20,000	53,000	137,000	326,000	14,000	32,000	80,000	201,000	465,000
Seymour[a]	6,000	11,000	22,000	44,000	79,000	4,000	9,000	20,000	46,000	99,000	10,000	20,000	42,000	90,000	178,000
Misc[e]	9,000	20,000	34,000	45,000	62,000	2,000	3,000	6,000	9,000	15,000	11,000	23,000	40,000	54,000	77,000
Misc[f]	2,000	2,000	3,000	8,000	10,000	1,000	3,000	4,000	9,000	13,000	3,000	5,000	7,000	17,000	23,000
Misc[g]	18,000	26,000	38,000	91,000	119,000	9,000	14,000	19,000	47,000	61,000	27,000	40,000	57,000	138,000	180,000
Misc[h]	2,000	2,000	5,000	11,000	14,000	0	1,000	1,000	2,000	2,000	2,000	3,000	6,000	13,000	16,000
Misc[i]	3,000	4,000	10,000	21,000	27,000	0	1,000	1,000	3,000	3,000	3,000	5,000	11,000	24,000	30,000
Summer	**400,000**	**600,000**	**991,000**	**1,775,000**	**3,338,000**	**190,000**	**303,000**	**509,000**	**882,000**	**1,497,000**	**590,000**	**903,000**	**1,500,000**	**2,657,000**	**4,835,000**
Chilko[a]	378,000	543,000	813,000	1,218,000	1,753,000	135,000	206,000	328,000	522,000	795,000	513,000	749,000	1,141,000	1,740,000	2,548,000
Late Stuart[a]	2,000	4,000	11,000	30,000	75,000	3,000	10,000	30,000	93,000	256,000	5,000	14,000	41,000	123,000	331,000
Quesnel	10,000	35,000	131,000	457,000	1,382,000	40,000	64,000	108,000	182,000	291,000	50,000	99,000	239,000	639,000	1,673,000
Stellako	10,000	18,000	36,000	70,000	128,000	12,000	23,000	43,000	85,000	155,000	22,000	41,000	79,000	155,000	283,000
Late	**150,000**	**335,000**	**887,000**	**2,671,000**	**4,500,000**	**107,000**	**181,000**	**320,000**	**617,000**	**1,148,000**	**257,000**	**516,000**	**1,207,000**	**3,288,000**	**5,648,000**
Cultus	3,000	5,000	7,000	11,000	15,000	1,000	1,000	2,000	2,000	2,000	4,000	6,000	9,000	13,000	17,000
Harrison[b]	18,000	72,000	341,000	1,621,000	2,594,000	19,000	24,000	31,000	35,000	36,000	37,000	96,000	372,000	1,656,000	2,630,000
Late Shuswap[a]	41,000	109,000	247,000	510,000	942,000	19,000	43,000	108,000	270,000	613,000	60,000	152,000	355,000	780,000	1,555,000
Portagea	2,000	4,000	10,000	23,000	48,000	2,000	5,000	11,000	24,000	50,000	4,000	9,000	21,000	47,000	98,000
Weaver	45,000	85,000	180,000	354,000	670,000	45,000	58,000	73,000	90,000	91,000	90,000	143,000	253,000	444,000	761,000
Birkenhead	39,000	53,000	93,000	139,000	213,000	20,000	43,000	85,000	182,000	338,000	59,000	96,000	178,000	321,000	551,000
Misc. non-Shuswap[l]	2,000	7,000	9,000	13,000	18,000	1,000	7,000	10,000	14,000	18,000	3,000	14,000	19,000	27,000	36,000
Total	**638,000**	**1,085,000**	**2,136,000**	**4,932,000**	**8,617,000**	**368,300**	**601,900**	**1,041,000**	**1,934,000**	**3,466,000**	**1,006,000**	**1,687,000**	**3,177,000**	**6,866,000**	**12,083,000**

a. Age-5 forecasts generated using preliminary age-4 productivity from the 2006 brood year (2010 returns)
b. Harrison are age-4 (in four year old columns) and age-3 (in five year old columns) forecasts

Below subscripts line up with same subscripts in Tables 1 & 2

e. Unforecasted mis. Early Summer Stocks (Early Shuwap stocks: S.Thompson); return timing most similar to Scotch/Seymour (Sc/Se)
f. Unforecasted misc. Early Summer stocks (N. Thomson tributaries; return timing most similar to Raft/Fennell (Ra/Fe)).
g. North Thompson River
h. Chilliwack Lake and Dolly Varden Creek (Esum)
i. Nahatlach River & Lake (Esum)
l. Unforecasted miscellaneous Late Run stocks (Harrison L.)

Table 7. All 'Long-Term Average Productivity' forecasts for the top-ranked models. Rows bolded and shaded light grey are the selected forecasts presented in Table 1 for each stock. Rows shaded darker grey are forecasts that were not selected, given that they are generated with models that specifically consider recent productivity (RS1, RS2, R1C, R2C), rather than long-term average productivity (the assumption of the forecasts under this scenario). ****Note: the Scotch, Seymour and Late Shuswap final total forecasts in Table 1 differ from those presented in this table, given that Table 1 age-5 recruitment forecasts are estimated using preliminary 2006 brood year productivity and 2007 cycle age-5 proportions. In this table age-5 recruits are forecast using the specified model and average age-proportions across all cycles.***

	Rank		Return Forecast				
PINK SALMON			**10%**	**25%**	**50%**	**75%**	**90%**
Power (Sea-Surface Salinity)	**1**	**NA**	**9,156,000**	**12,648,000**	**17,495,000**	**25,125,000**	**37,496,000**
Power	2	NA	12,006,000	17,340,000	26,865,000	41,313,000	58,672,000

SOCKEYE SALMON

RUN TIMING GROUP: EARLY STUART	**All**	**MPE**	**Return Forecast**				
EARLY STUART	**(Ranks)**		**10%**	**25%**	**50%**	**75%**	**90%**
Ricker (Pi)	**1**	**3**	**21,000**	**30,000**	**47,000**	**71,000**	**100,000**
Power	2	10	19,000	27,000	41,000	64,000	93,000
Ricker (PDO)	2	7	14,000	22,000	34,000	53,000	83,000
Ricker	5	9	13,000	19,000	31,000	49,000	76,000
Larkin	11	15	16,000	23,000	36,000	58,000	87,000

RUN TIMING GROUP: EARLY SUMMER	**All**	**MPE**	**Return Forecast**				
BOWRON	**(Ranks)**		**10%**	**25%**	**50%**	**75%**	**90%**
Ricker (PDO)	**1**	**1**	**5,000**	**7,000**	**12,000**	**20,000**	**33,000**
Ricker (Pi)	2	2	4,000	7,000	11,000	20,000	34,000
Power	3	5	6,000	8,000	13,000	20,000	32,000
Ricker	5	7	4,000	6,000	10,000	16,000	26,000
Larkin	7	13	3,000	5,000	8,000	15,000	24,000
FENNELL			**10%**	**25%**	**50%**	**75%**	**90%**
Ricker (Pi)	1	NA	22,000	41,000	79,000	156,000	320,000
TSA	**2**	**NA**	**7,000**	**13,000**	**25,000**	**47,000**	**84,000**
RAC	3	NA	10,000	18,000	33,000	63,000	110,000
Ricker	9	NA	14,000	22,000	38,000	64,000	107,000
Power	4	NA	14,000	21,000	35,000	60,000	93,000
Larkin	NA	NA	18,000	29,000	50,000	80,000	139,000
GATES			**10%**	**25%**	**50%**	**75%**	**90%**
Power	**1**	**4**	**7,000**	**10,000**	**17,000**	**28,000**	**47,000**
RAC	**1**	**1**	**7,400**	**12,000**	**21,000**	**36,000**	**58,000**
R2C	3	2	7,100	12,000	21,000	38,000	65,000
R1C	4	3	1,000	2,000	5,000	9,000	16,000
Ricker	6	11	5,200	9,300	17,000	31,000	51,000
Larkin	NA	NA	4,000	7,000	11,000	20,000	33,000
NADINA			**10%**	**25%**	**50%**	**75%**	**90%**
Power(juv)-Ei	**1**	**2**	**6,000**	**9,000**	**15,000**	**25,000**	**42,000**
Ricker (Pi)	2	3	4,000	6,000	11,000	19,000	32,000
Power(juv)-FrD-peak	3	5	6,000	9,000	14,000	25,000	39,000
Power (juv)-Pi	4	1	**4,000**	**6,000**	**11,000**	**19,000**	**32,000**
Ricker	7	11	4,000	8,000	13,000	22,000	37,000
Power	12	14	4,000	8,000	13,000	25,000	40,000
Larkin	NA	NA	3,000	7,000	12,000	22,000	35,000
PITT			**10%**	**25%**	**50%**	**75%**	**90%**
Ricker (Pi)	**1**	**NA**	**41,000**	**67,000**	**118,000**	**197,000**	**372,000**
Ricker (PDO)	2	NA	37,000	57,000	96,000	170,000	285,000
Larkin	3	NA	13,000	19,000	33,000	55,000	87,000
Ricker	8	NA	32,000	51,000	82,000	140,000	236,000
Power	4	NA	24,000	37,000	62,000	95,000	162,000
RAFT			**10%**	**25%**	**50%**	**75%**	**90%**
Power	**1**	**NA**	**19,000**	**28,000**	**44,000**	**69,000**	**104,000**
Ricker	2	NA	23,000	34,000	55,000	87,000	143,000
R1C	2	NA	7,400	13,000	24,000	44,000	77,000
Larkin	5	NA	18,000	28,000	43,000	71,000	114,000
SCOTCH*			**10%**	**25%**	**50%**	**75%**	**90%**
RS1	1	NA	16,000	41,000	118,000	338,000	875,000
Ricker (PDO)	**2**	**NA**	**17,000**	**31,000**	**61,000**	**131,000**	**266,000**
Ricker (FrD-mean)	3	NA	20,000	46,000	111,000	255,000	524,000
Ricker	5	NA	14,000	33,000	68,000	146,000	289,000
Power	6	NA	12,000	24,000	55,000	115,000	272,000
SEYMOUR*			**10%**	**25%**	**50%**	**75%**	**90%**
Power	**1**	**8**	**25,000**	**43,000**	**79,000**	**135,000**	**224,000**
Larkin	2	11	22,000	37,000	65,000	118,000	211,000
RAC	3	2	44,000	82,000	163,000	323,000	599,000
Ricker	7	10	27,000	46,000	83,000	148,000	246,000
Ricker (PI)	**4**	**1**	**43,000**	**71,000**	**127,000**	**238,000**	**387,000**
Ricker (PDO)	12	3	27,000	52,000	98,000	170,000	285,000

