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Pre-season run size forecasts for Fraser River sockeye for 2006

Prévision présaison des remontes de saumon rouge du fleuve Fraser pour 2006

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Abstract

Pre-season abundance forecasts are used for pre-season planning and during in-season assessments of run size for fishery management. Forecasts are produced annually by Fisheries and Oceans Canada (DFO). Forecasts of sockeye returns typically are made using a variety of models depending on data availability. In this year's assessment, a suite of biological and naïve models were assessed against standard performance measures. The biological models include models relating recruitment (and returns) to predictor variables (escapement, fry, smolts, and age-3 (jack) siblings in the case of Cultus Lake sockeye). We also investigate some environmental variables on model performance. These include Fraser River discharge, sea surface temperature (SST) data and the Pacific Decadal Oscillation index (PDO). Uncertainty in forecasts for 2006 is captured using Bayesian statistical inference. Nineteen stocks and four run timing groups were forecasted. Most of the forecasts are associated with large uncertainty. This is consistent with previous Fraser sockeye forecasts PSARC reviews and recent research on coast-wide salmon stocks ranging from Alaska to BC. Pre-season forecasts at the 50% probability level for all stocks totalled 17.4 million sockeye for 2006. By timing group, this includes 84,000 Early Stuart sockeye, 1.3 million Early Summer sockeye, 7.2 million Summer run and 8.8 million Late run sockeye.

Résumé

Les gestionnaires des pêches utilisent des prévisions présaison des remontes pour effectuer la planification préalable à la saison et évaluer la remonte pendant la saison. Ces prévisions sont produites chaque année par Pêches et Océans Canada (MPO). Les prévisions des remontes de saumons rouges sont habituellement effectuées à l'aide de différents modèles, selon la disponibilité des données. Au cours de l'évaluation de cette année, nous avons examiné une série de modèles biologiques et naïfs par rapport à des mesures de rendement standard. Parmi les modèles biologiques figurent des modèles liant le recrutement (et les remontes) à des variables explicatives (échappées, alevins, saumoneaux et saumons d'un an en mer (âge 3) dans le cas du saumon rouge du lac Cultus). Nous avons également investigué l'effet de certaines variables environnementales sur le rendement du modèle. Parmi celles-ci figurent le débit du fleuve Fraser, des données sur la température à la surface de la mer et l'indice d'oscillation décennale du Pacifique. L'inférence statistique bayesienne nous permet de prendre en considération l'incertitude dans les prévisions pour 2006. Nous avons établi des prévisions pour dix-neuf stocks et quatre groupes à période de remonte différente. La plupart des prévisions sont marquées par de grandes incertitudes, une situation qui concorde avec les examens de prévisions antérieures sur le saumon rouge du fleuve Fraser effectués par le CEESP et avec des recherches récentes sur les stocks de saumons répartis le long de la côte, de l'Alaska à la Colombie-Britannique. Les prévisions présaison pour tous les stocks, à un niveau de probabilité de 50 %, totalisaient 17,4 millions de saumons rouges pour 2006. Par groupe de période de remonte, les chiffres sont de 84 000 pour les poissons de remonte hâtive de la Stuart, 1,3 millions pour les poissons de remonte hâtive d'été, 7,2 millions pour le groupe de remonte d'été et 8,8 millions pour les saumons rouges de remonte tardive.

1. Introduction

Pre-season abundance forecasts of returning adult sockeye are requested by resource managers. They are used for pre-season planning and during in-season assessments of run size for fishery management. Pre-season forecasts are most useful early in the summer fishing season before reliance on in-season run size estimates. Forecasts are produced by Fisheries and Oceans Canada (DFO) as agreed under the US-Canada Pacific Salmon Treaty. Forecasts have been reviewed annually and a series of reports are publicly available:

http://www.dfo-mpo.gc.ca/csas/csas/Publications/Pub_Index_e.htm .

Forecasts of salmon returns are typically made using a variety of models depending on data availability. For all stocks the data include spawning escapement estimates that date back to the late 1940s. Nineteen stocks have paired escapement and recruitment data. A subset of stocks have juvenile abundance data in addition to escapement data. Several small populations only have escapement data. Data sources are described in Section 2. In this year's assessment, a suite of biological and naïve models are assessed against standard performance measures. The biological models include models relating recruitment (and returns) to predictor variables (escapement, fry, smolts, and age-3 (jack) siblings in the Case of Cultus Lake sockeye). We also investigate some environmental variables on model performance. These include Fraser River discharge, sea surface temperature (SST) data and the Pacific Decadal Oscillation index (PDO). Mueter et al. (2002) detected significant spatial covariation between coastal SST and the recruits-per-spawner survival index. Beamish et al. (2004) showed the PDO index significantly explained Fraser sockeye survival when data were aggregated by specific regimes compared to disaggregated data.

Uncertainty in forecasts for 2006 are captured using Bayesian statistical inference. The methodology is described in Section 3. Results of the analysis including 2006 forecasts are presented in Section 4. In keeping with past practice, forecasts are presented as distributions of age 4 + age 5 returns given data uncertainty. Finally, a discussion of results is presented in Section 5.

2. Data sources

Spawning escapement, fry, fall-fry, smolt and recruit estimates by stock are the primary data inputs. Most of these data were provided by the Pacific Salmon Commission in a Microsoft Access database. The spawning escapement data are estimates of the number of spawning females contributing to the spawning population based on sampling for potential egg deposition. These data are referred to as "effective females". Total adult escapement data was used for Cultus Lake sockeye because estimates of effective females are poorly determined for that stock. Many of the nineteen stocks have paired escapement – recruitment for 53 years (brood years 1948-2000). Escapement data are available up to the 2002 brood year (2006 return year). Age 3, 4 and 5 recruits were used in the analysis.

Estimates of juvenile sockeye fry from Nadina, Gates and Weaver spawning channels are available beginning respectively in 1968, 1973 and 1965 (Roberta Cooke, Fisheries and Oceans Canada, personal communication). In addition to the estimates of channel fry production, each of these systems have historical estimates of stream (ie 'wild') fry production (Gates: 1968-1989; Nadina: 1973-1984; Weaver: 1951-1988, broken series). The PSC production database also maintains these same records for channel and stream fry production in these three systems. For years where estimates of both channel and stream fry emigration exist, the total fry production is the sum of both estimates. Total production in recent years lacking stream fry estimates, are estimated by summing channel production and the product of stream effective female escapement and average historical stream fry production per effective female. Fry data for a maximum of three spawning locations (Forfar, Gluske and Kynoch creeks) in the Early Stuart timing group are available since 1990. (Keri Benner, Fisheries and Oceans Canada, personal communication). These data were expanded by the ratio of escapement in the sampled systems to the total Early Stuart escapement to estimate the total fry production for years that fry data are available.

Estimates of age-1 smolts for Chilko and Cultus sockeye were also used in the analysis. Chilko smolt data is available for most years starting in brood year 1949. Cultus smolts are available from brood year 1924 (Schubert et al. 2004) but recently have been estimated intermittently since the early 1950s with 28 years of data available in the 1951 and 2002 interval. Cultus sockeye smolt output has been supplemented by hatchery-reared smolts in recent years. Estimates of natural and hatchery survival rates have been estimated from marked-unmarked Cultus smolt-to-adult returns and assumed exploitation rates (Mike Bradford, Fisheries and Oceans Canada, personal communication). The data were used to estimate smolt survival rates in terms of natural smolt equivalents for years with hatchery supplementation (1999-2002 brood years). Estimates of jack returns to Cultus Lake sockeye in 2005 were derived from Sweltzer Creek fence counts. During August 18 to September 12 visual distinction between males, females, and jacks proved difficult. During that time period sockeye appeared to be smaller than usual and did not have well developed secondary sexual characteristics and small fish were often identified as females (Sue Grant, Fisheries and Oceans Canada, personal communication). After September 13 brood stock collection occurred and each fish was individually handled, secondary sexual characteristics were more developed, and scale analysis confirmed that the smaller fish were jacks rather than females. The August 18 - September 12 Cultus data were "corrected" by multiplying the total numbers of sockeye by the estimated proportions of males, females and jacks for the post September 12 period.

Mean spring-summer lighthouse SST data for April to July were derived from the data webpage of the Canadian Institute for Oceanographic Sciences website (http://www-sci.pac.dfo-mpo.gc.ca/osap/data/SearchTools/Searchlighthouse_e.htm). The temperature data were sampled at lighthouse locations which we felt best likely represented conditions experienced by juveniles during their initial stages of migration in the marine environment in the juvenile ocean entry year. The two locations were Entrance Island (Strait of Georgia, proximate to Nanaimo) and Pine Island (NE corner of Vancouver Island).

Mean Winter (November-March) PDO indices were from

http://jisao.washington.edu/pdo/PDO.latest .

Mean April-June Fraser River discharge and peak discharge data at Hope BC in the juvenile ocean-entry-year were accessed at the "Archived Hydrometric Data" webpage of Environment Canada (http://www.wsc.ec.gc.ca/hydat/H2O/).

The complete set of data for each stock used in the analysis are listed in Appendices. Appendix Table 1 lists the biological data. Appendix Table 2 lists the environmental data.

3. Methods

The methodology consists of the following steps:

1) choose candidate forecast models depending on data availability;
2) perform a retrospective analysis for each stock by sequentially forecasting abundance for years with observations of abundance;

3) evaluate model performance by comparing the retrospective forecasts with the abundance observations based standard performance criteria;

4) Identify the "best" forecast model from step 3 and present forecasts as posterior distributions of returns in 2006.

Several classes of forecast models were considered for each single stock analysis (Table 1). These include 1) naïve models that assume no underlying biological mechanism; 2) escapement-based models that assume a relationship between spawning escapement and adult recruitment; 3) juvenile-based models that theoretically eliminate some of the uncertainty in freshwater survival; 4) escapement or juvenile-based with covariates to assess potential environmental effects on forecast performance; and, 5) a jack-based sibling model for Cultus sockeye that theoretically eliminate some of the uncertainty in both freshwater and marine survival. Age-3 returns for other stocks are not usually available until the spring and jack models were not evaluated in this Working Paper. A mixed-effects (meta-population) model was also assessed using environmental covariates to assess common affects in mixed stock aggregates that potentially cannot be detected at the single stock level given stock-dependent residual noise.

The retrospective analysis compares recruitment (age-4 + age-5) resulting from each brood year escapement rather that the abundance in a given return year (different brood years). This was done to simplify the retrospective procedure for data restricted stocks where uncertainty and "holes" in the data series prevent a complete retrospective comparison of returns from adjacent return years. Abundance forecasts for 2006 however are based estimated age-4 returns from the 2002 brood and age-5 returns from the preceding (2001) brood year.

Effective female spawning escapement for 2001 (age-5 brood) and 2002 (age-4 brood) for populations without recruitment data were combined and reported in Table 3 as "miscellaneous" stocks. For the miscellaneous Late run, the forecast for Late Shuswap and non-Late Shuswap stocks are reported separately. Return forecasts were computed for miscellaneous stocks using the mean R/S for stocks with paired escapement and recruitment data within each timing group. Recruitment is then the product of brood escapement and the mean R/S. A forecast distribution was estimated using the mean and standard deviation for the R/S series. This is consistent with previous methods (i.e. Cass 1998).

3.1. Naïve models

Eight naïve models were considered. The first model, "R1C", simply forecasts abundance from the previous cycle year:

(1) $$R_t = R_{t-4} + \varepsilon_t ,$$

where R_t is the recruitment in the forecast year, R_{t-4} is the observed recruitment four years earlier and ε_t is the residual error with $\varepsilon_t \sim N(0,\sigma^2)$. The second naïve model, "R2C", forecasts abundance based on the geometric mean in the previous two cycle line years:

(2) $$R_t = \exp\left[\frac{\log(R_{t-4}) + \log(R_{t-8})}{2} + \varepsilon_t\right].$$

Similarly, a third naïve model, "RAC", uses the all-cycle line geometric mean abundance available in the data series to forecast abundance.

(3) $$R_t = \exp\left[\frac{\log(R_{t-4}) + \log(R_{t-8})... + \log(R_{t-n})}{N} + \varepsilon_t\right]$$

where *t-n* is the first year in the series of cycle years and *N* is the number of years of data within each cycle line. The fourth naïve model, "TSA", forecasts abundance using the geometric mean recruitment for all cycle lines of the stock.

Four additional naïve models were considered, each with the same structure as the previous four models. These latter four models produce estimates of recruits-per-spawner (like last cycle, like last two cycles, cycle average, time series average) which are then multiplied against the brood escapement to produce a recruitment forecast. Means and standard deviations for the recruitment rates are estimated in log transformed space.

3.2. Biological models

Bayes posterior parameter distributions for the biological models were estimated using BUGS (Bayesian software Using Gibbs Sampling) (http://www.mrc-bsu.cam.ac.uk/bugs/welcome.shtml). The R statistical software and the BRugs library were used to automate the analysis

(http://www.biostat.umn.edu/~brad/software/BRugs/).

BUGS model formulation for each class of forecast model in presented in Appendix 3. In each trial the MCMC burn-in length was set to 1000 samples from the posterior distribution. This was adequate based on the Gelman Rubin statistical test. A further 10,000 posterior samples were then used for parameter estimation.

Two escapement-based models were considered. The Ricker model (Ricker 1954) of the form:

(4) $$\log(R_t / S_t) = a - bS_t + \varepsilon_t$$

and a power model

(5) $$\log(R_t) = a + b\log(S_t) + \varepsilon_t$$

are based on the relationship between recruits R_t and spawning escapement S_t. Prior distributions for *a* and *b* are $Normal(\mu, \sigma^2)$. We assumed non-informative prior distributions a, b ~ $Normal(0,1e6)$ (i.e. a normal distribution with large variance) and allowed the model to estimate the parameters from the data. For stocks with escapement data extending back to the 1950s, the performance of the Ricker and power models were also evaluated for data restricted to each cycle line.

Juvenile data are available for 8 of the 19 stocks. Fry (Early Stuart, Stellako, Nadina, Gates, Weaver), in-lake fall-fry (Quesnel and Shuswap) or smolt data (Chilko and Cultus) were used in a power model for forecast adult abundance.

Annual estimates of spring Fraser River discharge measured at Hope and spring SST measured data in the juvenile ocean-entry year were added to equation (4) and (5). When included in a Ricker model for example:

(7) $$\log(R_t / S_t) = a - bS_t + \gamma X_{t+2} + \varepsilon_t,$$

γ represents the added effect of variable X_{t+2} in addition to spawning escapement S_t on recruitment variation.