*Table 7 Continued. All 'Long-Term Average Productivity' forecasts for the top-ranked models. *Note: the Scotch, Seymour and Late Shuswap final total forecasts in Table 1 differ from those presented in this table, given that Table 1 age-5 recruitment forecasts are estimated using preliminary 2006 brood year productivity and 2007 cycle age-5 proportions. In this table age-5 recruits are forecast using the specified model and average age-proportions across all cycles.*

RUN TIMING GROUP: SUMMER	All	MPE	Return Forecast				
CHILKO	(Ranks)		10%	25%	50%	75%	90%
Power (juv)	**1**	**NA**	**809,000**	**1,170,000**	**1,733,000**	**2,854,000**	**4,296,000**
Ricker (Ei)	1	NA	576,000	899,000	1,437,000	2,348,000	3,435,000
Ricker (FrD-peak)	3	NA	632,000	950,000	1,465,000	2,468,000	4,248,000
Ricker	4	NA	626,000	936,000	1,336,000	2,108,000	3,289,000
Power	19	NA	457,000	685,000	1,079,000	1,737,000	2,824,000
Larkin	13	NA	455,000	756,000	1,145,000	1,904,000	3,123,000
LATE STUART			10%	25%	50%	75%	90%
R1C	1	2	3,000	8,000	20,000	53,000	124,000
R2C	**2**	**3**	**12,000**	**29,000**	**75,000**	**195,000**	**459,000**
Power	3	5	24,000	46,000	82,000	161,000	312,000
Ricker-cyc	3	4	48,000	78,000	139,000	262,000	433,000
Ricker	7	10	18,000	34,000	75,000	158,000	332,000
Larkin	7	6	15,000	31,000	64,000	144,000	286,000
RAC	5	1	14,000	33,000	85,000	221,000	523,000
QUESNEL			10%	25%	50%	75%	90%
R1C	**1**	**NA**	**26,000**	**54,000**	**119,000**	**261,000**	**533,000**
R2C	2	NA	102,000	214,000	486,000	1,105,000	2,313,000
RAC	3	NA	16,000	47,000	153,000	499,000	1,450,000
RS1	4	NA	5,000	13,000	35,000	91,000	219,000
Ricker-cyc	**4**	**NA**	**121,000**	**182,000**	**299,000**	**552,000**	**980,000**
Power	6	NA	108,000	203,000	395,000	757,000	1,487,000
Larkin	7	NA	143,000	241,000	411,000	696,000	1,168,000
Ricker	12	NA	152,000	275,000	523,000	1,090,000	1,901,000
STELLAKO			10%	25%	50%	75%	90%
TSA	1	4	110,000	217,000	462,000	983,000	1,939,000
R2C	2	2	50,000	88,000	168,000	320,000	570,000
Ricker (PDO)	**3**	**5**	**113,000**	**200,000**	**350,000**	**571,000**	**991,000**
Ricker	9	11	133,000	213,000	340,000	553,000	901,000
Power	13	13	133,000	216,000	338,000	535,000	797,000
Larkin	8	14	149,000	212,000	323,000	486,000	717,000
R1C	**8**	**1**	**3,000**	**8,000**	**20,000**	**53,000**	**124,000**

RUN TIMING GROUP: LATE	All	MPE	Return Forecast				
CULTUS	(Ranks)		10%	25%	50%	75%	90%
Power(juv)-FrD-peak	**1**	**8**	**5,000**	**8,000**	**15,000**	**31,000**	**60,000**
Smolt-Jack (MS: 1951-2005 BY)	2	3	7,000	12,000	21,000	37,000	56,000
Power(juv)-PDO	3	9	6,000	11,000	19,000	39,000	77,000
Power(juv)	6	10	5,000	8,000	16,000	30,000	52,000
RJ2	**12**	**1**	**1,000**	**2,000**	**6,000**	**18,000**	**45,000**
RJ1	11	2	0	1,000	3,000	10,000	25,000
HARRISON			10%	25%	50%	75%	90%
Ricker (FrD-peak)	**1**	**NA**	**37,000**	**99,000**	**380,000**	**1,660,000**	**2,637,000**
Ricker (FrD-mean)	2	NA	26,000	46,000	93,000	189,000	392,000
Ricker (Pi)	3	NA	24,000	44,000	93,000	212,000	419,000
Ricker	6	NA	23,000	45,000	92,000	193,000	364,000
Power	10	NA	17,000	28,000	54,000	97,000	187,000
LATE SHUSWAP*			10%	25%	50%	75%	90%
Larkin	**1**	**2**	**136,000**	**304,000**	**960,000**	**3,592,000**	**8,693,000**
R1C	2	6	32,000	72,000	174,000	421,000	933,000
Ricker	3	9	144,000	290,000	892,000	3,077,000	8,168,000
Ricker (FrD-peak)	3	8	140,000	298,000	876,000	3,353,000	9,071,000
Power	12	7	120,000	273,000	707,000	2,590,000	6,162,000
Ricker (Pi)	**11**	**1**	**211,000**	**445,000**	**1,268,000**	**4,535,000**	**14,195,000**
Ricker (PDO)	9	3	138,000	313,000	852,000	2,764,000	8,301,000
PORTAGE			10%	25%	50%	75%	90%
Power	**1**	**3**	**4,000**	**9,000**	**19,000**	**37,000**	**68,000**
Ricker	2	10	5,300	10,000	21,000	41,000	83,000
Ricker (FrD-peak)	3	8	4,200	10,000	22,000	49,000	111,000
Ricker (Pi)	3	2	5,000	12,000	31,000	70,000	163,000
RAC	**6**	**1**	**5,000**	**11,000**	**26,000**	**60,000**	**127,000**
Larkin	12	16	3,900	7,900	17,000	35,000	72,000
WEAVER			10%	25%	50%	75%	90%
Power (juv)-PDO	**1**	**NA**	**185,000**	**281,000**	**440,000**	**717,000**	**1,142,000**
RJC	2	NA	81,000	144,000	274,000	520,000	925,000
Ricker (PDO)	3	NA	166,000	259,000	422,000	736,000	1,179,000
Ricker	11	NA	81,000	135,000	235,000	417,000	755,000
Larkin	12	NA	97,000	151,000	269,000	480,000	820,000
Power (juv)	6	NA	127,000	197,000	304,000	508,000	831,000
BIRKENHEAD			10%	25%	50%	75%	90%
Ricker (PDO)	**1**	**NA**	**163,000**	**254,000**	**456,000**	**810,000**	**1,410,000**
Power	2	NA	152,000	216,000	370,000	665,000	1,058,000
Ricker	3	NA	162,000	270,000	452,000	786,000	1,284,000
Larkin	7	NA	149,000	230,000	397,000	683,000	1,217,000

Table 8. All ***'Recent Productivity'*** *forecasts for the top-ranked models. Rows bolded and shaded light grey are the selected forecasts presented in Table 2 for each stock.* ****Note: the Early Stuart, Bowron, Scotch, Seymour, Chilko, Late Stuart, Late Shuswap and Portage final total forecasts in Table 3 differ from those presented in this table, given that Table 3 age-5 recruitment forecasts are estimated using preliminary 2006 brood year productivity and 2007 cycle age-5 proportions. In this table age-5 recruits are forecast using the specified model and average age-proportions across all cycles.***

RUN TIMING GROUP: EARLY STUART	Rank		Return Forecast				
EARLY STUART*	**All**	**MPE**	**10%**	**25%**	**50%**	**75%**	**90%**
RS4yr	**1**	**2**	**4,100**	**6,300**	**10,000**	**16,000**	**25,000**
RS8yr	1	3	4,500	7,100	12,000	19,000	30,000
KF	3	1	5,700	8,900	14,000	22,000	34,000
RS2	3	4	3,500	5,500	9,000	15,000	24,000
KF (2005 brood year preliminary age-4 data included)	NA	NA	5,000	7,200	11,000	17,000	24,000
Ricker (trunc 1990-2004)	NA	NA	7,400	9,900	13,700	19,800	27,900
Power (trunc 1990-2004)	NA	NA	6,400	8,900	13,400	20,000	30,000
RUN TIMING GROUP: EARLY SUMMER	**Rank**		**Return Forecast**				
BOWRON*			**10%**	**25%**	**50%**	**75%**	**90%**
RS4yr	**1**	**2**	**800**	**1,400**	**2,700**	**5,300**	**9,600**
KF	2	3	1,900	3,000	5,300	8,800	15,300
LLY	2	1	NA	NA	NA	NA	NA
RS8yr	4	4	1,000	2,000	3,000	6,000	12,000
KF (2005 brood year preliminary age-4 data included)	NA		2,000	3,000	4,000	7,000	11,000
Ricker (trunc 1990-2004)	NA		1,900	3,200	5,700	10,600	18,700
Power (trunc 1990-2004)	NA		4,500	7,100	11,000	18,100	30,100
FENNELL			**10%**	**25%**	**50%**	**75%**	**90%**
Power	**1**		**14,000**	**21,000**	**35,000**	**60,000**	**93,000**
RAC	2		10,000	18,000	33,000	63,000	110,000
TSA	3		7,300	13,000	25,000	47,000	84,000
RS8yr	6		9,000	17,000	35,000	72,000	138,000
KF	7		9,200	15,000	30,000	58,000	103,000
KF (2005 brood year preliminary age-4 data included)	NA		4,100	7,800	16,000	29,000	51,000
RS4yr	13		8,000	17,000	40,000	93,000	199,000
Ricker (trunc 1990-2004)	NA		13,300	19,800	31,600	51,400	81,000
Power (trunc 1990-2004)	NA		9,700	15,100	23,900	39,000	65,200
GATES			**10%**	**25%**	**50%**	**75%**	**90%**
KF	**1**	**3**	**3,000**	**5,000**	**8,000**	**14,000**	**23,000**
RS8yr	2	5	2,000	4,000	7,000	13,000	24,000
RS4yr	2	2	2,000	3,000	7,000	13,000	25,000
KF (2005 brood year preliminary age-4 data included)	NA	NA	2,000	3,000	5,500	10,000	19,000
Ricker (trunc 1990-2004)	NA	NA	3,000	5,000	9,000	16,000	29,000
Power (trunc 1990-2004)	NA	NA	3,000	6,000	11,000	21,000	38,000
NADINA			**10%**	**25%**	**50%**	**75%**	**90%**
Ricker (FrD-mean)	**1**	**9**	**4,000**	**7,000**	**12,000**	**21,000**	**37,000**
Ricker (Ei)	2	6	4,000	7,000	12,000	22,000	36,000
Ricker	3	8	4,000	8,000	14,000	22,000	37,000
KF	4	2	4,000	6,000	11,000	19,000	30,000
RS4yr	7	1	2,000	3,000	8,000	19,000	42,000
RS8yr	14	5	1,000	3,000	6,000	14,000	28,000
KF (2005 brood year preliminary age-4 data included)	NA		3,000	5,000	9,000	16,000	27,000
Ricker (trunc 1990-2004)	NA		3,000	5,000	10,000	23,000	45,000
Power (trunc 1990-2004)	NA		3,000	6,000	11,000	24,000	46,000
PITT			**10%**	**25%**	**50%**	**75%**	**90%**
Ricker	**1**		**32,000**	**51,000**	**82,000**	**140,000**	**236,000**
Ricker (Pi)	2		41,000	67,000	118,000	197,000	372,000
Ricker (FrD-peak)	2		33,000	53,000	90,000	160,000	258,000
Power	2		24,000	37,000	62,000	95,000	162,000
KF	10		16,000	25,000	43,000	76,000	115,000
RS4yr	16		4,000	10,000	26,000	67,000	158,000
RS8yr	17		8,000	20,000	55,000	150,000	371,000
KF (2005 brood year preliminary age-4 data included)	NA		2,000	3,500	6,500	12,000	20,000
Ricker (trunc 1990-2004)	NA		34,300	60,000	107,400	206,100	365,100
Power (trunc 1990-2004)	NA		23,900	40,900	70,800	115,900	194,600
RAFT			**10%**	**25%**	**50%**	**75%**	**90%**
Ricker (PDO)	**1**		**29,000**	**44,000**	**68,000**	**108,000**	**171,000**
Ricker (Pi)	1		27,000	42,000	65,000	108,000	164,000
Ricker-cyc	3		10,000	17,000	37,000	75,000	143,000
KF	15		21,000	32,000	51,000	83,000	137,000
RS4yr	17		8,000	16,000	34,000	72,000	141,000
RS8yr	19		11,000	21,000	45,000	95,000	185,000
KF (2005 brood year preliminary age-4 data included)	NA		13,000	21,000	35,000	62,000	102,000
Ricker (trunc 1990-2004)	NA		23,800	37,600	65,300	115,500	194,700
Power (trunc 1990-2004)	NA		20,200	31,800	54,500	89,700	150,800

*Table 8 Continued. All 'Recent Productivity' forecasts for the top-ranked models. *Note: the Early Stuart, Bowron, Scotch, Seymour, Chilko, Late Stuart, Late Shuswap and Portage final total forecasts in Table 3 differ from those presented in this table, given that Table 3 age-5 recruitment forecasts are estimated using preliminary 2006 brood year productivity and 2007 cycle age-5 proportions. In this table age-5 recruits are forecast using the specified model and average age-proportions across all cycles.*

SCOTCH*			**10%**	**25%**	**50%**	**75%**	**90%**
KF	**1**		**11,000**	**23,000**	**55,000**	**133,000**	**260,000**
Ricker (PDO)	2		17,000	31,000	61,000	131,000	266,000
RS4yr	3		13,000	32,000	85,000	225,000	540,000
RS1	3		16,000	41,000	118,000	338,000	875,000
RS8yr	11		14,000	32,000	78,000	192,000	430,000
KF (2005 brood year preliminary age-4 data included)	NA		6,500	15,000	37,000	90,000	196,000
Ricker (trunc 1990-2004)	NA		12,200	25,400	52,000	115,900	247,500
Power (trunc 1990-2004)	NA		13,300	29,200	58,500	143,000	390,100
SEYMOUR*			**10%**	**25%**	**50%**	**75%**	**90%**
RS4yr	**1**	**4**	**12,000**	**21,000**	**42,000**	**81,000**	**147,000**
RS2	2	6	20,000	38,000	81,000	171,000	334,000
MRS	3	14	24,000	44,000	87,000	174,000	323,000
RS8yr	5	1	16,000	30,000	57,000	111,000	200,000
KF	7	2	15,000	28,000	54,000	99,000	175,000
KF (2005 brood year preliminary age-4 data included)	NA		14,000	26,000	48,000	89,000	165,000
Ricker (trunc 1990-2004)	NA		15,000	25,900	50,000	94,400	175,800
Power (trunc 1990-2004)	NA		14,500	26,300	47,600	89,400	155,400
RUN TIMING GROUP: SUMMER	**Rank**		**Return Forecast**				
CHILKO*			**10%**	**25%**	**50%**	**75%**	**90%**
RJ4yr(smolt)	**1**		**465,000**	**669,000**	**1,001,000**	**1,500,000**	**2,158,000**
RJ8yr	2		520,000	771,000	1,193,000	1,847,000	2,737,000
LLY	3		NA	NA	NA	NA	NA
KF	4		331,000	538,000	892,000	1,407,000	2,144,000
KF (2005 brood year preliminary age-4 data included)	NA		186,000	303,000	501,000	844,000	1,325,000
Ricker (trunc 1990-2004)	NA		343,600	528,300	846,900	1,394,000	2,115,900
Power (trunc 1990-2004)	NA		357,600	579,500	926,200	1,357,000	2,169,000
LATE STUART*			**10%**	**25%**	**50%**	**75%**	**90%**
LLY	1	4	NA	NA	NA	NA	NA
RAC	2	1	14,000	33,000	85,000	221,000	523,000
RS8yr	**3**	**3**	**3,000**	**7,000**	**18,000**	**50,000**	**124,000**
RS4yr	**4**	**2**	**3,000**	**7,000**	**18,000**	**47,000**	**115,000**
KF	6	5	5,600	12,000	30,000	70,000	153,000
KF (2005 brood year preliminary age-4 data included)	NA		3,000	7,800	19,000	45,000	101,000
Ricker (trunc 1990-2004)	NA		10,800	16,700	27,900	45,900	74,800
Power (trunc 1990-2004)	NA		16,500	28,100	50,800	91,600	158,400
QUESNEL			**10%**	**25%**	**50%**	**75%**	**90%**
RAC	**1**		**16,000**	**47,000**	**153,000**	**499,000**	**1,450,000**
Larkin	2		143,000	241,000	411,000	696,000	1,168,000
R1C	3		26,000	54,000	119,000	261,000	533,000
RS4yr	4		11,000	22,000	50,000	113,000	234,000
KF	7		21,000	42,000	77,000	146,000	260,000
RS8yr	10		22,000	47,000	107,000	247,000	524,000
KF (2005 brood year preliminary age-4 data included)	NA		13,000	22,000	43,000	92,000	165,000
Ricker (trunc 1990-2004)	NA		56,500	98,100	178,400	306,000	579,000
Power (trunc 1990-2004)	NA		52,800	99,400	183,900	371,200	695,300
STELLAKO			**10%**	**25%**	**50%**	**75%**	**90%**
RS4yr	**1**	**1**	**22,000**	**41,000**	**79,000**	**155,000**	**283,000**
KF	2	4	63,000	92,000	140,000	217,000	316,000
R1C	2	3	17,000	30,000	59,000	113,000	204,000
RS8yr	10		28,000	54,000	110,000	225,000	429,000
KF (2005 brood year preliminary age-4 data included)	NA		16,000	27,000	50,000	83,000	147,000
Ricker (trunc 1990-2004)	NA		79,300	121,900	190,900	303,800	466,100
Power (trunc 1990-2004)	NA		89,100	147,800	228,000	370,300	594,400
RUN TIMING GROUP: LATE	**Rank**		**Return Forecast**				
CULTUS			**10%**	**25%**	**50%**	**75%**	**90%**
Smolt-Jack (MS: 1999-2004 BY)	**NA**	**3**	**4,000**	**6,000**	**9,000**	**13,000**	**17,000**
KF (smolt)	1	6	1,000	3,000	7,000	15,000	32,000
Power(juv)-FrD-peak	3	8	1,000	3,000	6,000	12,000	24,000
KF (2005 brood year preliminary age-4 data included)	NA		1,100	2,300	4,600	9,500	19,500
Ricker (trunc 1990-2004)	NA		1,300	3,100	6,700	15,400	34,100
Power (trunc 1990-2004)	NA		2,000	5,000	12,800	29,800	81,400