The final biological model is a sibling model that includes priors for modelling smolt-to-adult survival and age-3 jack proportions. The priors were based on the historical distribution of smolt survival rates and jack proportions. Jack abundance estimates in 2005 were only available for Cultus Lake sockeye at the time forecasts were requested. For all other stocks, jack data are not usually available until February or March of the forecast year. The joint posterior distribution for smolt survival s_s and jack proportion p_3 given the smolt N_t and jack $E_{3,t}$ abundance for brood year t is

(8) $$\Pr(s_s, p_3 \mid N_t, E_{3,t}) \propto Beta(\alpha_s, \beta_s) Beta(\alpha_3, \beta_3) Poisson(N_t s_s p_3)$$

where s_s is beta distributed with prior parameters α_s *and* β_s. Parameter p_3 is beta distributed with parameters α_3 *and* β_3 estimated from age-3 proportion data

(9) $$p_3 = \frac{R_3}{R_3 + R_4 + R_5}.$$

The likelihood function is Poisson with an expected value equal to the predicted jack abundance based on smolt abundance N_t, smolt survival s_s, and the age-3 proportion p_3. A posterior forecast for the total return (age-4 plus age-5) is

(10) $$R_t = N_{t-1} s_t (1 - p_{t,3}).$$

A version of this model was used to forecast 2005 Cultus Lake sockeye returns (Wood and Parken 2005). Equation (8) includes the additional prior for jack proportions and therefore admits added uncertainty in the historical jack proportion that was fixed in the 2005 forecast.

The proportion of age 4+5 returns R_{4+5} in 2006 for all models was estimated from:

(6) $$R_{4+5} = p_4 R_t + (1 - p_4) R_{t-1}$$

where p_4 is the estimated proportion of recruits R_t returning at age-4 in 2006 and R_{t-1} recruits from the previous brood returning at age-5 in 2006. In the biological models, the prior distribution of p_4 is beta distributed with parameters estimated from the historical data series. In the naïve models p_4 is the historical mean.

Table 1. List of candidate models and data requirements.

Model Name	Model Type	Model Method	Data Applied: Returns	Escpamement & Adult Recruitment	Juvenile Estimates	Environmental
R1C	Naïve	Same returns as 4 years previous	X			
R2C	Naïve	Average of returns 4 & 8 years previous	X			
RAC	Naïve	Average returns on cycle line	X			
TAC	Naïve	Time Series Average Return	X			
Power	Biological	Power function combining all cycles		X		
Power-cyc	Biological	Power function based on 1 cycle line		X		
Ricker	Biological	Ricker function combining all cycles		X		
Ricker-cyc	Biological	Ricker function based on 1 cycle line		X		
Power-fry	Biological				X	
Smolt-Jack	Biological	Bayesian			X	
Ricker-disc	Biological & Environmental	Multiple regression		X		Average spring Fraser discharge
Ricker-peak	Biological & Environmental	Multiple regression		X		Peak spring Fraser discharge
Ricker-ei Ricker-pi	Biological & Environmental	Multiple regression		X		Average spring-summer Lighthouse SST
Ricker-PDO	Biological & Environmental	Multiple regression		X		Winter Pacific Decadal Oscillation Index

3.3. The retrospective analysis

Forecast performance for candidate models was evaluated in a retrospective analysis by comparing forecast recruitment to estimated (observed) recruitment for years that data are available. In this way only data that would have been available for a given past forecast year is used in the analysis. Most model inputs were initialized with data from the first half of the data series. We then sequentially forecast subsequent years for all years in the second half of the series with paired data points of predictor and recruitment variables. Cycle-line models have at most 12 paired data points and were initialized with available data for 1948 to 1990 in an attempt to reduce the error resulting from low sample sizes in the retrospective analysis.

For stocks with juvenile data or juvenile-jack data, the retrospective analysis occurred in a two-step process. We first compared the performance of juvenile (and the juvenile-jack model in the case of Cultus sockeye) against the theoretically less informative escapement-based and the naïve models. In these tests, the performance assessment only included years with juvenile data. Typically, the series of juvenile data is shorter than the escapement and naïve data series. For example, for Early Stuart sockeye, there are 11 years of paired fry and recruit data (1990-2000) to retrospectively compute forecast error and compared model performance. The model was initialized using 1990-1994 paired fry-recruit data. Forecast error was then sequentially computed for each subsequent year starting in 1995 and ending in 2000; the last year with available fry-recruitment data. Beginning in 1995, only forecast data available from 1990 to 1994 was used in the retrospective analysis. A forecast was then projected for 1995 and the median recruitment forecast was compared to the observed recruits in the 1995 brood. The model was updated with data from 1990 to 1995 and the median forecast for 1996 was computed and compared to the observed recruits in 1996. This procedure was continued to obtain 6 years of paired forecast and observed recruit data points (1995-2000) from which to compute the performance measures. Accordingly, all other candidate naïve and escapement models were initialized using all the available data from the first year in the respective data series (1948 for Early Stuart) to 1994 and forecast error was computed for 1995. As with the fry-based model, this procedure continued in annual time steps for the remaining five years of paired data points. This process was repeated for all other candidate models to compute performance measures consistently for the same six years. The "best" model was then selected from among all the candidate naïve and biological models.

Overall, if the theoretically superior juvenile or juvenile-sibling model out performed the escapement or naïve models, then the retrospective analysis was terminated and the "best" model was determined to be the juvenile-based model. If the escapement or naïve models proved superior then a second set of retrospective analyses were performed that excluded the juvenile or juvenile-jack models. This second step occurred to compare model performance over the longer time series of escapement and naïve model data.

3.4. Performance measures

We used three quantitative measures of model performance, referred to as *performance measures* (PM's) (Haeseker et al, 2005):

1. Mean raw error (MRE)
2. Mean absolute error (MAE)
3. Root mean square error (RMSE)

Each of these is a measure of the variability between the forecasted and observed recruitment. MRE is the average, across all forecasted years, of the difference between forecasted and observed recruitment.

$$\text{Mean Raw Error} = \frac{\sum_{t=1}^{n}(\hat{R}_t - R_t)}{n}$$

A value of zero is the best possible result for MRE, but as Haeseker et al (2005) indicate, large positive errors can be offset by large negative errors leading to a mean close to zero. This issue is addressed by use of the MAE measure, whereby the absolute value of the differences is calculated before the average is taken.

$$\text{Mean Absolute Error} = \frac{\sum_{t=1}^{n} \left| \hat{R}_t - R_t \right|}{n}$$

RMSE was the measure used in previous Fraser sockeye forecast papers (Cass, 1998). The RMSE criterion is appropriate for minimizing extreme high or low forecast errors and is calculated as:

$$\text{RMSE} = \sqrt{\frac{\sum_{t=1}^{n} (\hat{R}_t - R_t)^2}{n}}$$

If all three PM's of a single model were close to zero, this would suggest it is the best choice. Thus an averaging of the model's rank placement was calculated. Each forecast model was ranked by it's placement within each performance measure (ie rank=1 for PM closest to zero etc, separately for each stock). Thus, each model would have three values of ranked placement, one for each PM. The average of the overall rank was used to gauge each model's overall placement, and to indicate which model should be chosen for forecasting 2006 returns. The model with the best average rank was judged to be the 'best' forecast. We choose to exclude the MRE in the calculation of the mean rank and therefore in the "best" model selection process. MRE is a measure of positive-negative deviation. In order to rank the absolute value of the MRE is needed. That step negates the usefulness MRE compared to the MAE criteria.

Haeseker et al. (2005) used the RMSE estimate as an indicator of forecast error. As Haeseker et al. point out, the model with the lowest RMSE would have the narrowest confidence intervals around the forecast and the model with the lowest RMSE estimate would also have the lowest variance. The RMSE calculation has a form similar to that for estimating the standard deviation of a sample (σ) and was used here to estimate forecast distributions for stock with best performing naive model assuming log-normal error where:

$$\sigma = \sqrt{\frac{\sum_{t=1}^{n} (\log(\hat{R})_t - \log(R_t))^2}{n}}$$

The amount of variation in observed recruits explained by the model can also be used to judge model performance relative to the amount of error explained by a particular forecast model (Haeseker et al. 2005). This is based on the multiple R-Squared statistic of a linear regression of observed versus forecast abundance from the retrospective analysis. This additional measure was computed for the "best" performing model to assess the overall amount of variation explained by the best performing model.

4. Results

Nineteen stocks were forecasted. The performance of each stock is listed in Appendix Table 4. A survey across stocks suggests that there is no universally optimal forecast model. The breakdown of optimal model by category is presented in Table 2

Table 2. Summary of the best performing forecast model by model category.

Model Category	*Number of Stocks Optimally Forecasted*
Naïve	7 of 19 stocks
Biological Escapement	12 of 19 stocks
Biological Escapement by cycle	1 of 10
Biological Juvenile	4 of 8
Biological Juvenile – jack	1 of 1
Biological & Environmental	1 of 10

Biological models outperformed naïve models by 13:19. Biological models that included juveniles out-performed other model by 4:8. Biological models that included an environmental component perform worse than biological models that consider only stock (or fry) and recruitment. Of the 10 stocks considered to have sufficient data (1950-present) to fit a Ricker cycle-line model only 1 (Seymour) performed best.

Biological models rely on the historical range of escapement and recruitment to confidently fit a relationship. Escapements beyond the range historically experienced can lead to highly uncertain forecasts. In 2002 escapement to Late Shuswap was 1.6 times the historic high, while Harrison escapement was the highest on record. We did not consider escapement-based models in the performance evaluation for these stocks

A summary of the results for each of the major timing groups (Early, Stuart, Early Summer, Summer and Late runs) and stocks within each group are presented below. Return forecasts at the 10%, 25%, 50%, 75% and 90% probability of achieving the specified run size along with mean returns are presented in Table 3. The "best" forecast for 2006 returns is discussed in the context of historical returns. For each of the 19 stock-specific forecasts, the trends in spawning escapement, recruits-per-spawner and return time series are shown in Figures 1, 2 and 3, respectively. In Figure 1, escapement is represented by estimates of effective female spawners. For these plots, only the natural stream spawners are considered, not channel escapement. Channel escapement was excluded to allow for a comparison to the estimated 12 year rate of change line. Rate of change was derived from a linear fit to 12 generational average data points represented by escapement during 1990-2004.

4.1. Early Stuart Sockeye

Despite the limited data series (1990-present) and the potential measurement uncertainty in the expansion from the three index spawning systems to the total system, the highest ranked forecast of the seven candidate models is the fry-based model. The model only explained 25% of the variation in recruitment but ranked the highest in all performance measures (Appendix Table 4).

The 2006 median (50%) forecast is 84,000 sockeye. Based on the 2006 forecast distribution, there is a 25% probability that the return will exceed 124,000 sockeye and a 75% probability that the return will exceed 55,000 sockeye (Table 3).

The limited data and a noticeable outlier (brood year 1996) in the retrospective residuals (Fig. 4A), the posterior distribution (Fig 4B) and the probability distribution (Fig 4C) of the forecast reflect the forecast uncertainty. In five years of the seven retrospective forecasts used to assess error, the 25-75% percentiles of the distribution included the observed recruitment. Recent spawning escapements have declined from the peak in brood year 1993 (Fig. 1) and the recruits-per-spawner has been highly variable but generally has trended downward since the 1980s (Fig 2). Returns for brood years 1970-2004 have been highly variable and are now low (Fig. 3). The median (50%) forecast of 84,000 sockeye is 65% of the 1970-2004 mean return on the 2006 cycle and 23% of the all-year mean for the same period.

Table 3. Pre-season forecasts for 2006 by stock/timing group and probability

Sockeye stock/timing group	Forecast model[b]	Meanc Run Size[c]		Probability of Achieving Specified Run Sizes[a]				
		all cycles	2006 cycle	0.1	0.25	0.5	0.75	0.9
Early Stuart	fry	**362,000**	**129,000**	**175,000**	**124,000**	**84,000**	**55,000**	**38,000**
Early Summer		**492,000**	**586,000**	**4,545,000**	**2,412,000**	**1,303,000**	**721,000**	**435,000**
Bowron	Ricker-pi	35,000	21,000	85,000	54,000	34,000	22,000	15,000
Fennell [f]	TSA	25,000	13,000	692,000	140,000	24,000	4,000	1,000
Gates [g]	power	58,000	21,000	50,000	31,000	20,000	11,000	7,000
Nadina	fry	82,000	24,000	94,000	54,000	29,000	16,000	9,000
Pitt	power	67,000	56,000	292,000	194,000	124,000	75,000	51,000
Raft	power	29,000	14,000	172,000	109,000	71,000	43,000	28,000
Scotch	R1C	49,000	119,000	567,000	319,000	168,000	89,000	50,000
Seymour	Ricker-cyc	147,000	318,000	1,039,000	656,000	393,000	253,000	166,000
Misc[d]	R/S	-	-	1,553,630	854,554	439,831	208,412	108,115
Summer		**4,669,000**	**3,943,000**	**23,240,000**	**13,052,000**	**7,158,000**	**4,020,000**	**2,484,000**
Chilko	smolt	1,636,000	1,597,000	3,110,000	2,257,000	1,689,000	1,215,000	932,000
Late Stuart	R1C	686,000	305,000	2,017,000	803,000	288,000	104,000	41,000
Quesnel [h]	R1C	1,824,000	1,538,000	16,786,000	9,104,000	4,613,000	2,338,000	1,268,000
Stellako	R1C	523,000	503,000	1,327,000	888,000	568,000	363,000	243,000
Late		**3,196,000**	**8,143,000**	**28,586,000**	**16,314,000**	**8,812,000**	**4,734,000**	**2,726,000**
Cultus	smolt-jack	28,000	28,000	18,000	11,000	5,800	3,000	1,000
Harrison [i]	TSA	35,000	45,000	184,000	90,000	41,000	19,000	9,000
Late Shuswap [j]	RAC	2,206,000	6,745,000	21,605,000	12,359,000	6,644,000	3,572,000	2,043,000
Portage	Ricker	52,000	80,000	269,000	134,000	67,000	34,000	18,000
Weaver	fry	384,000	594,000	1,117,000	656,000	411,000	259,000	175,000
Birkenhead	power	491,000	651,000	1,120,000	713,000	433,000	274,000	183,000
Misc Shuswap[e]	R/S	-	-	3,819,395	2,100,807	1,081,266	512,352	265,786
Misc. non-Shuswap[e]	R/S	-	-	454,052	249,745	128,542	60,909	31,597
TOTAL		**8,719,000**	**12,801,000**	**56,546,000**	**31,902,000**	**17,357,000**	**9,530,000**	**5,683,000**

[a] probability that the actual run size will exceed the specified projection
[b] see text for model descriptions
[c] 1970-2004 mean
[d] unforecasted miscellaneous Early Summer stocks
[e] unforecasted miscellaneous Late stocks

[f] Fennell performance measures of TSA and RAC models were nearly indistinguishable. Brood effective females (4800) were nearly double the cycle line average (2680) and 25% greater than the time series average (3861). This lends weight to the choice of the TSA model which forecasts double that of the RAC model.

[g] Gates Power model ranked third in the MAE measure, because the Fry and MRS models tied for the first rank. This influenced the average rank of the Power model. However, because the Power model is virtually the same or superior on all measures and has narrower bounds on the forecast it was the model chosen.

[h] Fry based models for Quesnel ranked third, with much greater RMSE (uncertainty) than the top two models. The fry model forecast was 6.2M (1.2M - 28M). Additionally, the top three models were all "naive", outperforming all escapement based models. While Quesnel escapement was near the historic maximum, productivity has been low relative to historic values - even during years of low escapement. Fry sizes are lower than average suggesting a conservative forecast would be appropriate.

[i] Harrison brood escapement exceeds the historical range. Use of any escapement based model would be invalid. The best ranking naïve model was chosen.

[j] The RAC model outperformed all fry models for Late Shuswap. Fry models still have great uncertainty because of their short time series (forecast 9M intervals ranging 3M to 39M). Brood escapement was 1.6x the historic maximum. Any escapement based forecast would be outside the predictive range of the model, making it invalid. Therefore only naive models were considered.

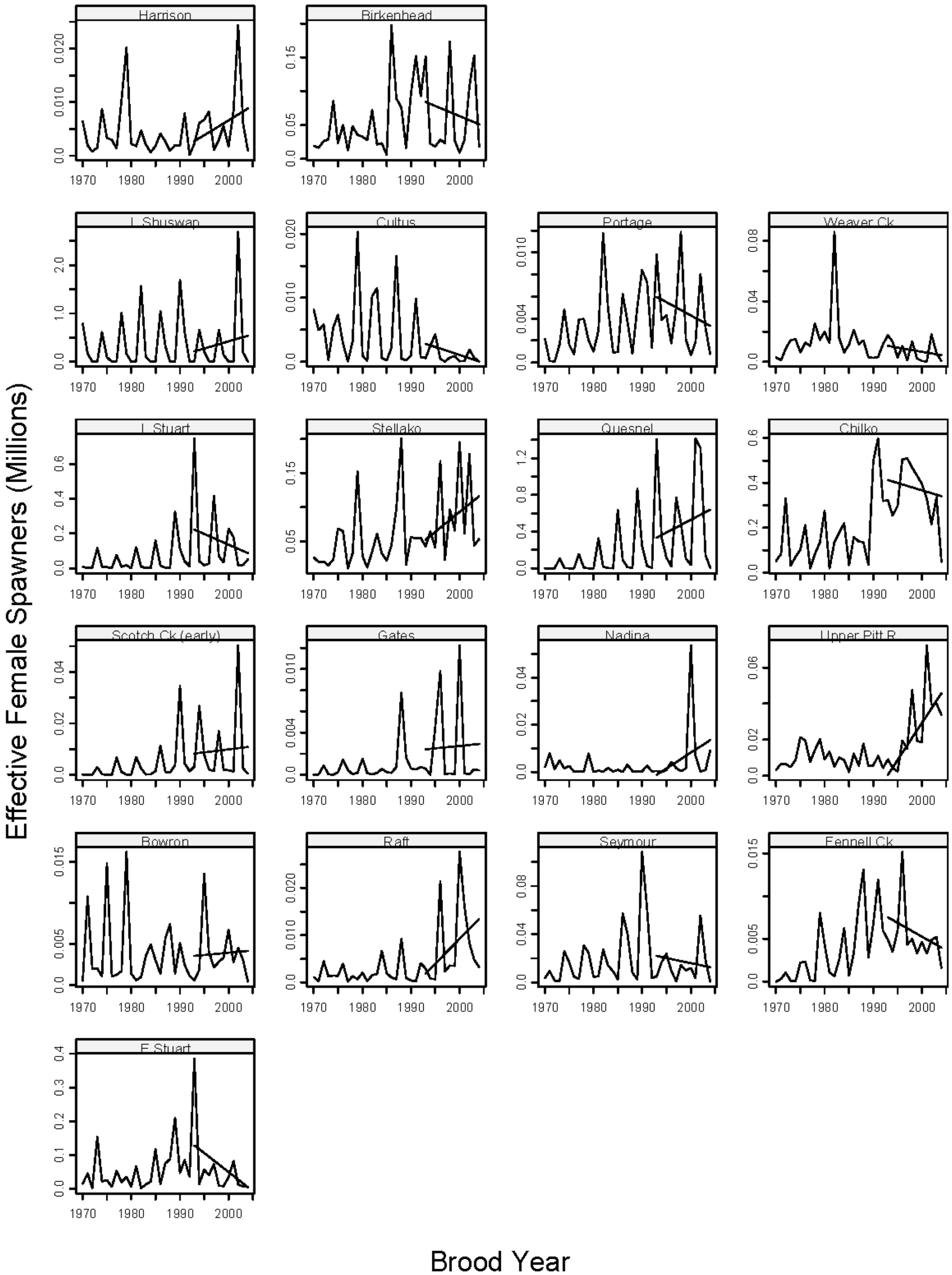

Figure 1. Time series of effective female spawner escapement, excluding channels. The straight line in each plot, indicating a smoothed rate of change for each stock, represents a linear fit to 10 years of generational averages. See text for further details.

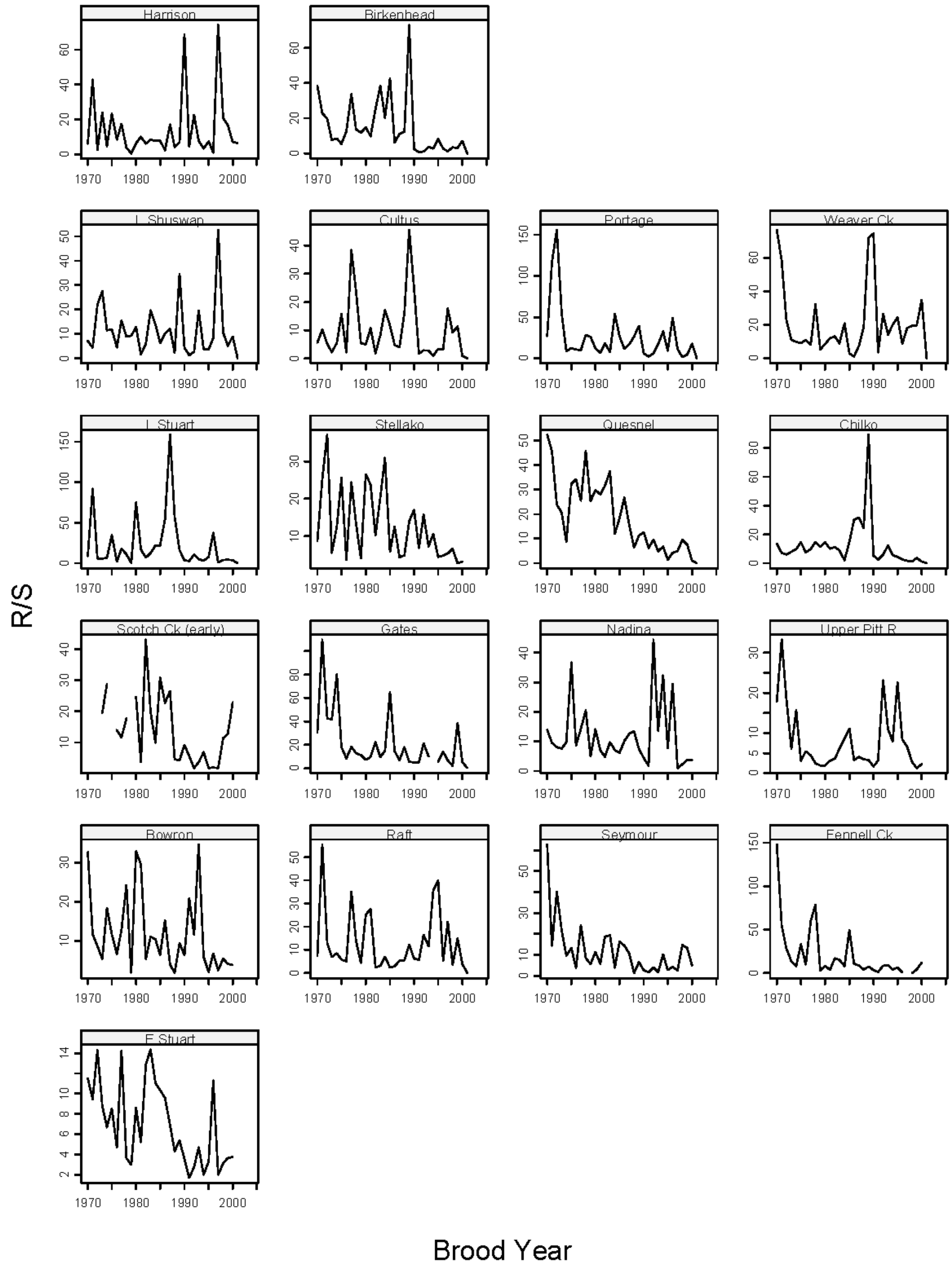

Figure 2. Time series of recruits per effective adult spawner for forecasted stocks. Stocks with channels included channel escapement in the estimate of R/S.

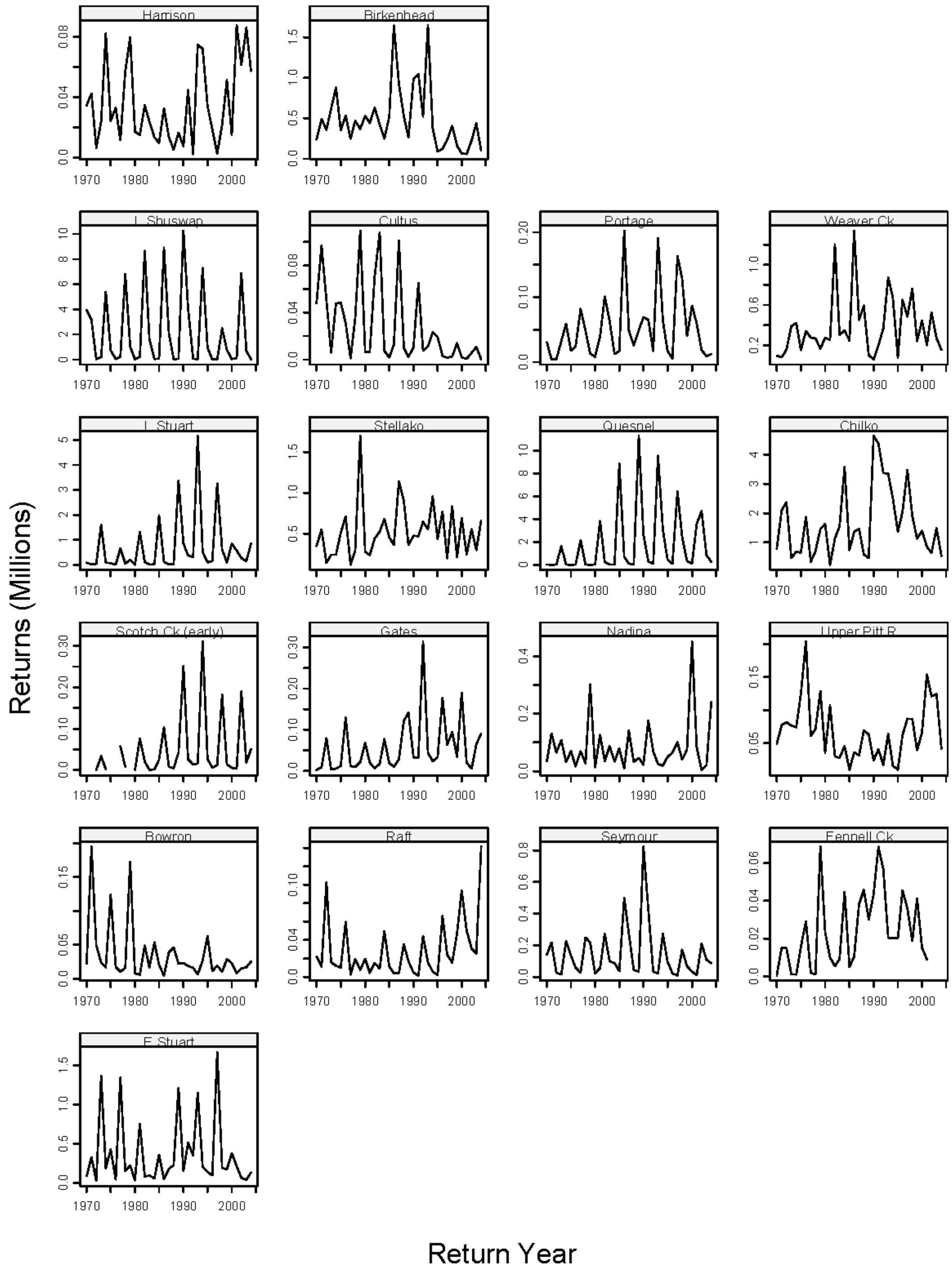

Figure 3. Time series of annual returns by stock.