*Table 8 Continued. All 'Recent Productivity' forecasts for the top-ranked models. *Note: the Early Stuart, Bowron, Scotch, Seymour, Chilko, Late Stuart, Late Shuswap and Portage final total forecasts in Table 3 differ from those presented in this table, given that Table 3 age-5 recruitment forecasts are estimated using preliminary 2006 brood year productivity and 2007 cycle age-5 proportions. In this table age-5 recruits are forecast using the specified model and average age-proportions across all cycles.*

HARRISON			**10%**	**25%**	**50%**	**75%**	**90%**
Ricker (FrD-mean)	**1**		**37,000**	**96,000**	**372,000**	**1,656,000**	**2,630,000**
Ricker (FrD-peak)	2		25,000	47,000	99,000	208,000	442,000
KF	3		36,000	67,000	145,000	320,000	672,000
KF (2005 brood year preliminary age-4 data included)	NA		122,000	189,000	283,000	455,000	832,000
Ricker (trunc 1990-2004)	NA		42,800	81,600	171,500	0.3963	781,000
Power (trunc 1990-2004)	NA		18,600	37,700	80,000	181,200	421,800
LATE SHUSWAP*			**10%**	**25%**	**50%**	**75%**	**90%**
Ricker-cyc	1	4	74,000	140,000	271,000	567,000	1,261,000
Ricker (Pi)	**2**	**2**	**211,000**	**445,000**	**1,268,000**	**4,535,000**	**14,195,000**
Ricker (Ei)	3	12	102,000	214,000	611,000	3,039,000	8,390,000
KF	13	19	18,000	60,000	247,000	896,000	2,668,000
Larkin	7	1	136,000	304,000	960,000	3,592,000	8,693,000
RS4yr	14	13	70,000	144,000	320,000	713,000	1,468,000
RS8yr	18	15	175,000	347,000	744,000	1,595,000	3,168,000
KF (2005 brood year preliminary age-4 data included)	NA	NA	48,000	116,000	372,000	1,443,000	3,513,000
Ricker (trunc 1990-2004)	NA	NA	99,900	294,400	986,300	3,352,500	9,297,700
Power (trunc 1990-2004)	NA	NA	82,900	214,300	584,000	2,054,800	5,971,200
PORTAGE*			**10%**	**25%**	**50%**	**75%**	**90%**
LLY	1	1	NA	NA	NA	NA	NA
KF	**2**	**3**	**3,000**	**7,000**	**14,000**	**30,000**	**61,000**
Ricker (FrD-mean)	3	9	4,000	9,000	21,000	49,000	115,000
RS8yr	8	2	2,000	4,000	10,000	21,000	44,000
RS4yr	14	8	2,000	4,000	9,000	20,000	42,000
KF (2005 brood year preliminary age-4 data included)	NA		1,500	3,800	9,000	20,900	47,800
Ricker (trunc 1990-2004)	NA		2,500	4,700	9,300	18,100	36,400
Power (trunc 1990-2004)	NA		4,200	7,300	15,000	27,800	50,800
WEAVER			**10%**	**25%**	**50%**	**75%**	**90%**
Ricker (FrD-peak)	**1**		**90,000**	**143,000**	**253,000**	**444,000**	**761,000**
Ricker (FrD-mean)	2		86,000	141,000	238,000	427,000	854,000
Ricker (PDO)	3		166,000	259,000	422,000	736,000	1,179,000
KF	11		79,000	139,000	235,000	431,000	738,000
RS8yr	20		49,000	90,000	177,000	349,000	644,000
RS4yr	21		34,000	71,000	161,000	364,000	758,000
KF (2005 brood year preliminary age-4 data included)	NA		35,000	75,000	157,000	322,000	542,000
Ricker (trunc 1990-2004)	NA		113,800	172,600	275,500	438,800	687,200
Power (trunc 1990-2004)	NA		123,200	180,000	277,100	435,100	664,500
BIRKENHEAD			**10%**	**25%**	**50%**	**75%**	**90%**
KF	**1**		**59,000**	**96,000**	**178,000**	**321,000**	**551,000**
Ricker	2		162,000	270,000	452,000	786,000	1,284,000
RS1	2		45,000	115,000	327,000	929,000	2,378,000
RS8yr	9		37,000	83,000	204,000	504,000	1,137,000
RS4yr	14		36,000	86,000	225,000	590,000	1,406,000
KF (2005 brood year preliminary age-4 data included)	NA		41,000	68,000	125,000	212,000	372,000
Ricker (trunc 1990-2004)	NA		83,200	140,800	260,300	551,700	1,048,100
Power (trunc 1990-2004)	NA		55,700	101,800	177,600	324,700	600,800

Table 9. List of candidate models organized by their two broad categories (non-parametric and biological) with descriptions. Models are described in detail in Grant et al. (2010) Appendices 1 to 3. Where applicable, models use effective female spawner data (EFS) as predictor variables unless otherwise indicated by '(juv)' or '(smolt)' next to the model, where juvenile fry data or smolt data are used instead of EFS data.

Model Category	Description
A. Non-Parametric Models	
R1C	return from 4 years previous
R2C	Average return from 4 & 8 years previous
RAC	Average return on the cycle line on the time series
TSA	Average return across all cycle lines on the time series
RS1	Product of average productivity from 4 years previous and EFS (or juv/smolt)
RS2	Product of average productivity from 4 & 8 years previous and EFS (or juv/smolt)
RS4yr[1]	Product of average productivity from last 4 years and EFS (or juv/smolt)
RS8yr[1]	Product of average productivity from last 8 years and EFS (or juv/smolt)
RS	Product of average productivity on time series for specified stocks and EFS (or juv/smolt) (used for miscellaneous stocks)
B. Biological Models	
Power	Bayesian
Power-cyc	Bayesian (cycle line data only)
Ricker	Bayesian
Ricker-cyc	Bayesian (cycle line data only)
Larkin	Bayesian
KF Ricker[1]	Kalman Filtered Ricker model (Bayesian)
Covariates for Biological models (e.g. Power (FrD-mean))	
FrD-mean	mean Fraser discharge (April to June) http://www.wateroffice.ec.gc.ca/index_e.html
Ei	Entrance Island sea-surface-temperature (April to June) http://www.pac.dfo-mpo.gc.ca/sci/OSAP/data/SearchTools/Searchlighthouse_e.htm
Pi	Pine Island sea-surface-temperature (April to July) http://www.pac.dfo-mpo.gc.ca/sci/OSAP/data/SearchTools/Searchlighthouse_e.htm
FrD-peak	peak Fraser discharge http://www.wateroffice.ec.gc.ca/index_e.html
PDO	Pacific Decadal Oscillation http://jisao.washington.edu/pdo/PDO.latest

1. models used exclusively in 'Recent Productivity' forecasts

APPENDIX 1: LONG-TERM AVERAGE RETROSPECTIVE ANALYSES

RUN-TIMING: EARLY STUART

EARLY STUART

	MRE	Abs(MRE)	Rank	MAE	Rank	MPE	Abs(MPE)	Rank	RMSE	Rank	Overall Rank
LLY	0	0	1	0.383	18	2.790	2.790	12	0.592	18	13
TSA	0.015	0.015	3	0.288	17	10.969	10.969	18	0.404	14	14
R1C	0.051	0.051	12	0.236	12	1.642	1.642	4	0.388	11	10
R2C	0.079	0.079	14	0.271	15	3.890	3.890	14	0.385	10	16
RAC	0.009	0.009	2	0.204	5	5.782	5.782	16	0.302	3	5
MRS	0.226	0.226	17	0.254	13	2.576	2.576	11	0.4	13	17
RS1	0.107	0.107	15	0.218	9	1.211	1.211	1	0.326	9	8
RS2	0.124	0.124	16	0.179	2	1.250	1.250	2	0.293	2	2
RSC	0.258	0.258	18	0.286	16	2.875	2.875	13	0.454	17	18
Ricker	0.044	0.044	9	0.204	5	2.251	2.251	9	0.302	3	5
Power	0.046	0.046	10	0.14	1	2.427	2.427	10	0.188	1	2
Larkin	-0.03	0.025	4	0.225	10	3.994	3.994	15	0.395	12	11
Ricker-cyc	0.034	0.034	6	0.254	13	6.677	6.677	17	0.417	16	14
Ricker (FrD-mean)	0.058	0.058	13	0.208	8	2.225	2.225	8	0.324	8	9
Ricker (Ei)	0.046	0.046	10	0.229	11	1.972	1.972	5	0.407	15	11
Ricker (Pi)	-0.04	0.039	7	0.18	3	1.306	1.306	3	0.317	7	1
Ricker (FrD-Peak)	0.042	0.042	8	0.205	7	2.051	2.051	6	0.308	5	5
Ricker (PDO)	0.027	0.027	5	0.203	4	2.113	2.113	7	0.314	6	2