Early Stuart

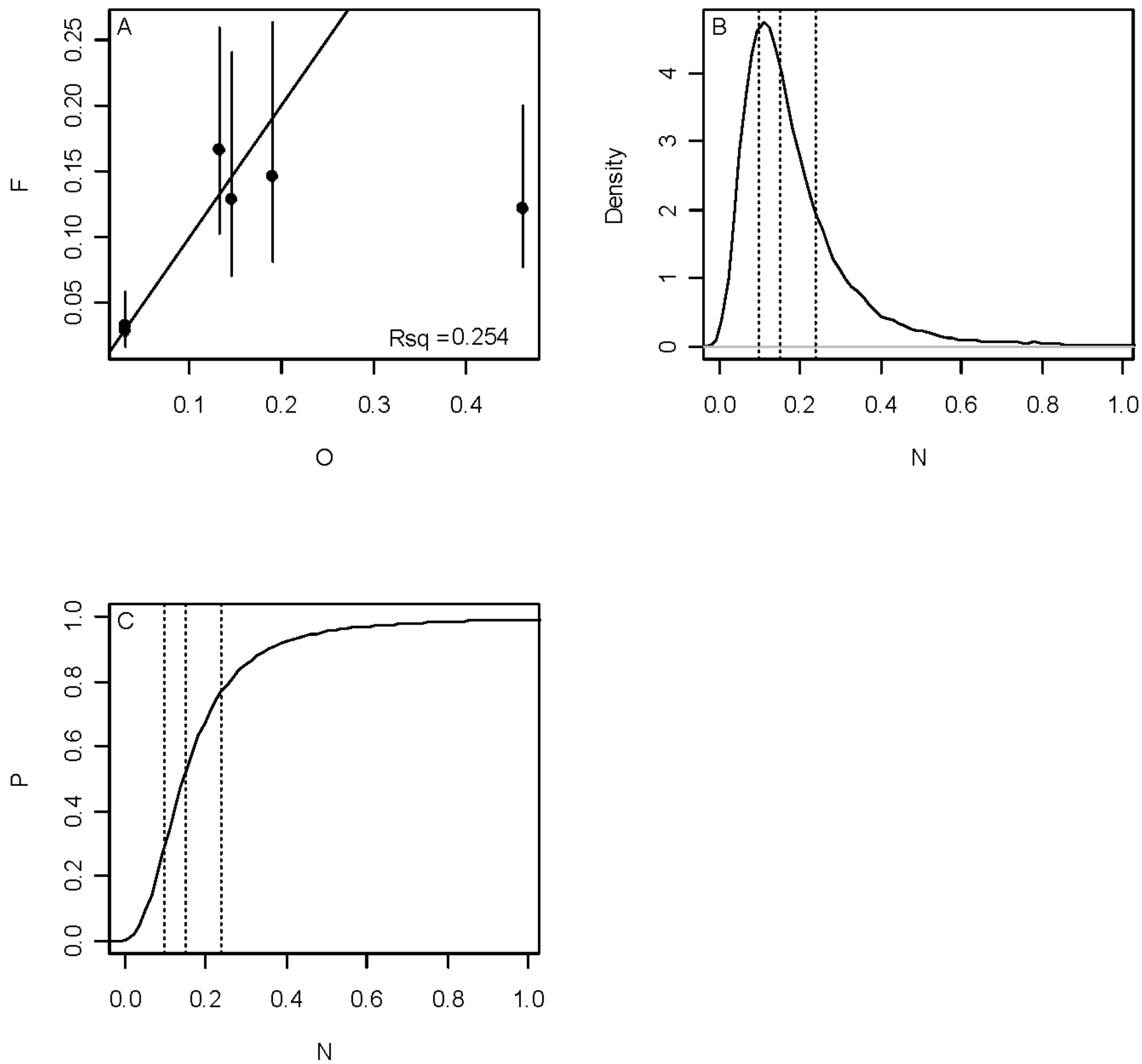

Figure 4. A) Retrospective forecasts (F) in millions for fish versus observed recruits (O) for the "best" performing candidate model (fry-based power model). Error bars are centred on the median (50%) estimate and show the 25% and 75% percentiles. The diagonal line is the 1:1 line. B) Probability density of the "posterior" distribution for the 2006 return forecast (N) in millions of fish. Vertical lines show the 25%, 50% and 75% percentiles. C) The probability distribution of the 2006 return forecast.

4.2 Early Summer run sockeye

The 2006 forecasts for the following eight Early Summer stocks account 66% of the 1.3 million for the 50% probability level returns. For numerous miscellaneous stocks catch is not directly estimated in the historical data and therefore forecasts of returns was estimated indirectly from the stocks identified below based on the mean and standard deviation of R/S.

4.2.2. Bowron Lake

The best performing model of the 13 candidate models for Bowron Lake sockeye was a Ricker model that included the mean Pine Island SST for April-June in the 2004 ocean-entry year (Appendix Table 4). On average, based on the MRE performance criteria, all candidate models have over forecasted the observed recruitment. The model explained 33% of the recruitment variation in retrospective forecasts but the 25-75% forecast distribution percentiles failed to include the observed recruitment 41% of the time or 11 of the 25 years used in the comparison (Fig. 5).

The 2006 median (50%) forecast based on the best performing model is 34,000 sockeye. Based on the 2006 forecast distribution, there is a 25% probability that the return will exceed 54,000 sockeye and a 75% probability that the return will exceed 22,000 sockeye (Table 3).

Spawning escapement has been without trend since 1970 and the trend fit shows a slight increase (Fig. 1). The R/S series has been highly variable over the 1970-2000 brood period but has declined to low levels since the mid-1990s (Fig. 2). Returns have fluctuated without trend since the mid-1970s (Fig. 3). The 2006 median (50%) forecast is 61% greater than the 1970-2004 cycle average and nearly equal to the all-year average.

4.2.3. Raft River

The escapement-based power model was the best performing model for Raft River sockeye. The model explained 72% recruitment variation. In terms of precision however, the 50% forecasts were only included in the 25-75% forecast distribution percentiles in only 33% of the time or in 9 of the 27 years in the retrospective analysis (Fig. 6).

The 2006 median (50%) forecast is 71,000 sockeye. Based on the 2006 forecast distribution, there is a 25% probability that the return will exceed 109,000 sockeye and a 75% probability that the return will exceed 44,000 sockeye (Table 3). Spawning escapement has increased since the mid-1990s, R/S has declined (Fig. 2) and returns have increased (Fig. 3). The 2006 forecast return is nearly 5 times the cycle mean and 2.4 times the all-year past three decade mean (Table 3).

4.2.4. Gates Creek

Gates escapement-based power model ranked third in the MAE measure, because the Fry and MRS models tied for the first rank. This influenced the average rank of the Power model. However, because the Power model is virtually the same or superior on all measures and has narrower bounds on the forecast it was the model chosen. The power model explained 56% of the variation in recruitment. The 25-75% forecast distribution percentiles included the observed recruits in only 35 % of the time or 6 of the 17 years in the retrospective comparison (Fig. 7). The 2006 median (50%) forecast is 20,000 sockeye. Based on the 2006 forecast distribution, there is a 25% probability that the return will exceed 31,000 sockeye and a 75% probability that the return will exceed 11,000 sockeye (Table 3).

Spawning escapement has been without trend in the past three decades (Fig. 1). Occasional large positive spikes in escapement have dominated the data series. The R/S survival index has undergone a long-term downward trend (Fig. 2) and returns have fluctuated without a trend (Fig. 3).

4.2.5. Nadina River

The fry-based power model was the best model and explained 28% of the recruitment variation in Nadina sockeye. The 25-75% forecast distribution percentiles included the observed recruitment in only 36% of the time or 5 of 15 years (Fig. 8). For most years since the 1973 start-up of the Nadina spawning channel, wild Nadina sockeye have been disproportionately low. Spawning escapement has increased in the last decade (Fig. 1). The R/S has declined from highs in the 1990s (Fig. 2) and returns have been without a trend (Fig. 3). The 2006 median (50%) forecast is 29,000 sockeye. There is a 25% probability that the return will exceed 54,000 sockeye and a 75% probability that the return will exceed 16,000 sockeye (Table 3).

4.2.6. Scotch Creek

Paired escapement and recruitment data for Scotch Creek was not routinely estimated prior to about 1980 and the forecasts are only based on data for the 1980-2002 brood-years. The best performing model was the R1C naïve model (Appendix Table 4). That model explained 83% of the recruitment variation based on the retrospective comparison (Fig. 9). Apart from the persistent population cycles, escapement has been without trend in the last few decades (Fig. 1), R/S have fluctuated with a recent increasing trend (Fig. 2) and returns have slightly increased.

The 2006 median (50%) forecast is 168,000 sockeye. Based on the forecast distribution, there is a 25% probability that the return will exceed 319,000 sockeye and a 75% probability that the return will exceed 89,000 sockeye (Table 3). The 50% forecast is 1.4 times the cycle mean and 3.4 times the all-year mean for the 1974-2004 period (Table 3).

4.2.7. Seymour River

Sockeye from Seymour River have persistent 4-year cycles in abundance and is dominant on the 2006 cycle. Of the 13 candidate models, the cycle-line Ricker model was the best performer (Appendix Table 4). The model explained 41% of the recruitment variation. The 25-75% forecast distribution percentiles included the observed recruitment 36% of the time or in 4 of 11 dominant cycle line years (Fig. 10). Escapement trends have fluctuated without a trend in the past decade (Fig. 1) and R/S increased slightly following a decline in the 1970 to 1990 brood year period (Fig. 2).

The 2006 median (50%) forecast is 393,000 sockeye. Based on the 2006 forecast distribution, there is a 25% probability that the return will exceed 656,000 sockeye and a 75% probability that the return will exceed 253,000 sockeye (Table 3). The 50% forecast is 24% greater than the 1974-2004 cycle line mean return and 2.7 times the all-year mean return.

4.2.8. Fennell Creek

While performance measures of the all-year time series average model (TSA) and cycle line average (RAC) model were nearly indistinguishable the TSA forecast was the best performing model. All the models performed poorly and the "best" model accounted for 25% of the recruitment variation. The very high forecast uncertainty is illustrated in the retrospective residuals and probability distribution of the 2006 forecast (Fig. 11).

The 2006 median (50%) forecast is 24,000 sockeye. Based on the 2006 forecast distribution, there is a 25% probability that the return will exceed 140,000 sockeye and a 75% probability that the return will exceed 4,000 sockeye (Table 3). The 50% forecast is 85% greater than the cycle line mean and 97% of the all-year mean for the 1974-2004 period. Escapement has declined since the late 1990s (Fig. 1) and R/S levels have been low since the mid 1980s (Fig. 2).

4.2.9. Upper Pitt River

The escapement-based power model was the best performing model (Appendix Table 4). The forecast model only explained 14% of the recruitment forecast and the relationship between observed recruits and retrospective forecasts was not significant (t-test; P>0.05). Only 29% or 7 of 28 retrospective forecast distributions had 25-75% percentiles that included the observed recruitment (Fig 12). Based on the performance criteria, there is little difference between naïve forecasts and the power model. Clearly, the 2006 forecast for Upper Pitt River sockeye is highly uncertain.

The 2006 median (50%) forecast is 124,000 sockeye based on the power model. There is a 25% probability that the return will exceed 194,000 sockeye and a 75% probability that the return will exceed 75,000 sockeye (Table 3).

Escapement to the Upper Pitt has increased substantially in the last decade (Fig. 1) and R/S has declined in the past five years (Fig. 2). Returns have declined following high returns in the mid-1990s. The 50% forecast is 2.2 times the cycle line mean and 1.8 times the all-year mean for the 1974-2004 period.

Bowron

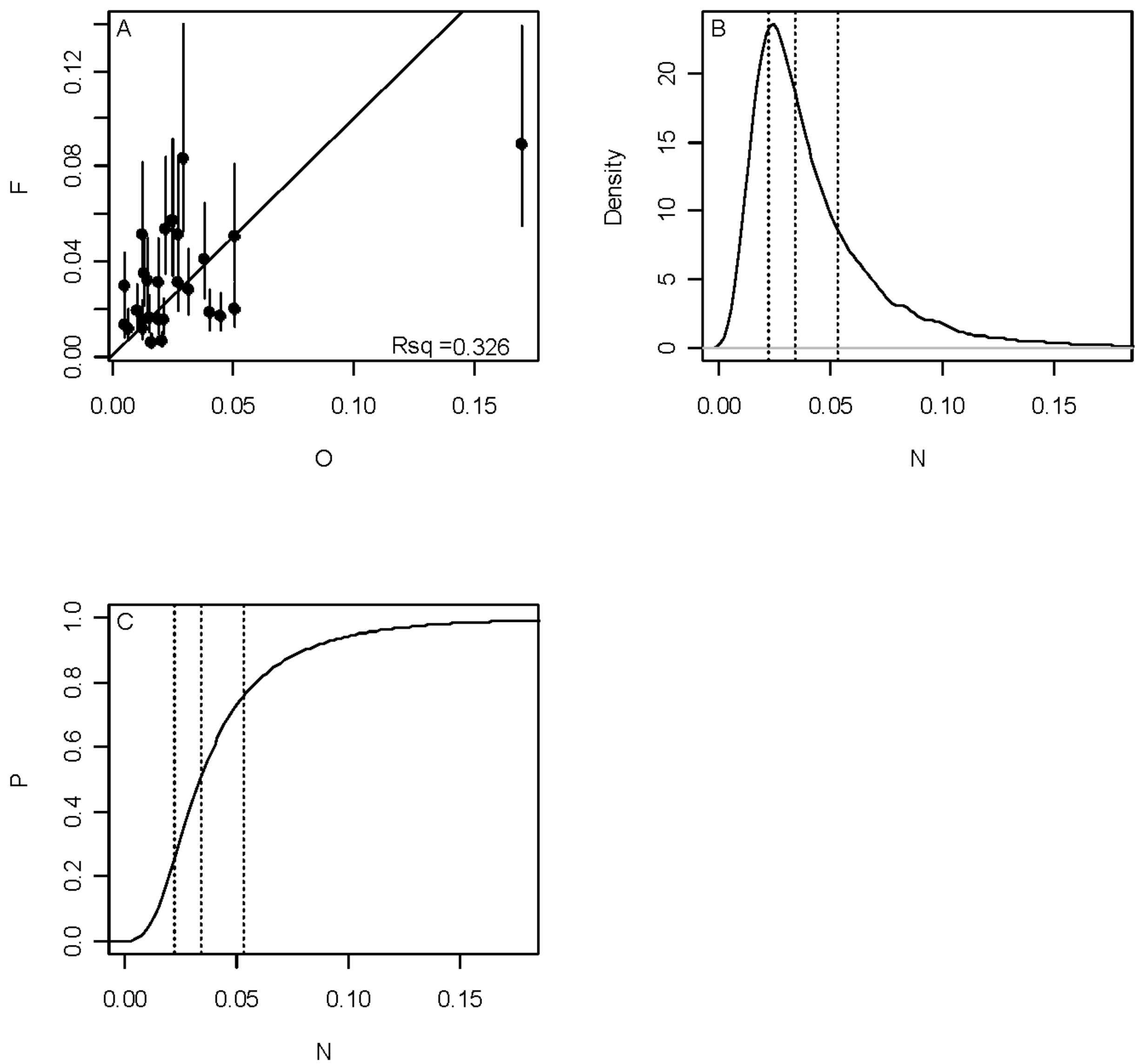

Figure 5. A) Retrospective forecasts (F) in millions for fish versus observed recruits (O) for the “best” performing candidate model (fry-based power model). Error bars are centred on the median (50%) estimate and show the 25% and 75% percentiles. The diagonal line is the 1:1 line. B) Probability density of the “posterior” distribution for the 2006 return forecast (N) in millions of fish. Vertical lines show the 25%, 50% and 75% percentiles. C) The probability distribution of the 2006 return forecast.

Raft

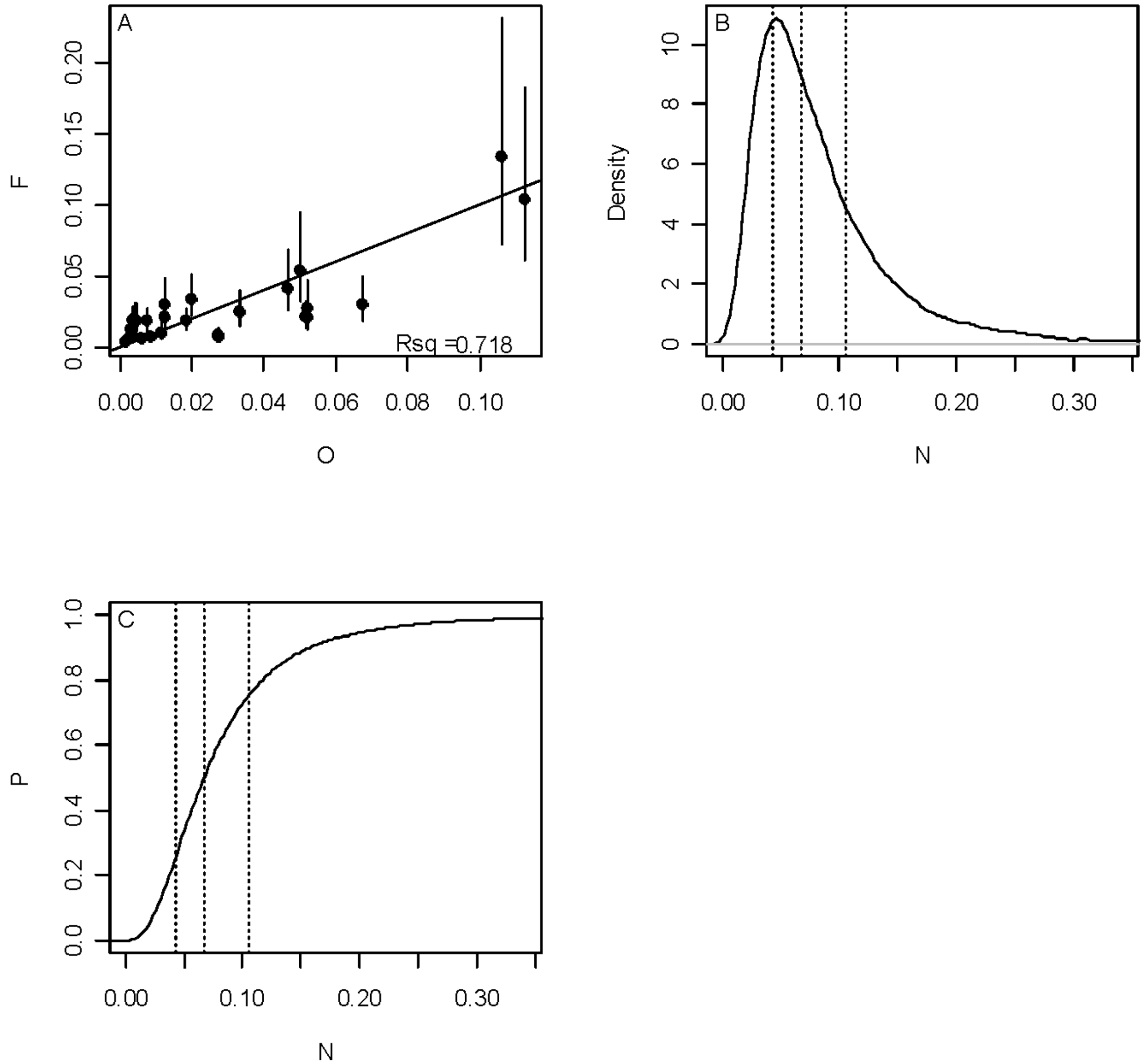

Figure 6. A) Retrospective forecasts (F) in millions for fish versus observed recruits (O) for the "best" performing candidate model (escapement-based power model). Error bars are centred on the median (50%) estimate and show the 25% and 75% percentiles. The diagonal line is the 1:1 line. B) Probability density of the "posterior" distribution for the 2006 return forecast (N) in millions of fish. Vertical lines show the 25%, 50% and 75% percentiles. C) The probability distribution of the 2006 return forecast.

Gates

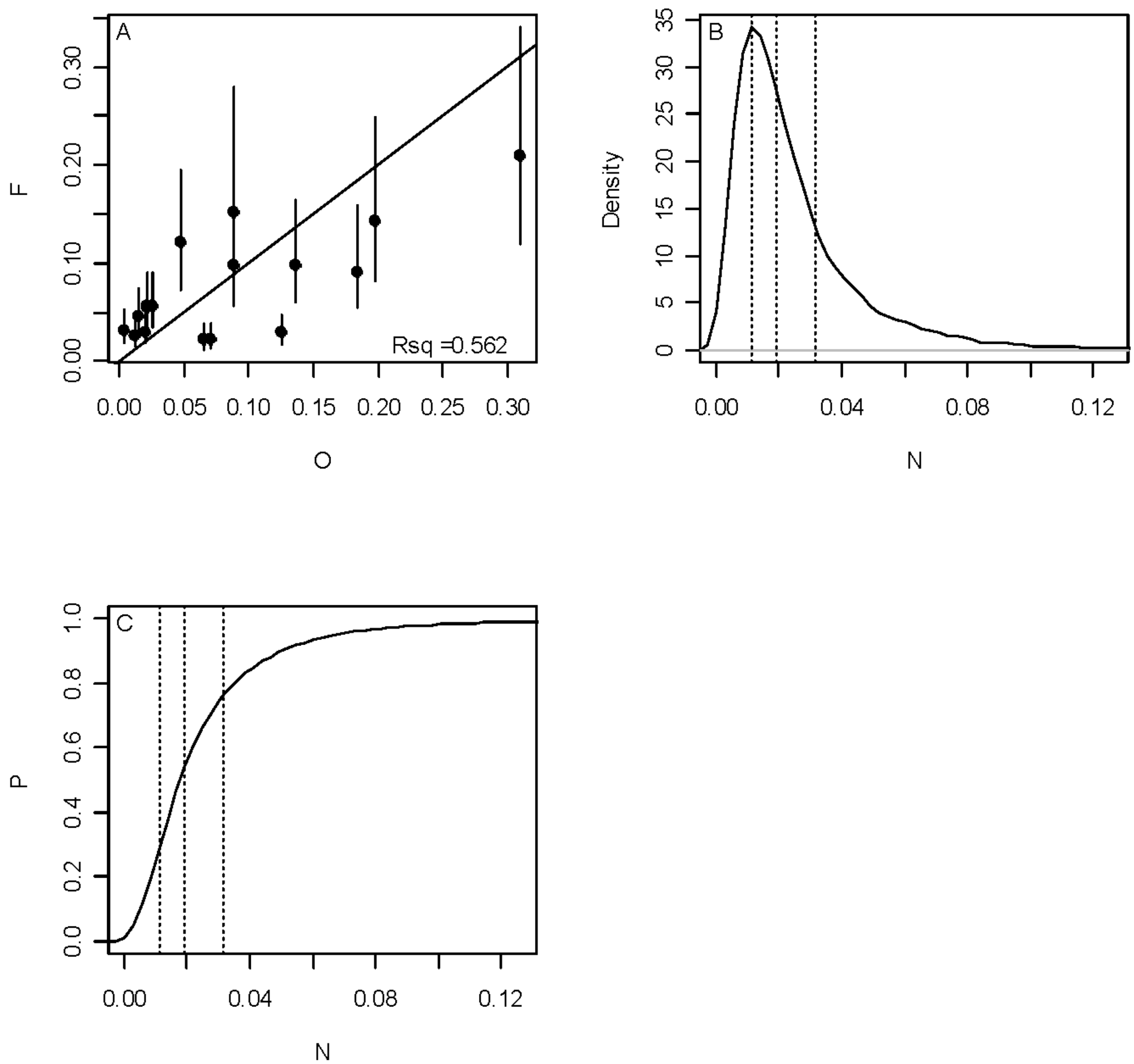

Figure 7. A) Retrospective forecasts (F) in millions for fish versus observed recruits (O) for the "best" performing candidate model (escapement-based power model). Error bars are centred on the median (50%) estimate and show the 25% and 75% percentiles. The diagonal line is the 1:1 line. B) Probability density of the "posterior" distribution for the 2006 return forecast (N) in millions of fish. Vertical lines show the 25%, 50% and 75% percentiles. C) The probability distribution of the 2006 return forecast.

Nadina

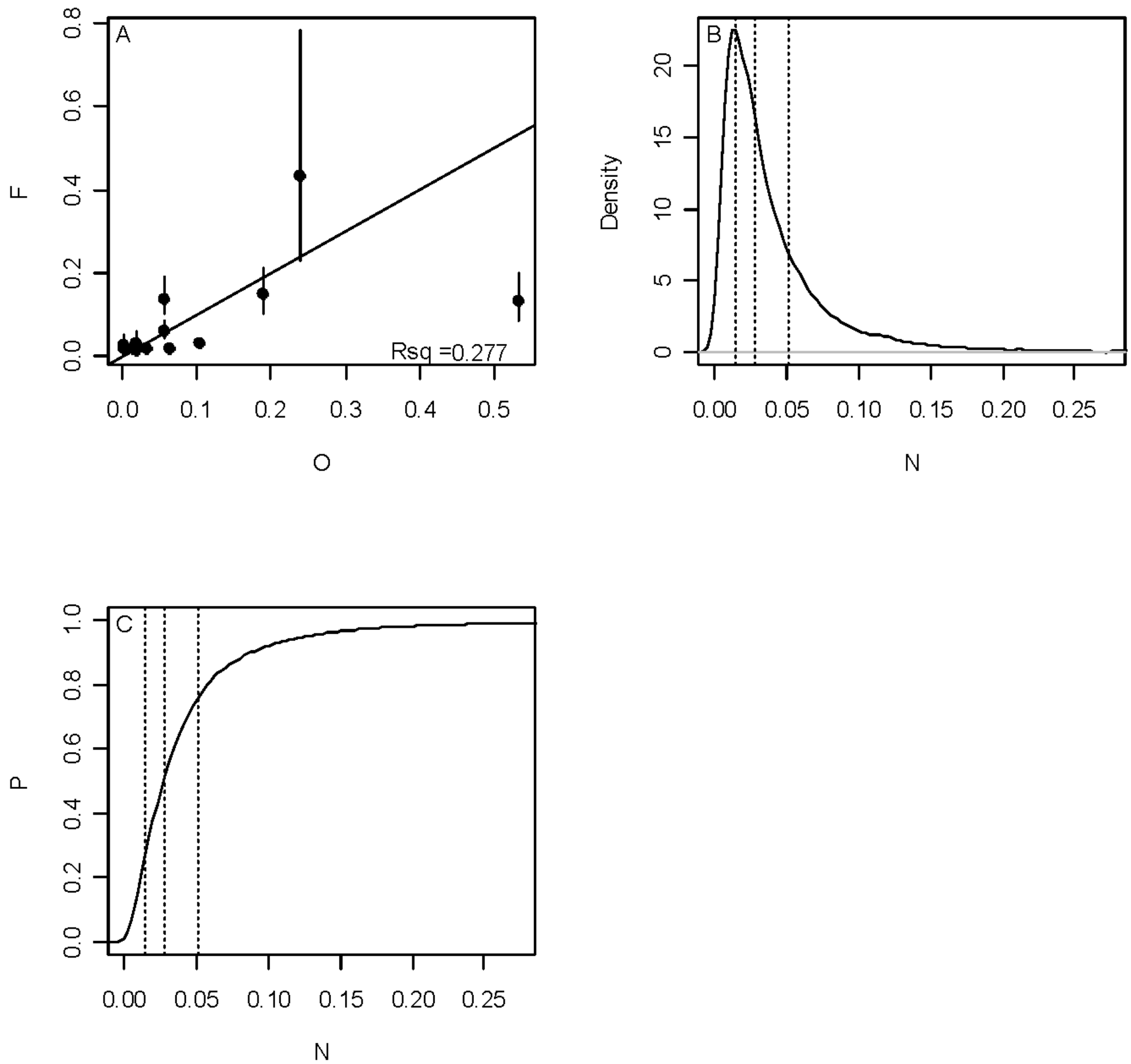

Figure 8. A) Retrospective forecasts (F) in millions for fish versus observed recruits (O) for the "best" performing candidate model (fry-based power model). Error bars are centred on the median (50%) estimate and show the 25% and 75% percentiles. The diagonal line is the 1:1 line. B) Probability density of the "posterior" distribution for the 2006 return forecast (N) in millions of fish. Vertical lines show the 25%, 50% and 75% percentiles. C) The probability distribution of the 2006 return forecast.