RUN-TIMING: EARLY SUMMER

BOWRON

	MRE	Abs(MRE)	Rank	MAE	Rank	MPE	Abs(MPE)	Rank	RMSE	Rank	Overall Rank
LLY	0	0	1	0.016	1	0.549	0.548581	1	0.022	1	1
TSA	0.028	0.028	17	0.029	16	3.171	3.170898	18	0.032	11	16
R1C	0.007	0.007	2	0.022	12	1.218	1.217896	4	0.036	13	8
R2C	0.009	0.009	5	0.021	9	1.262	1.261605	5	0.033	12	8
RAC	0.029	0.029	18	0.033	17	2.894	2.893842	17	0.045	17	18
MRS	0.016	0.016	11	0.025	13	1.505	1.505179	12	0.039	14	13
RS1	0.026	0.026	16	0.038	18	1.754	1.753541	15	0.061	18	17
RS2	0.016	0.016	11	0.027	15	1.481	1.481499	11	0.043	16	14
RSC	0.017	0.017	14	0.026	14	1.593	1.592709	13	0.041	15	15
Ricker	0.012	0.012	7	0.02	6	1.289	1.289317	8	0.026	6	5
Power	0.01	0.01	6	0.019	4	1.280	1.280428	6	0.024	5	4
Larkin	0.016	0.016	11	0.018	3	1.610	1.610155	14	0.022	1	7
Ricker-cyc	0.018	0.018	15	0.02	6	1.809	1.808825	16	0.026	6	12
Ricker (FrD-mean)	0.012	0.012	7	0.021	9	1.284	1.284079	7	0.027	9	10
Ricker (Ei)	0.012	0.012	7	0.021	9	1.379	1.37903	10	0.027	9	11
Ricker (Pi)	0.007	0.007	2	0.017	2	1.004	1.004424	3	0.023	4	3
Ricker (FrD-Peak)	0.012	0.012	7	0.02	6	1.309	1.308761	9	0.026	6	6
Ricker (PDO)	0.007	0.007	2	0.019	4	0.991	0.991339	2	0.022	1	2

FENNELL

	MRE	Abs(MRE)	Rank	MAE	Rank	MPE	Abs(MRE)	Rank	RMSE	Rank	Overall Rank
LLY	0.001	0.001	3	0.019	9	0.403	0.403113	3	0.024	9	6
TSA	-0.007	0.007	10	0.016	1	0.178	0.177985	2	0.02	1	2
R1C	0	0	1	0.021	12	0.541	0.541248	6	0.025	11	10
R2C	-0.001	0.001	3	0.018	6	0.440	0.439842	4	0.023	7	5
RAC	-0.007	0.007	10	0.016	1	0.083	0.083278	1	0.022	5	3
MRS	0.055	0.055	15	0.058	15	2.758	2.757663	15	0.077	15	15
RS1	0.02	0.02	14	0.037	14	1.380	1.37974	14	0.048	14	14
RS2	0.017	0.017	13	0.032	13	1.122	1.121895	13	0.041	13	13
RSC	0.059	0.059	16	0.061	16	3.052	3.052332	16	0.077	15	16
Ricker	0.008	0.008	12	0.017	3	0.782	0.781685	12	0.02	1	9
Power	0.005	0.005	6	0.017	3	0.562	0.561669	7	0.021	3	4
Ricker (FrD-mean)	0.006	0.006	9	0.019	9	0.727	0.726781	11	0.024	9	11
Ricker (Ei)	0.005	0.005	6	0.018	6	0.716	0.716134	9	0.022	5	7
Ricker (Pi)	0	0	1	0.017	3	0.533	0.532915	5	0.021	3	1
Ricker (FrD-Peak)	0.003	0.003	5	0.018	6	0.668	0.667872	8	0.023	7	7
Ricker (PDO)	0.005	0.005	6	0.02	11	0.724	0.723657	10	0.025	11	11
Larkin	time series too short to evaluate retrospectively										
Ricker-cyc	time series too short to evaluate retrospectively										

GATES

	MRE	Abs(MRE)	Rank	MAE	Rank	MPE	Abs(MRE)	Rank	RMSE	Rank	Overall Rank
LLY	-0.001	0.001	1	0.077	16	1.211	1.211496	5	0.118	15	10
TSA	-0.013	0.013	11	0.049	6	1.527	1.527244	9	0.082	13	11
R1C	0.011	0.011	9	0.044	4	1.009	1.008577	3	0.069	6	4
R2C	0.011	0.011	9	0.039	2	0.947	0.946847	2	0.065	3	3
RAC	-0.01	0.01	7	0.036	1	0.353	0.353078	1	0.062	2	1
MRS	0.043	0.043	14	0.048	5	2.096	2.095864	14	0.065	3	9
RS1	0.05	0.05	16	0.069	15	2.757	2.756935	16	0.142	16	16
RS2	0.028	0.028	13	0.053	10	1.452	1.452265	8	0.08	11	14
RSC	0.044	0.044	15	0.056	13	2.271	2.270593	15	0.074	7	15
Ricker	0.009	0.009	5	0.052	9	1.660	1.659571	11	0.074	7	6
Power	0.004	0.004	4	0.039	2	1.211	1.210971	4	0.054	1	1
Ricker (FrD-mean)	0.01	0.01	7	0.054	12	1.748	1.747603	13	0.077	9	13
Ricker (Ei)	0.009	0.009	5	0.06	14	1.444	1.443673	7	0.098	14	12
Ricker (Pi)	-0.001	0.001	1	0.051	8	1.289	1.289426	6	0.08	11	5
Ricker (FrD-Peak)	0.003	0.003	3	0.053	10	1.597	1.596802	10	0.078	10	7
Ricker (PDO)	0.013	0.013	11	0.049	6	1.740	1.74016	12	0.067	5	8
Larkin	time series too short to evaluate retrospectively										
Ricker-cyc	time series too short to evaluate retrospectively										

NADINA

	MRE	Abs(MRE)	Rank	MAE	Rank	MPE	Abs(MPE)	Rank	RMSE	Rank	Overall Rank
LLY	-0.008	0.008	6	0.102	21	2.554	2.553856	24	0.151	20	21
TSA	-0.01	0.01	8	0.069	14	3.274	3.273635	26	0.111	13	18
R1C	-0.001	0.001	1	0.07	15	0.775	0.774692	16	0.128	18	16
R2C	-0.002	0.002	3	0.066	13	1.237	1.237067	20	0.111	13	14
RAC	-0.008	0.008	6	0.075	18	2.975	2.975202	25	0.122	17	20
MRS	0.013	0.013	9	0.08	19	0.905	0.905281	17	0.13	19	19
RS1	0.134	0.134	25	0.178	25	1.634	1.634056	23	0.398	25	25
RS2	0.14	0.14	26	0.181	26	1.489	1.488849	22	0.479	26	26
RSC	0.054	0.054	23	0.108	22	1.177	1.176618	19	0.209	22	22
MRJ	-0.017	0.017	16	0.065	12	0.5365	0.536535	7	0.101	4	9
RJ1	0.068	0.068	24	0.118	23	1.420	1.419992	21	0.267	24	24
RJ2	0.053	0.053	22	0.119	24	1.103	1.10298	18	0.256	23	23
RJC	-0.006	0.006	5	0.074	17	0.641	0.64067	10	0.116	15	13
Ricker	-0.015	0.015	13	0.056	3	0.642	0.641607	11	0.103	8	7
Power	-0.001	0.001	1	0.07	15	0.726	0.725824	14	0.118	16	12
Ricker (FrD-mean)	-0.014	0.014	12	0.057	4	0.684	0.684438	12	0.105	11	9
Ricker (Ei)	-0.02	0.02	19	0.053	1	0.591	0.591027	9	0.101	4	6
Ricker (Pi)	-0.026	0.026	21	0.053	1	0.436	0.436409	3	0.1	3	2
Ricker (FrD-Peak)	-0.018	0.018	18	0.062	10	0.686	0.686092	13	0.103	8	14
Ricker (PDO)	-0.013	0.013	9	0.058	6	0.774	0.774082	15	0.106	12	11
Power (juv)	-0.016	0.016	14	0.061	9	0.478	0.478356	4	0.101	4	4
Power (juv)(FrD-mear	0.003	0.003	4	0.081	20	0.519	0.518716	6	0.156	21	17
Power(juv)(Ei)	-0.017	0.017	16	0.057	4	0.424	0.424442	2	0.098	1	1
Power (juv) (Pi)	-0.020	0.02	19	0.059	7	0.382	0.381544	1	0.101	4	4
Power(juv)(FrD-Peak)	-0.016	0.016	14	0.06	8	0.497	0.496655	5	0.099	2	3
Power(juv)(PDO)	-0.013	0.013	9	0.064	11	0.576	0.576283	8	0.103	8	8
Larkin	time series too short to evaluate retrospectively										
Ricker-cyc	time series too short to evaluate retrospectively										

PITT

	MRE	Abs(MRE)	Rank	MAE	Rank	MPE	Abs(MPE)	Rank	RMSE	Rank	Overall Rank
LLY	0	0	1	0.03	9	0.443	0.442984	10	0.038	9	9
TSA	0.017	0.017	13	0.034	10	1.242	1.242235	13	0.041	10	13
R1C	0.003	0.003	5	0.039	12	0.809	0.809408	12	0.049	13	12
R2C	0.003	0.003	5	0.039	12	0.773	0.77309	11	0.047	12	10
RAC	0.018	0.018	14	0.038	11	1.268	1.268185	14	0.044	11	14
MRS	0.058	0.058	15	0.069	15	1.752	1.751647	16	0.106	15	15
RS1	0.076	0.076	18	0.098	18	1.554	1.5536	15	0.138	18	18
RS2	0.065	0.065	17	0.083	17	1.880	1.879523	17	0.132	17	17
RSC	0.061	0.061	16	0.071	16	1.930	1.930325	18	0.108	16	16
Ricker	0.004	0.004	7	0.013	4	0.370	0.370369	9	0.017	5	8
Power	0.005	0.005	10	0.012	1	0.357	0.356804	6	0.016	1	4
Larkin	-0.008	0.008	12	0.012	1	-0.104	0.103806	1	0.016	1	3
Ricker-cyc	-0.006	0.006	11	0.044	14	0.170	0.170334	2	0.051	14	11
Ricker (FrD-mean)	0.004	0.004	7	0.013	4	0.358	0.357514	7	0.017	5	6
Ricker (Ei)	0.002	0.002	4	0.013	4	0.303	0.302956	5	0.017	5	4
Ricker (Pi)	0.001	0.001	3	0.012	1	0.236	0.236054	3	0.016	1	1
Ricker (FrD-Peak)	0.004	0.004	7	0.013	4	0.360	0.359516	8	0.017	5	7
Ricker (PDO)	0	0	1	0.013	4	0.237	0.23744	4	0.016	1	2

RAFT

	MRE	Abs(MRE)	Rank	MAE	Rank	MPE	Abs(MPE)	Rank	RMSE	Rank	Overall Rank
LLY	-0.001	0.001	2	0.024	15	0.719	0.718926	14	0.03	14	13
TSA	-0.003	0.003	3	0.022	13	2.110	2.110204	18	0.027	13	14
R1C	-0.005	0.005	10	0.013	3	0.037	0.036809	2	0.018	2	2
R2C	-0.007	0.007	11	0.014	5	0.164	0.16443	4	0.02	4	7
RAC	-0.003	0.003	3	0.017	10	1.566	1.566345	17	0.022	11	11
MRS	0.012	0.012	14	0.022	13	0.633	0.633456	12	0.036	15	15
RS1	0.029	0.029	18	0.042	18	0.891	0.891259	16	0.068	18	18
RS2	0.022	0.022	17	0.034	17	0.795	0.794743	15	0.053	17	17
RSC	0.016	0.016	16	0.026	16	0.674	0.674277	13	0.042	16	16
Ricker	-0.003	0.003	3	0.013	3	0.448	0.448374	9	0.018	2	2
Power	0	0	1	0.011	1	0.566	0.566464	11	0.016	1	1
Larkin	-0.003	0.003	3	0.017	10	-0.034	0.03367	1	0.021	8	5
Ricker-cyc	-0.013	0.013	15	0.017	10	-0.218	0.217598	5	0.022	11	11
Ricker (FrD-mean)	-0.003	0.003	3	0.014	5	0.503	0.503418	10	0.02	4	5
Ricker (Ei)	-0.004	0.004	8	0.014	5	0.440	0.44044	7	0.02	4	7
Ricker (Pi)	-0.007	0.007	11	0.014	5	0.239	0.239081	6	0.021	8	10
Ricker (FrD-Peak)	-0.004	0.004	8	0.014	5	0.443	0.442511	8	0.021	8	9
Ricker (PDO)	-0.007	0.007	11	0.012	2	0.156	0.156014	3	0.02	4	4

SCOTCH

	MRE	Abs(MRE)	Rank	MAE	Rank	MPE	Abs(MPE)	Rank	RMSE	Rank	Overall Rank
LLY	0	0	1	0.172	16	5.176	5.176173	15	0.287	16	16
TSA	-0.027	0.027	12	0.116	15	5.864	5.863768	16	0.191	15	15
R1C	-0.03	0.03	13	0.06	11	0.722	0.722342	2	0.145	12	9
R2C	-0.026	0.026	11	0.062	12	0.735	0.735066	3	0.145	12	10
RAC	-0.031	0.031	14	0.051	6	0.831	0.831271	5	0.136	11	7
MRS	-0.014	0.014	8	0.055	7	1.351	1.350785	11	0.099	6	8
RS1	-0.01	0.01	4	0.039	3	0.645	0.644815	1	0.06	3	1
RS2	-0.002	0.002	2	0.062	12	1.116	1.115783	9	0.102	7	11
RSC	0.053	0.053	16	0.059	10	2.047	2.047381	14	0.106	8	13
Ricker	-0.012	0.012	5	0.045	5	0.991	0.991356	7	0.083	5	5
Power	-0.035	0.035	15	0.055	7	0.827	0.827064	4	0.128	10	6
Ricker (FrD-mean)	-0.013	0.013	6	0.039	3	0.963	0.963198	6	0.078	4	3
Ricker (Ei)	0.02	0.02	9	0.085	14	1.785	1.785187	13	0.167	14	14
Ricker (Pi)	0.02	0.02	9	0.023	1	1.764	1.763964	12	0.031	1	4
Ricker (FrD-Peak)	-0.013	0.013	6	0.058	9	1.225	1.224774	10	0.109	9	11
Ricker (PDO)	0.009	0.009	3	0.031	2	1.082	1.081981	8	0.042	2	2
Larkin	time series too short to evaluate retrospectively						0				
Ricker-cyc	time series too short to evaluate retrospectively						0				

SEYMOUR

	MRE	Abs(MRE)	Rank	MAE	Rank	MPE	Abs(MPE)	Rank	RMSE	Rank	Overall Rank
LLY	0.001	0.001	3	0.186	18	2.094	2.093507	17	0.266	14	13
TSA	-0.022	0.022	10	0.142	15	2.978	2.97768	18	0.198	12	15
R1C	-0.001	0.001	3	0.111	9	0.744	0.744028	5	0.179	10	5
R2C	0	0	1	0.119	12	0.744	0.743843	4	0.181	11	6
RAC	-0.024	0.024	11	0.091	4	0.669	0.668978	2	0.151	3	3
MRS	0.057	0.057	15	0.115	11	1.253	1.252585	14	0.208	13	14
RS1	0.091	0.091	17	0.16	17	1.703	1.703099	16	0.301	17	18
RS2	0.09	0.09	16	0.156	16	1.198	1.197796	12	0.338	18	17
RSC	0.105	0.105	18	0.136	13	1.419	1.418539	15	0.288	15	16
Ricker	-0.014	0.014	7	0.1	7	0.940	0.939577	10	0.157	5	7
Power	0	0	1	0.099	5	0.927	0.926971	8	0.155	4	1
Larkin	0.009	0.009	6	0.069	1	1.079	1.079072	11	0.093	1	2
Ricker-cyc	0.031	0.031	13	0.069	1	1.220	1.219845	13	0.097	2	7
Ricker (FrD-mean)	-0.014	0.014	7	0.111	9	0.937	0.937426	9	0.171	9	11
Ricker (Ei)	-0.027	0.027	12	0.099	5	0.865	0.864692	7	0.162	7	9
Ricker (Pi)	-0.044	0.044	14	0.089	3	0.281	0.281408	1	0.159	6	4
Ricker (FrD-Peak)	-0.016	0.016	9	0.109	8	0.852	0.852355	6	0.17	8	9
Ricker (PDO)	-0.002	0.002	5	0.141	14	0.678	0.677869	3	0.294	16	12

RUN-TIMING: SUMMER

CHILKO

	MRE	Abs(MRE)	Rank	MAE	Rank	MPE	Abs(MPE)	Rank	RMSE	Rank	Overall Rank
LLY	0.037	0.037	5	0.969	17	0.677	0.676992	18	1.333	18	15
TSA	-0.325	0.325	21	0.923	15	0.533	0.533177	12	1.305	16	17
R1C	0.134	0.134	14	1.167	21	0.764	0.763835	20	1.61	22	21
R2C	0.132	0.132	13	1.121	20	0.774	0.774445	22	1.439	20	20
RAC	-0.323	0.323	20	0.932	16	0.457	0.456563	6	1.364	19	16
MRS	0.882	0.882	25	1.495	25	1.514	1.514295	26	1.953	23	25
RS1	1.023	1.023	26	2.063	27	1.314	1.314409	25	3.369	27	26
RS2	0.41	0.41	23	1.395	24	0.808	0.808419	23	2.064	24	24
RSC	1.094	1.094	27	1.727	26	1.613	1.612546	27	2.265	26	27
MRJ	0.074	0.074	9	0.874	14	0.548	0.548359	14	1.201	13	13
RJ1	0.401	0.401	22	1.329	23	0.716	0.715675	19	2.125	25	23
RJ2	0.215	0.215	19	1.176	22	0.629	0.62866	17	1.562	21	22
RJC	0.16	0.16	16	0.985	19	0.587	0.587218	16	1.288	15	18
Ricker	-0.036	0.036	4	0.791	4	0.544	0.544354	13	1.131	4	3
Power	0.201	0.201	18	0.982	18	0.765	0.764949	21	1.316	17	19
Larkin	0.709	0.709	24	0.728	1	1.078	1.078153	24	0.978	1	13
Ricker (FrD-mean)	-0.052	0.052	6	0.822	10	0.527	0.52734	10	1.146	7	8
Ricker (Ei)	0.004	0.004	2	0.785	3	0.533	0.532847	11	1.083	2	1
Ricker (Pi)	-0.105	0.105	11	0.835	12	0.482	0.482281	9	1.157	9	11
Ricker (FrD-Peak)	0.001	0.001	1	0.8	6	0.549	0.549423	15	1.109	3	3
Ricker (PDO)	-0.106	0.106	12	0.799	5	0.464	0.464084	8	1.158	10	9
Power (juv)	-0.064	0.064	7	0.78	2	0.418	0.417945	4	1.133	5	1
Power(juv)(FrD-mean)	-0.066	0.066	8	0.819	9	0.393	0.392725	3	1.139	6	5
Power (juv) (Ei)	-0.017	0.017	3	0.818	8	0.463	0.463397	7	1.178	12	7
Power (juv) (Pi)	-0.19	0.19	17	0.827	11	0.318	0.317599	1	1.173	11	10
Power(juv)(FrD-Peak)	-0.087	0.087	10	0.8	6	0.420	0.420216	5	1.152	8	6
Power (juv) (PDO)	-0.142	0.142	15	0.855	13	0.362	0.362295	2	1.216	14	12