Scotch

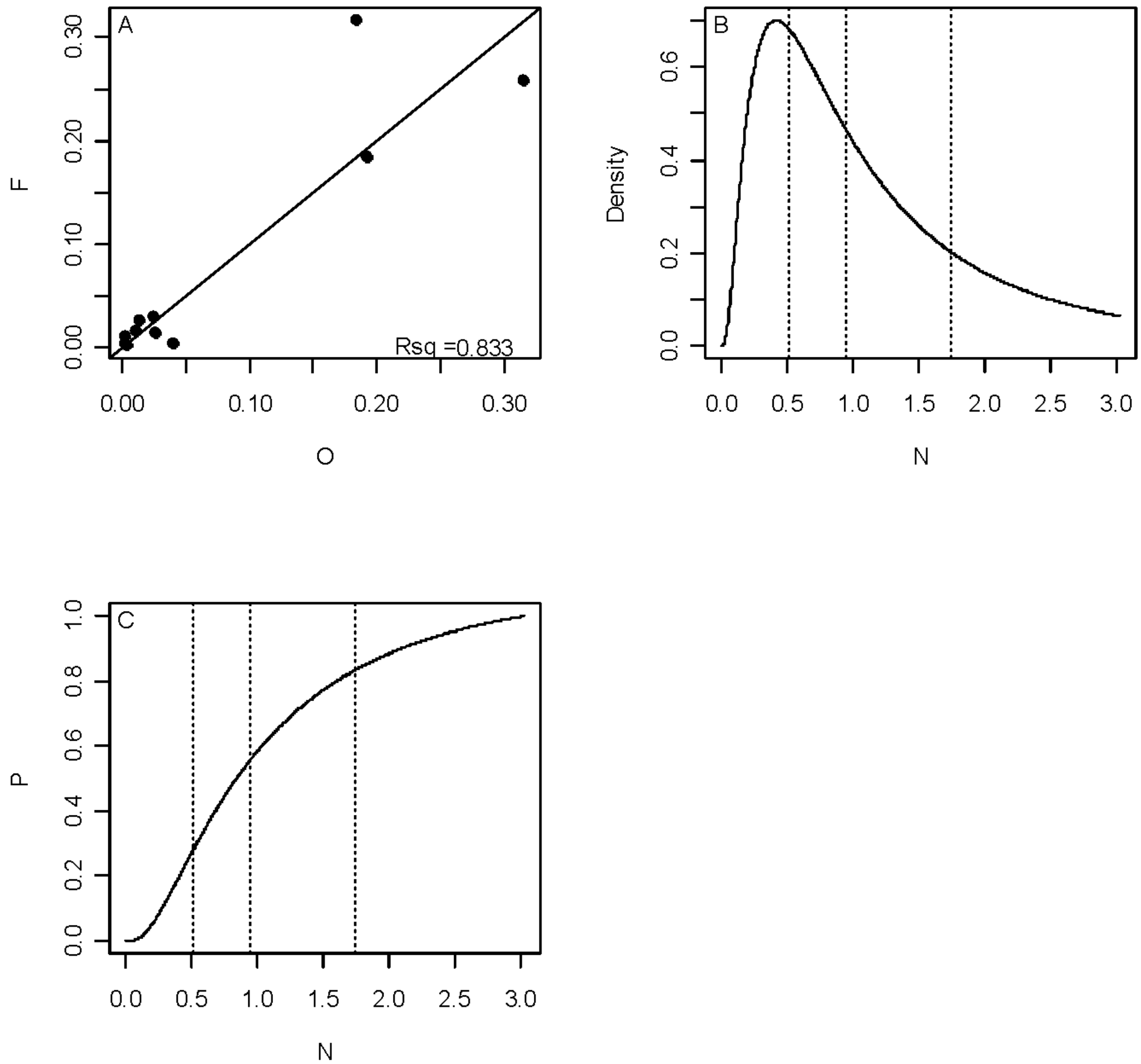

Figure 9. A) Retrospective forecasts (F) in millions for fish versus observed recruits (O) for the "best" performing candidate model (R1C naïve model). The diagonal line is the 1:1 line. B) Probability density of the "posterior" distribution for the 2006 return forecast (N) in millions of fish. Vertical lines show the 25%, 50% and 75% percentiles. C) The probability distribution of the 2006 return forecast. Note error bars in (A) are not computed for naïve models.

Seymour

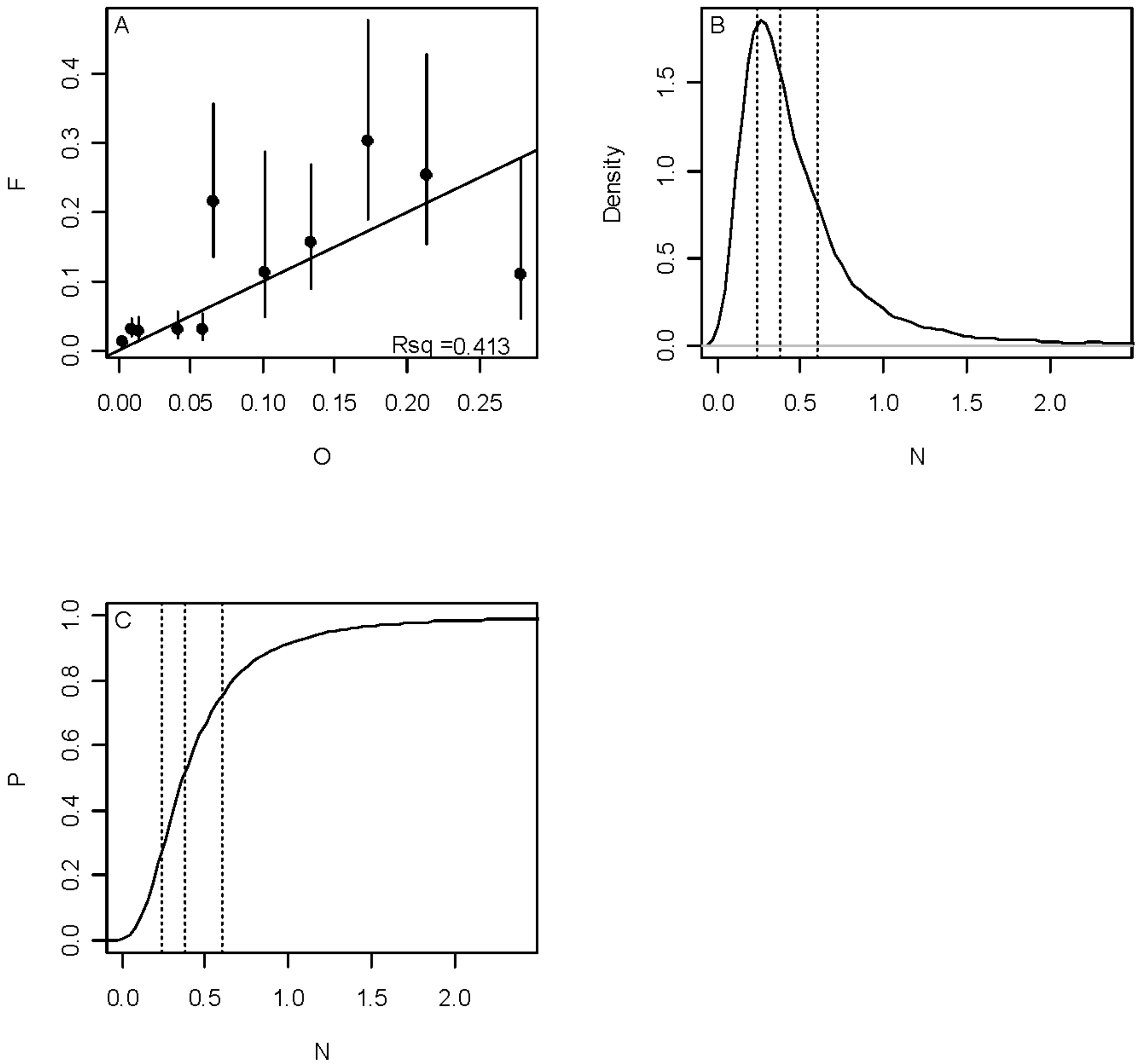

Figure 10. A) Retrospective forecasts (F) in millions for fish versus observed recruits (O) for the "best" performing candidate model (2006 cycle Ricker model). Error bars are centred on the median (50%) estimate and show the 25% and 75% percentiles. The diagonal line is the 1:1 line. B) Probability density of the "posterior" distribution for the 2006 return forecast (N) in millions of fish. Vertical lines show the 25%, 50% and 75% percentiles. C) The probability distribution of the 2006 return forecast.

Fennell

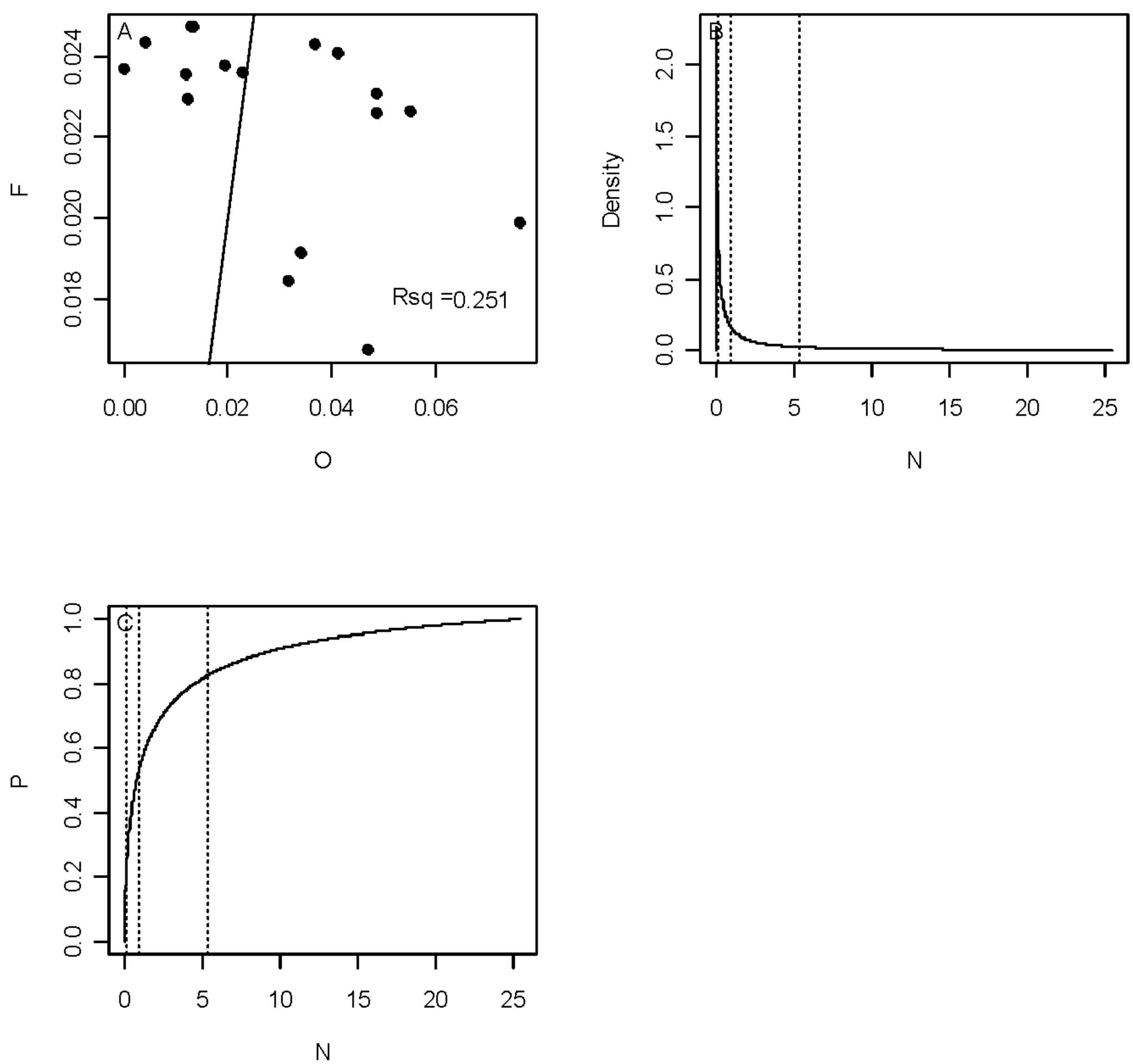

Figure 11. A) Retrospective forecasts (F) in millions for fish versus observed recruits (O) for the “best” performing candidate model (RAC naïve model). The diagonal line is the 1:1 line. B) Probability density of the “posterior” distribution for the 2006 return forecast (N) in millions of fish. Vertical lines show the 25%, 50% and 75% percentiles. C) The probability distribution of the 2006 return forecast. Note error bars in (A) are not computed for naïve models.

Upper Pitt

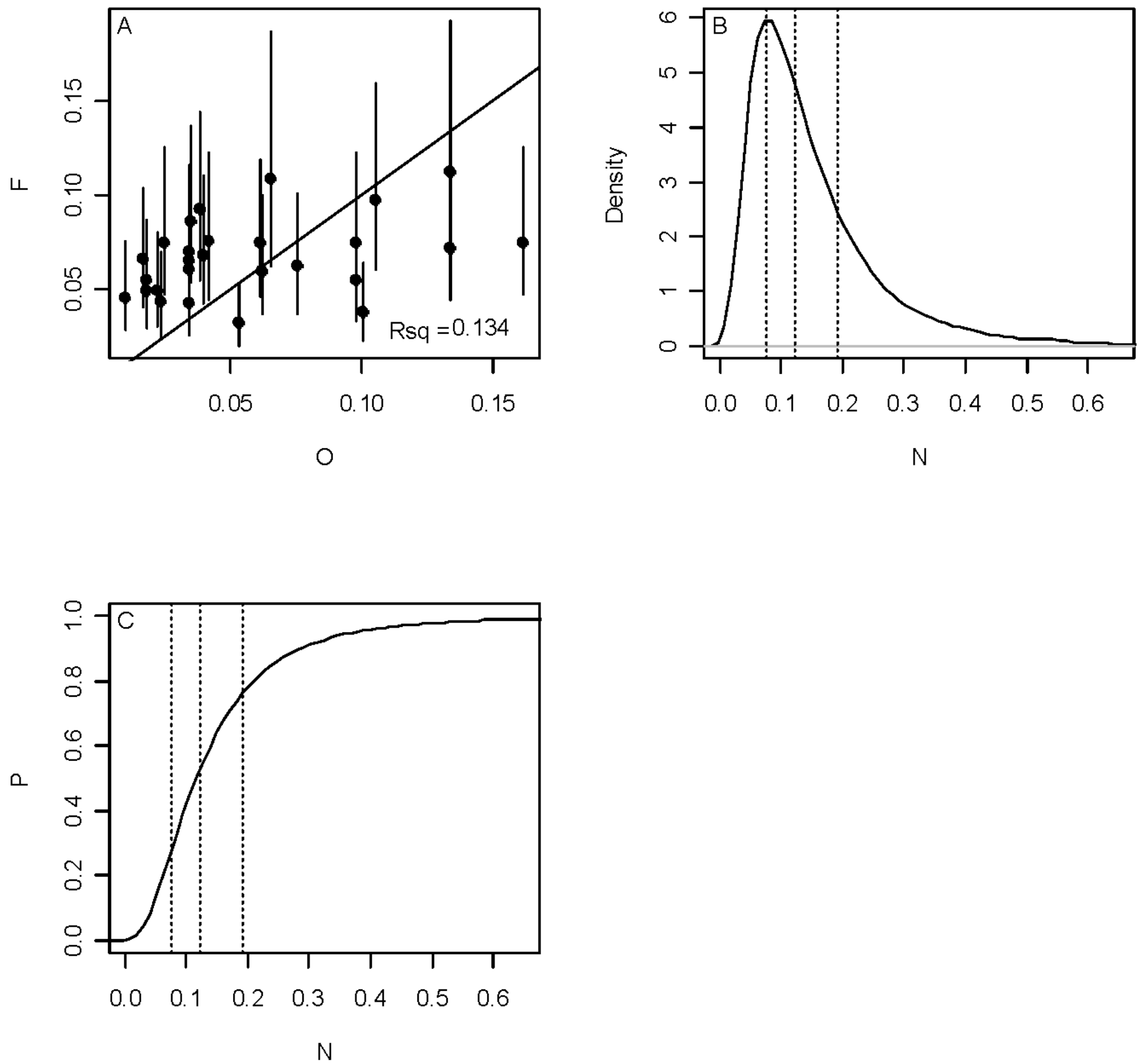

Figure 12. A) Retrospective forecasts (F) in millions for fish versus observed recruits (O) for the “best” performing candidate model (escapement-based power model). Error bars are centred on the median (50%) estimate and show the 25% and 75% percentiles. The diagonal line is the 1:1 line. B) Probability density of the “posterior” distribution for the 2006 return forecast (N) in millions of fish. Vertical lines show the 25%, 50% and 75% percentiles. C) The probability distribution of the 2006 return forecast.