LATE STUART

	MRE	abs(MRE)	Rank	MAE	Rank	MPE	abs(MPE)	Rank	RMSE	Rank	Overall Rank
LLY	-0.009	0.009	3	1.133	16	2.509	2.508768	15	1.808	15	13
TSA	-0.281	0.281	14	0.697	7	4.331	4.331142	18	1.261	11	14
R1C	-0.001	0.001	1	0.485	1	0.814	0.814111	2	0.818	1	1
R2C	0.003	0.003	2	0.541	5	0.883	0.882527	3	1.002	5	2
RAC	-0.314	0.314	15	0.527	4	0.057	0.056913	1	0.961	4	5
MRS	0.811	0.811	17	1.128	15	2.287	2.28703	12	2.542	17	15
RS1	1.263	1.263	19	1.546	19	4.913	4.913411	19	3.403	19	18
RS2	0.996	0.996	18	1.269	18	3.750	3.75027	17	3.344	18	17
RSC	0.698	0.698	16	1.142	17	2.456	2.455757	13	2.276	16	16
Ricker	-0.09	0.09	7	0.743	10	2.007	2.007324	10	1.239	10	8
Power	-0.19	0.19	13	0.513	2	1.321	1.320733	5	0.957	3	3
Larkin	0.1	0.1	9	0.76	12	1.371	1.371138	6	1.234	9	6
Ricker-cyc	0.071	0.071	5	0.696	6	0.893	0.893179	4	1.229	8	3
Ricker (FrD-mean)	-0.092	0.092	8	0.727	8	2.577	2.576565	16	1.217	7	9
Ricker (Ei)	0.032	0.032	4	0.782	14	2.471	2.470623	14	1.377	14	12
Ricker (Pi)	-0.173	0.173	11	0.755	11	1.489	1.489286	9	1.308	13	11
Ricker (FrD-Peak)	-0.101	0.101	10	0.735	9	2.260	2.259875	11	1.209	6	6
Ricker (PDO)	-0.173	0.173	11	0.774	13	1.428	1.427629	7	1.278	12	10

QUESNEL

	MRE	abs(MRE)	Rank	MAE	Rank	MPE	Abs(MPE)	Rank	RMSE	Rank	Overall Rank
LLY	-0.002	0.002	1	3.551	18	3.637	3.636715	17	5.005	15	14
TSA	-1.385	1.385	4	2.283	10	7.416	7.415791	18	3.688	5	9
R1C	-0.08	0.08	2	1.102	1	0.226	0.225797	2	1.846	1	1
R2C	-0.218	0.218	3	1.337	2	0.069	0.069477	1	2.262	2	2
RAC	-1.515	1.515	6	1.639	3	-0.642	0.642428	3	2.995	3	3
MRS	2.565	2.565	17	3.164	16	2.705	2.705071	15	5.974	17	17
RS1	1.587	1.587	7	1.911	4	1.790	1.790204	14	3.354	4	4
RS2	1.995	1.995	13	2.262	8	1.606	1.605598	13	4.007	8	11
RSC	2.969	2.969	18	3.453	17	3.209	3.208887	16	6.522	18	18
Ricker	1.918	1.918	11	2.391	12	1.230	1.23047	10	4.704	12	12
Power	1.478	1.478	5	2.18	7	1.188	1.187702	8	4.255	10	6
Larkin	2.019	2.019	14	2.089	5	1.028	1.02808	5	4.092	9	7
Ricker-cyc	1.838	1.838	10	2.267	9	0.823	0.823213	4	3.87	6	4
Ricker (FrD-mean)	1.977	1.977	12	2.47	13	1.276	1.275507	11	4.79	13	13
Ricker (Ei)	2.123	2.123	16	2.611	14	1.169	1.168812	7	4.992	14	14
Ricker (Pi)	2.039	2.039	15	2.646	15	1.114	1.113646	6	5.187	16	16
Ricker (FrD-Peak)	1.655	1.655	8	2.098	6	1.375	1.375394	12	3.953	7	7
Ricker (PDO)	1.806	1.806	9	2.291	11	1.189	1.188846	9	4.432	11	10

STELLAKO

	MRE	abs(MRE)	Rank	MAE	Rank	MPE	abs(MPE)	Rank	RMSE	Rank	Overall Rank
LLY	0.002	0.002	1	0.285	13	0.398	0.397795	3	0.354	13	6
TSA	-0.021	0.021	3	0.208	1	0.422	0.421561	4	0.263	2	1
R1C	0.054	0.054	10	0.252	9	0.348	0.347706	1	0.348	12	8
R2C	0.059	0.059	11	0.208	1	0.363	0.362758	2	0.264	3	2
RAC	-0.02	0.02	2	0.251	7	0.460	0.459725	7	0.299	8	5
MRS	0.273	0.273	16	0.455	16	1.110	1.11016	17	0.619	16	16
RS1	0.438	0.438	19	0.62	19	1.059	1.059216	15	1.233	19	19
RS2	0.402	0.402	18	0.555	18	1.065	1.064595	16	1.113	18	17
RSC	0.349	0.349	17	0.526	17	1.282	1.281988	19	0.754	17	17
Ricker	0.052	0.052	8	0.25	6	0.515	0.515386	11	0.295	7	8
Power	0.09	0.09	13	0.299	15	0.552	0.551697	13	0.356	14	14
Larkin	0.173	0.173	14	0.236	3	0.803	0.802536	14	0.262	1	8
Ricker-cyc	0.243	0.243	15	0.298	14	1.237	1.236868	18	0.378	15	15
Ricker (FrD-mean)	0.047	0.047	7	0.251	7	0.492	0.49206	10	0.293	6	6
Ricker (Ei)	0.053	0.053	9	0.255	10	0.517	0.517453	12	0.301	9	12
Ricker (Pi)	0.028	0.028	4	0.249	5	0.442	0.441949	6	0.291	5	4
Ricker (FrD-Peak)	0.043	0.043	6	0.264	11	0.473	0.4734	9	0.306	10	11
Ricker (PDO)	0.029	0.029	5	0.245	4	0.438	0.43803	5	0.286	4	3
KF	0.087	0.087	12	0.274	12	0.460	0.459789	8	0.346	11	13

RUN-TIMING: LATE

CULTUS

	MRE	Abs(MRE)	Rank	MAE	Rank	MPE	Abs (MPE	Rank	RMSE	Rank	Overall Rank
LLY	0.001	0.001	3	0.024	14	4.022	4.021733	13	0.04	16	12
TSA	0.026	0.026	16	0.034	17	53.697	53.69707	17	0.035	14	16
R1C	0.003	0.003	9	0.015	11	5.434	5.433674	15	0.023	11	12
R2C	0.007	0.007	12	0.016	12	5.135	5.135025	14	0.024	12	15
RAC	0.032	0.032	17	0.032	15	36.604	36.60414	16	0.043	17	17
MRS	-0.008	0.008	14	0.012	10	1.378	1.377892	4	0.022	10	10
MRJ	-0.004	0.004	11	0.01	3	1.526	1.525584	5	0.016	4	6
RJ1	-0.007	0.007	12	0.022	13	0.916	0.915888	2	0.028	13	11
RJ2	-0.022	0.022	15	0.032	15	0.558	0.558156	1	0.039	15	12
RJC	0	0	1	0.011	9	1.855	1.854739	6	0.017	6	5
Smolt-Jack (1950-2009)	0.003	0.003	9	0.009	1	1.303	1.303198	3	0.013	1	2
Power (juv)	-0.001	0.001	3	0.01	3	2.941	2.940953	10	0.018	7	6
Power (juv)(FrD-mean)	-0.001	0.001	3	0.01	3	2.660	2.659589	7	0.018	7	4
Power (juv) (Ei)	-0.001	0.001	3	0.01	3	2.973	2.973158	12	0.018	7	8
Power (juv) (Pi)	0.002	0.002	8	0.01	3	2.970	2.970303	11	0.015	3	8
Power(juv)(FrD-Peak)	0	0	1	0.009	1	2.734	2.733851	8	0.013	1	1
Power(juv)(PDO)	0.001	0.001	3	0.01	3	2.807	2.80684	9	0.016	4	3

HARRISON

	MRE	Abs(MRE)	Rank	MAE	Rank	MPE	Abs (MPE	Rank	RMSE	Rank	Overall Rank
LLY	0	0	1	0.05	12	4.443	4.443087	7	0.082	11	8
TSA	-0.026	0.026	13	0.039	8	2.569	2.569304	4	0.074	8	11
R1C	-0.014	0.014	11	0.043	11	0.550	0.5503	2	0.086	12	12
R2C	-0.02	0.02	12	0.039	8	0.448	0.447856	1	0.078	10	8
RAC	-0.027	0.027	14	0.035	1	0.650	0.649991	3	0.076	9	6
MRS	0.006	0.006	9	0.054	13	2.933	2.93333	5	0.118	13	13
RS1	0.163	0.163	15	0.186	15	13.839	13.83927	16	0.613	15	15
RS2	0.164	0.164	16	0.201	16	9.137	9.136778	15	0.798	16	16
RSC	0.011	0.011	10	0.058	14	3.069	3.068792	6	0.122	14	14
Ricker	-0.003	0.003	3	0.038	7	5.352	5.352081	12	0.068	5	6
Power	0	0	1	0.042	10	5.637	5.637441	14	0.07	7	10
Ricker (FrD-mean)	-0.003	0.003	3	0.037	5	5.098	5.097764	9	0.066	1	2
Ricker (Ei)	-0.003	0.003	3	0.037	5	5.440	5.440421	13	0.067	3	4
Ricker (Pi)	-0.005	0.005	8	0.036	2	5.217	5.217198	10	0.067	3	3
Ricker (FrD-Peak)	-0.004	0.004	6	0.036	2	5.007	5.006961	8	0.066	1	1
Ricker (PDO)	-0.004	0.004	6	0.036	2	5.280	5.279642	11	0.068	5	4