4.3. Summer run sockeye

The total forecast return for Summer run stocks is 7.2 million sockeye and is equal to the sum of the following four stocks.

4.3.1. Late Stuart

The R1C naive model was the "best" model. The model accounted for 58% of the variation in recruitment based on the retrospect analysis (Fig. 13). On average, all models tended to under forecast based on the MRE criteria. The R1C model had low MRE and MAE and the lowest RMSE; giving it the highest rank among the 13 candidate models (Appendix Table 4).

The 2006 median (50%) forecast is 288,000 sockeye. Based on the 2006 forecast distribution, there is a 25% probability that the return will exceed 803,000 sockeye and a 75% probability that the return will exceed 104,000 sockeye (Table 3).

Spawning escapement increased between the late 1980s with a peak in 1993 and declined thereafter. Estimates of R/S have been at relatively low levels since the 1990s and returns have been low. The 50% forecast is 94% of the cycle mean and 41% of the all-year mean in the 1974-2004 period.

4.3.2. Stellako

The best performing model is the R1C. The model has the lowest MRE and the second lowest RMSE. The model only explained 14% of the recruitment variation (Fig. 14).

The 2006 median (50%) forecast is 568,000 sockeye for the R2C model. Based on the 2006 forecast distribution, there is a 25% probability that the return will exceed 888,000 sockeye and a 75% probability that the return will exceed 363,000 sockeye (Table 3).

Escapement to the Stellako River has increased slightly overall in the last decade (Fig. 1) and R/S has declined (Fig. 2). The 50% forecast is 113% of the cycle mean and 109% of the all-year mean for the 1974-2004 period.

4.3.3. Chilko

Assessment data for Chilko sockeye has a time series of smolt data dating back to 1951. Of the 13 candidate models, the bests performing model was the smolt-based power model (Appendix Table 4). The model, however, only explained 18% of the recruitment variation. The slope of the regression of observed recruitment versus the forecast recruitment was however significantly different from zero (t-test; $P<0.05$). The model resulted in the lowest MAE and RMSE. Most models tended to under forecast, on average, based on the MRE criteria. The smolt model consistently under forecasted the high recruitments (>3 million) in 1980, 1986-88 and 1993 and only 14 of 26 forecast distribution percentiles in the 25% to 75% interval include the observed recruitment (Fig. 15).

The 2006 median (50%) forecast is 1.7 million sockeye. Based on the 2006 forecast distribution, there is a 25% probability that the return will exceed 2.6 million sockeye and a 75% probability that the return will exceed 1.2 million sockeye (Table 3).

Chilko spawning escapement increased in the 1990s but has recently declined (Fig. 1). Recruit survival (R/S) has declined in the past decade following a spike in the late 1980s. The 50% forecast is 106% of the cycle mean and 103% of the 1974-2004 all-year mean (Table 3).

4.3.4. Quesnel

Acoustic-based estimates of "fall-fry" have been mainly made on the dominant and subdominant broods beginning in 1976 (Appendix 1). The fry-based power model did not perform as well as the Ricker or the R1C naive model in the retrospective analysis for years with fry data (Appendix Table 4). The R1C model was the best model of the 13 candidate models based on the entire data series (i.e. omitting the fry model). The R1C model explains 79% of the recruitment variation for years in the all-year retrospective analysis (Fig. 16). The relationship between observed recruitment and the retrospective forecasts is highly significant (t-test; $P<0.01$). While Quesnel escapement was near the historic maximum, productivity has been low relative to historic values - even during years of low escapement. Fry sizes are lower than average suggesting a conservative forecast would be appropriate.

The 2006 median (50%) forecast is 4.6 million sockeye. Based on the 2006 forecast distribution, there is a 25% probability that the return will exceed 9.1 million sockeye and a 75% probability that the return will exceed 2.3 million sockeye (Table 3).

Spawning escapements have increased on all cycles with record high levels in 2001 (Fig. 1). The R/S survival index has declined significantly since 1981 and is now at low levels (Fig. 2). These trends explain why all the escapement-based biological models based on all years of data under forecast recruitment as revealed in the MRE statistic (Appendix Table 4). The 2006 median forecast is 3 times the 1974-2004 cycle mean and 2.5 times the all-year mean (Table 3).

Late Stuart

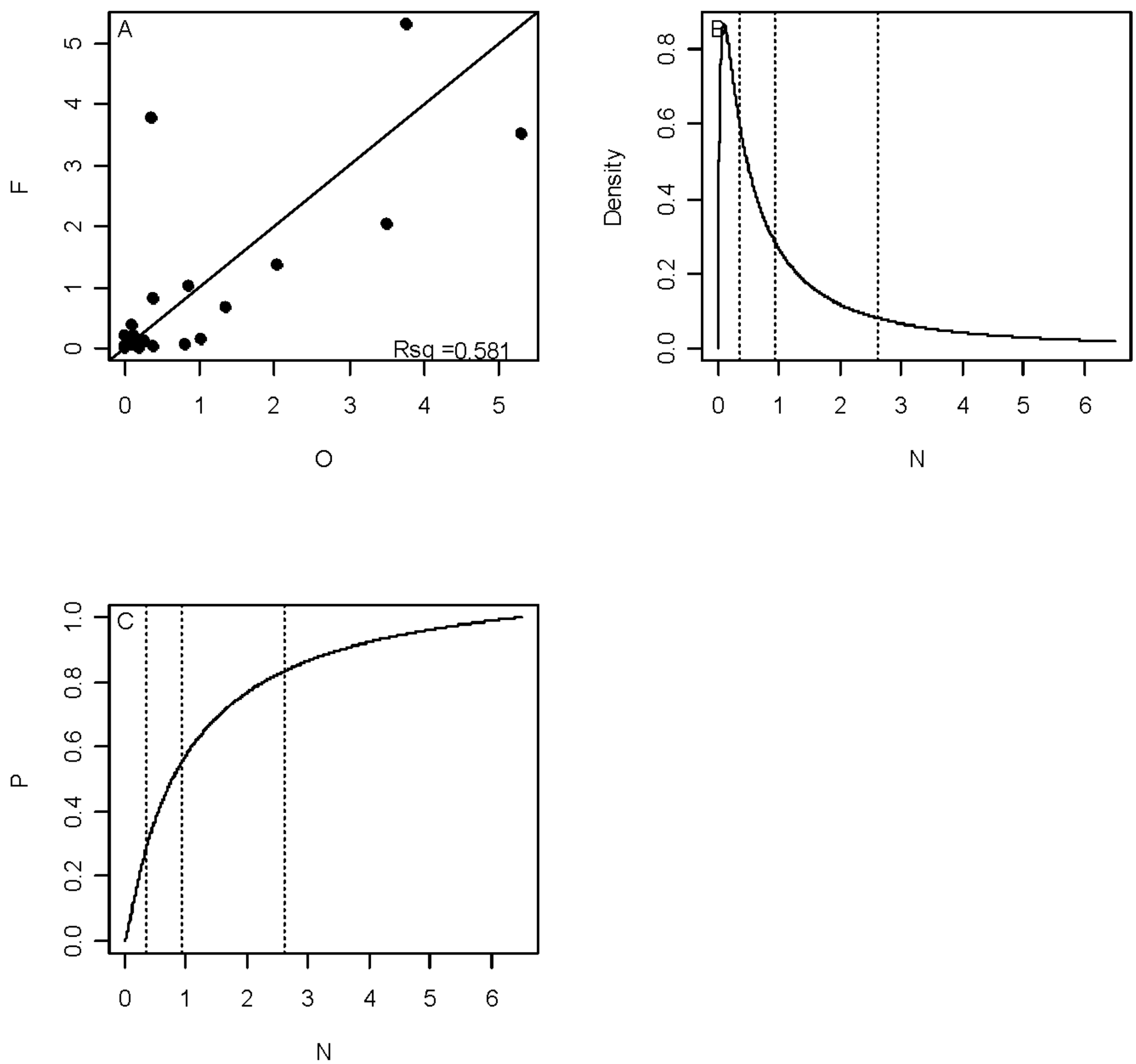

Figure 13. A) Retrospective forecasts (F) in millions for fish versus observed recruits (O) for the "best" performing candidate model (fry-based power model. The diagonal line is the 1:1 line. B) Probability density of the "posterior" distribution for the 2006 return forecast (N) in millions of fish. Vertical lines show the 25%, 50% and 75% percentiles. C) The probability distribution of the 2006 return forecast. Note error bars in (A) are not computed for naïve models

Stellako

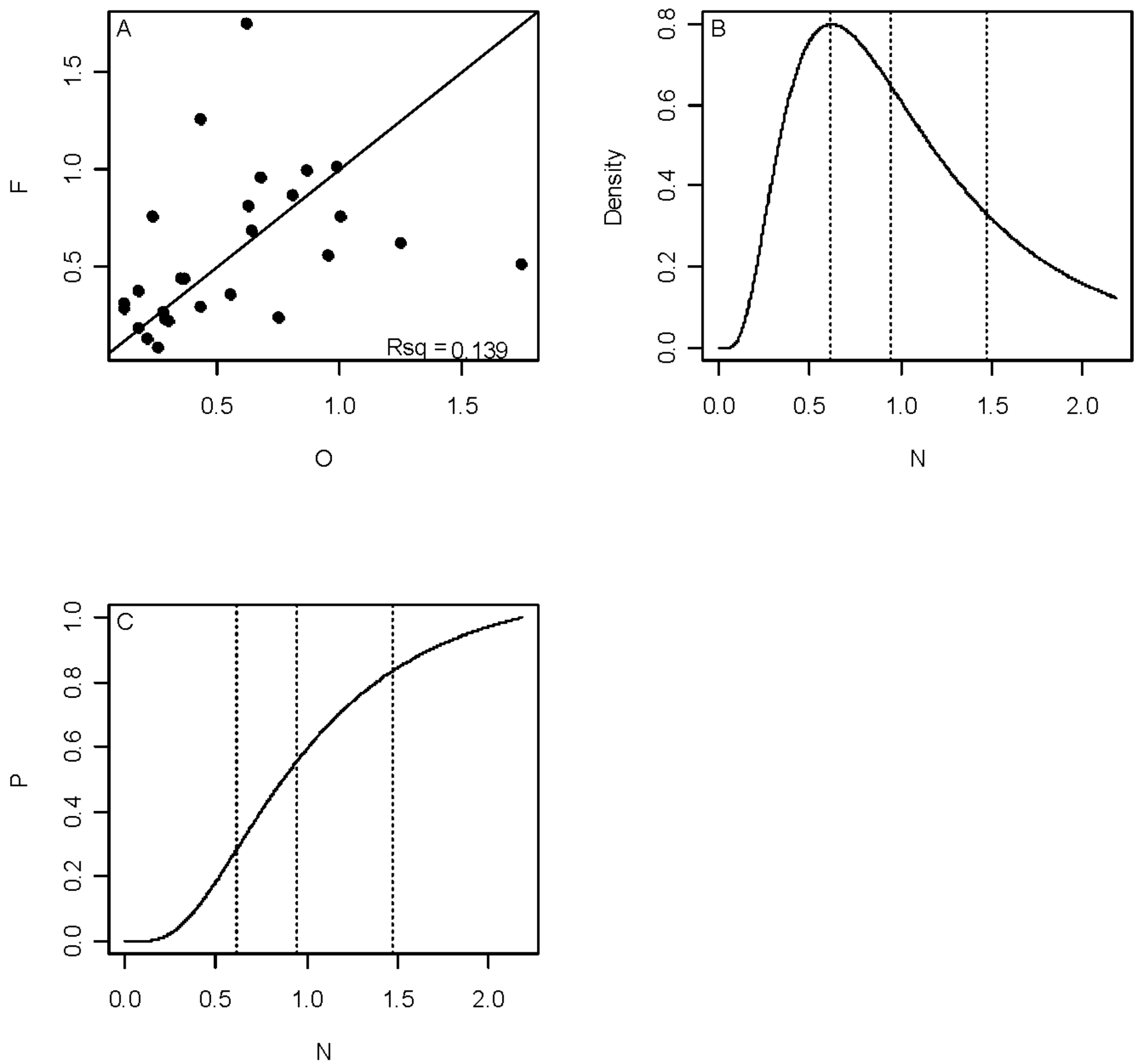

Figure 14. A) Retrospective forecasts (F) in millions for fish versus observed recruits (O) for the "best" performing candidate model (R2C naive model. The diagonal line is the 1:1 line. B) Probability density of the "posterior" distribution for the 2006 return forecast (N) in millions of fish. Vertical lines show the 25%, 50% and 75% percentiles. C) The probability distribution of the 2006 return forecast. Note error bars in (A) are not computed for naïve models