LATE SHUSWAP

	MRE	Abs(MRE)	Rank	MAE	Rank	MPE	Abs (MPE	Rank	RMSE	Rank	Overall Rank
LLY	0	0	1	3.813	18	11.283	11.283	17	5.214	18	13
TSA	-0.099	0.099	8	2.788	17	67.213	67.213	18	3.472	16	15
R1C	0.024	0.024	3	0.852	4	0.790	0.790	6	1.659	6	2
R2C	-0.006	0.006	2	0.978	8	1.069	1.069	12	1.737	8	7
RAC	-0.127	0.127	9	0.769	2	0.814	0.814	10	1.48	3	5
MRS	1.049	1.049	17	1.536	14	1.555	1.555	13	3.32	15	15
RS1	1.449	1.449	18	2.178	16	2.196	2.196	16	4.898	17	18
RS2	0.959	0.959	16	1.589	15	1.992	1.992	15	3.213	14	17
RSC	0.816	0.816	15	1.48	13	1.732	1.732	14	2.958	13	14
Ricker	0.048	0.048	4	0.92	6	0.799	0.799	8	1.579	5	3
Power	0.505	0.505	13	1.149	12	0.793	0.793	7	2.339	12	12
Larkin	0.077	0.077	6	0.773	3	0.607	0.607	2	1.247	2	1
Ricker-cyc	0.429	0.429	11	0.725	1	0.848	0.848	11	1.2	1	5
Ricker (FrD-mean)	-0.153	0.153	10	1.116	10	0.751	0.751	5	1.86	9	10
Ricker (Ei)	-0.459	0.459	12	0.94	7	0.708	0.708	4	1.669	7	7
Ricker (Pi)	-0.677	0.677	14	1.073	9	0.209	0.209	1	2.077	11	11
Ricker (FrD-Peak)	0.076	0.076	5	0.893	5	0.809	0.809	9	1.533	4	3
Ricker (PDO)	-0.09	0.09	7	1.148	11	0.655	0.655	3	1.951	10	9

PORTAGE

	MRE	Abs(MRE)	Rank	MAE	Rank	MPE	Abs(MPE)	Rank	RMSE	Rank	Overall Rank
LLY	0.002	0.002	2	0.054	16	1.069	1.069185	7	0.078	16	10
TSA	-0.015	0.015	11	0.041	9	1.236	1.235601	11	0.06	10	10
R1C	0.005	0.005	3	0.046	11	1.039	1.039401	6	0.063	13	9
R2C	0.006	0.006	4	0.049	15	1.384	1.383746	12	0.065	14	13
RAC	-0.018	0.018	13	0.037	4	0.444	0.44358	1	0.056	6	6
MRS	0.03	0.03	16	0.048	13	2.026	2.026076	15	0.065	14	16
RS1	0.029	0.029	15	0.059	17	1.721	1.720507	14	0.094	17	17
RS2	0.016	0.016	12	0.046	11	1.435	1.435019	13	0.062	12	14
RSC	0.024	0.024	14	0.048	13	2.205	2.204842	17	0.06	10	15
Ricker	-0.001	0.001	1	0.036	2	1.224	1.223924	10	0.049	1	2
Power	-0.008	0.008	7	0.035	1	0.856	0.855655	3	0.05	2	1
Larkin	0.03	0.03	16	0.04	8	2.188	2.187964	16	0.05	2	12
Ricker (FrD-mean)	-0.006	0.006	4	0.037	4	1.150	1.149911	9	0.055	5	5
Ricker (Ei)	-0.012	0.012	8	0.039	7	0.912	0.912322	5	0.058	8	7
Ricker (Pi)	-0.013	0.013	9	0.036	2	0.828	0.828313	2	0.057	7	3
Ricker (FrD-Peak)	-0.006	0.006	4	0.037	4	1.133	1.13342	8	0.054	4	3
Ricker (PDO)	-0.013	0.013	9	0.041	9	0.890	0.890455	4	0.058	8	8
Ricker-cyc	time series too short to evaluate retrospectively										

WEAVER

	MRE	Abs(MRE)	Rank	MAE	Rank	MPE	Abs (MPE	Rank	RMSE	Rank	Overall Rank
LLY	-0.001	0.001	1	0.241	21	0.559	0.558546	17	0.298	21	18
TSA	0.036	0.036	11	0.215	20	0.927	0.926733	22	0.245	8	19
R1C	0.093	0.093	24	0.295	25	1.552	1.552007	26	0.417	26	26
R2C	0.118	0.118	25	0.272	24	1.733	1.73321	27	0.389	24	25
RAC	0.053	0.053	19	0.194	17	1.079	1.079027	25	0.275	18	23
MRS	-0.052	0.052	17	0.202	18	0.550	0.549677	15	0.28	19	21
RS1	0.205	0.205	27	0.381	27	1.056	1.055718	24	0.616	27	27
RS2	0.027	0.027	8	0.267	23	0.936	0.936032	23	0.371	23	22
RSC	-0.021	0.021	4	0.211	19	0.726	0.726076	21	0.297	20	20
MRJ	0.004	0.004	2	0.181	4	0.5422	0.542172	14	0.25	10	6
RJ1	0.13	0.13	26	0.298	26	0.6266	0.626558	19	0.408	25	24
RJ2	0.027	0.027	8	0.244	22	0.4445	0.444507	4	0.314	22	15
RJC	0.025	0.025	6	0.173	3	0.4784	0.478444	6	0.248	9	2
Ricker	-0.026	0.026	7	0.187	9	0.691	0.69147	20	0.257	13	11
Power	-0.056	0.056	20	0.19	14	0.504	0.50355	10	0.252	11	13
Larkin	-0.073	0.073	23	0.187	9	0.3783	0.378338	2	0.265	16	12
Ricker (FrD-mean)	-0.036	0.036	11	0.19	14	0.621	0.621308	18	0.253	12	13
Ricker (Ei)	-0.049	0.049	16	0.189	11	0.555	0.555034	16	0.26	15	17
Ricker (Pi)	-0.068	0.068	22	0.192	16	0.417	0.417133	3	0.265	16	16
Ricker (FrD-Peak)	-0.052	0.052	17	0.186	6	0.518	0.518328	11	0.258	14	10
Ricker (PDO)	-0.056	0.056	20	0.158	2	0.255	0.254689	1	0.217	2	3
Power (juv)	-0.032	0.032	10	0.181	4	0.5199	0.519886	12	0.232	4	6
Power (juv)(FrD-mean)	-0.023	0.023	5	0.186	6	0.5316	0.531576	13	0.231	3	4
Power (juv) (Ei)	-0.038	0.038	14	0.189	11	0.4992	0.499242	9	0.243	6	9
Power (juv) (Pi)	-0.044	0.044	15	0.189	11	0.4625	0.462492	5	0.243	6	8
Power (juv) (FrD-Peak)	-0.036	0.036	11	0.186	6	0.4942	0.494227	7	0.24	5	5
Power (juv) (PDO)	-0.008	0.008	3	0.152	1	0.4956	0.495567	8	0.207	1	1
Ricker-cyc	time series too short										

BIRKENHEAD

	MRE	Abs(MRE)	Rank	MAE	Rank	MPE	Abs (MPE	Rank	RMSE	Rank	Overall Rank
LLY	0.016	0.016	3	0.356	13	0.688	0.688	1	0.491	12	**8**
TSA	-0.097	0.097	11	0.315	10	0.993	0.993	11	0.444	10	**13**
R1C	0.018	0.018	4	0.352	12	0.944	0.944	10	0.522	14	**11**
R2C	0.04	0.04	8	0.359	14	1.463	1.463	12	0.498	13	**14**
RAC	-0.105	0.105	12	0.316	11	0.840	0.840	7	0.449	11	**12**
MRS	0.331	0.331	15	0.55	15	2.794	2.794	15	0.754	15	**15**
RS1	0.642	0.642	18	0.896	18	2.877	2.877	16	1.886	18	**18**
RS2	0.526	0.526	17	0.801	17	3.402	3.402	18	1.484	17	**17**
RSC	0.388	0.388	16	0.612	16	3.188	3.188	17	0.854	16	**16**
Ricker	**-0.041**	**0.041**	**9**	**0.26**	**5**	**0.759**	**0.759**	**2**	**0.403**	**5**	**3**
Power	**-0.011**	**0.011**	**2**	**0.252**	**4**	**0.856**	**0.856**	**8**	**0.388**	**4**	**2**
Larkin	0.151	0.151	13	0.186	1	1.587	1.587	13	0.222	1	**7**
Ricker-cyc	0.167	0.167	14	0.196	2	1.686	1.686	14	0.261	2	**10**
Ricker (FrD-mean)	-0.043	0.043	10	0.285	9	0.793	0.793	5	0.422	7	**9**
Ricker (Ei)	-0.021	0.021	5	0.276	8	0.819	0.819	6	0.422	7	**6**
Ricker (Pi)	-0.029	0.029	6	0.271	7	0.781	0.781	3	0.422	7	**4**
Ricker (FrD-Peak)	-0.039	0.039	7	0.264	6	0.783	0.783	4	0.407	6	**4**
Ricker (PDO)	**-0.007**	**0.007**	**1**	**0.239**	**3**	**0.928**	**0.928**	**9**	**0.379**	**3**	**1**