Chilko

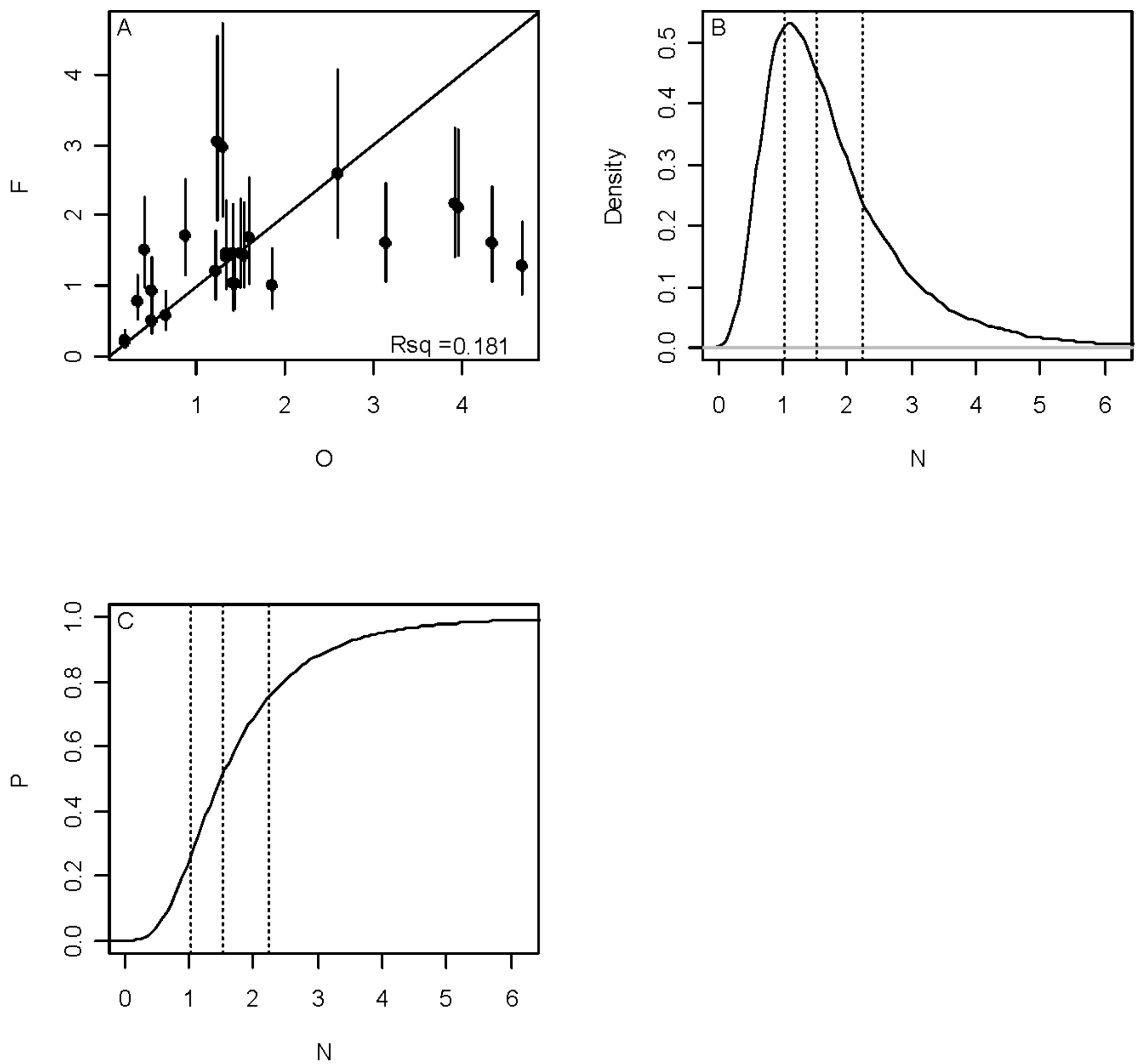

Figure 15. A) Retrospective forecasts (F) in millions for fish versus observed recruits (O) for the "best" performing candidate model (fry-based power model). Error bars are centred on the median (50%) estimate and show the 25% and 75% percentiles. The diagonal line is the 1:1 line. B) Probability density of the "posterior" distribution for the 2006 return forecast (N) in millions of fish. Vertical lines show the 25%, 50% and 75% percentiles. C) The probability distribution of the 2006 return forecast.

Quesnel

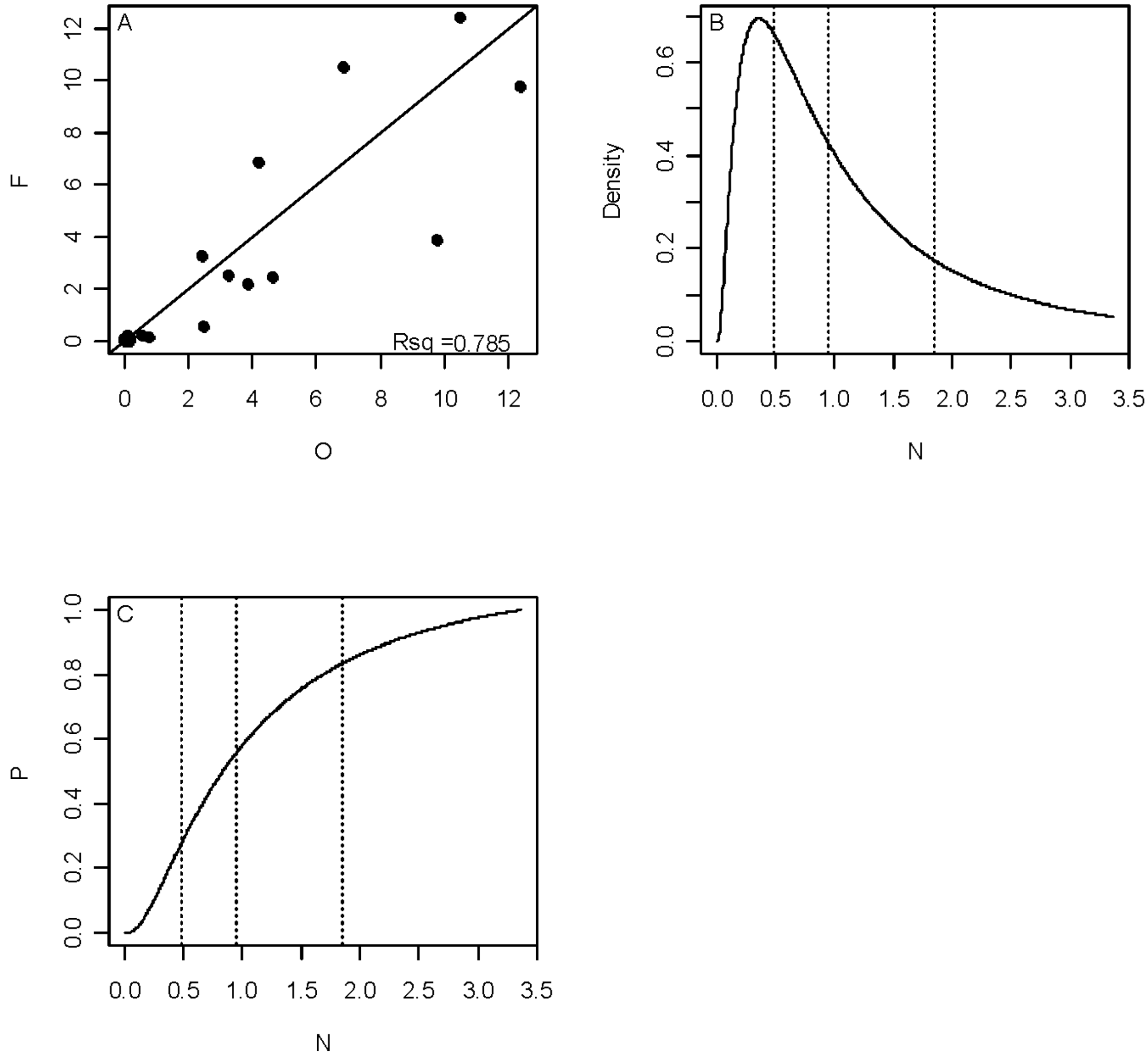

Figure 16. A) Retrospective forecasts (F) in millions for fish versus observed recruits (O) for the "best" performing candidate model (R2C naive model). The diagonal line is the 1:1 line. B) Probability density of the "posterior" distribution for the 2006 return forecast (N) in millions of fish. Vertical lines show the 25%, 50% and 75% percentiles. C) The probability distribution of the 2006 return forecast. Note error bars in (A) are not computed for naïve models.

4.4. Late run sockeye

The 2006 forecasts for the following six Late run stocks account 86% of the 8.8 million total for the timing group for the 50% probability level returns. For numerous miscellaneous stocks catch is not directly estimated in the historical data and therefore forecasts of returns was estimated indirectly from the stocks identified below based on the mean and standard deviation of R/S.

4.4.1. Birkenhead River

Except for the cycle line based Ricker model, all the biological models under forecasted recruitment based on the MRE criteria. Of the 13 candidate models, the bests performing model was the escapement-based power model (Appendix Table 4). The model resulted in the lowest MAE and RMSE and explained 13% of the recruitment variation. The residuals from the retrospective reveal a number of years with unexplained outliers and the slope of the regression of observed recruit versus forecast recruits was not significant (t-test; P>0.05). Only 9 of 27 (33%) forecast distribution percentiles in the 25% to 75% interval include the observed recruitment (Fig. 17). The 2006 median (50%) forecast is 433,000 sockeye. Based on the 2006 forecast distribution, there is a 25% probability that the return will exceed 713,000 sockeye and a 75% probability that the return will exceed 274,000 sockeye (Table 3).

The time series of spawning escapements has been highly variable and without trend (Fig. 1). The R/S has been persistently low since brood year 1990 (Fig. 2). In part, this explains why the biological models, based on the retrospective analysis, under forecasted the observed recruitment. The median (50%) forecast is 67% of the cycle mean and 88% of the all-year mean for the 1974-2004 period (Table 3).

4.4.2. Portage Creek

The escapement-based power model is the best model. It only explained 17% of the recruitment variation and failed to include the observed recruits in 10 of 24 retrospective forecast years (Fig. 18). The model has consistently under forecast several years of high recruitment. The 2006 median (50%) forecast is 67,000 sockeye. Based on the 2006 forecast distribution, there is a 25% probability that the return will exceed 134,000 sockeye and a 75% probability that the return will exceed 34,000 sockeye (Table 3). The median forecast is 84% of the cycle mean and 1.3 times the all-year mean returns for the 1974-2004 period.

4.2.2. Late run Shuswap Lake

The effective female spawning escapement in 2002 to the Late Shuswap complex exceeded the previous recorded high in 1990 by a factor of 1.6. Escapement-based forecast models therefore were not considered valid predictors of recruitment in 2006. Fall-fry abundance estimates based on acoustic sampling methods (Hume et al. 1996) are available for most dominant and subdominant brood years, including the 2002 dominant brood. The fry estimates for the 2002 brood are within the range of historical data (Appendix 1). In the retrospective model performance that compares the fry-based model with alternative naïve models for years with fry data the RAC naïve model out-performed the fry model and the other naïve models using the MRA and RMSE criteria (Appendix Table 4). Specifically, fry models still have great uncertainty (higher RMSE) because of their short time series (forecast 9M intervals ranging 3M to 39M). The fry-based power model was therefore rejected in favour of naïve models. The RAC model also out-performed the other naïve models when the entire years of data were included in the retrospective assessment and is considered the best performing model.

The all-year RAC model explained 82% of the variation in recruitment but, on average, tended to under forecast compared to the R1C and R2C (cycle line) naive models (Appendix Table 4).

The relationship between observed recruitment and forecast recruitment for the RAC model, based on the retrospective analysis (Fig. 19), was highly significant (t-test; $P<0.01$). The 2006 median (50%) forecast is 6.6 million sockeye. Based on the 2006 forecast distribution, there is a 25% probability that the return will exceed 12.4 million sockeye and a 75% probability that the return will exceed 3.6 million (Table 3).

In the 1974 to-2004 period, the escapement and return time series on the dominant cycle line have been without an obvious trend (Fig. 1 and Fig 2). The 50% forecast is 99% of the 1974-2002 cycle line mean and 3 times greater than the all-year mean (Table 3).

4.2.3. Weaver Creek

The best performing model was the fry power model but it was only marginally better than the RAC naïve model (Appendix Table 4). The fry model only explained 13% of the recruitment variation and the slope of the regression between observed recruits and the retrospective forecasts was not significant (t-test; $P>0.05$). The lack of relationship is shown in the residual plot of the retrospective performance (Fig. 20). The 2006 median (50%) forecast is 411,000 sockeye. Based on the 2006 forecast distribution, there is a 25% probability that the return will exceed 656,000 sockeye and a 75% probability that the return will exceed 259,000 sockeye (Table 3).

Escapement and returns to the natural spawning system has declined slightly in the past decade. For the combine natural and channel systems, the R/S series has fluctuated without a trend. The median forecast is 69% of cycle line mean and 107% of the all-year mean return for the 1974-2004 period.

4.2.4. Harrison River

The TSA naïve model was the best performing model of all the candidate models except for the escapement-based Ricker-PDO model. Because the brood-year escapement exceeded the historical range, escapement-based models were not considered valid. The retrospective residual plot reveals high variability (Fig 21). The model explained a mere 3% of the recruitment variation based on the retrospective analysis and is the worst performance for any stock. The 2006 median (50%) forecast is 41,000 sockeye. Based on the 2006 forecast distribution, there is a 25% probability that the return will exceed 90,000 sockeye and a 75% probability that the return will exceed 19,000 sockeye (Table 3).

Escapement, R/S and returns have increased in the past decade. The 2006 median forecast is 91% of the cycle line mean and 117% of the all-year mean for the 1974-2004 period.

4.2.5. Cultus Lake

The best performing model was the jack proportion + smolt survival model (Equation 10) in the MRE and RMSE performance criteria (Appendix Table 4). The smolt-based power model was the second best performing model overall and tied the jack-smolt model in the MRE criteria. The jack-smolt model was selected from among the 7 candidate models as the best model to forecast 2006 returns. The model explained 81% of the recruitment variation based on the relationship between the observed recruits versus the retrospective forecasts. The 25-75% percentiles of the forecast distributions included the observed recruitment in 6 of the 13 years in the retrospective analysis. The 2006 median (50%) forecast is 5,800 sockeye. There is a 25% probability that the return will exceed 11,000 sockeye and a 75% probability that returns will exceed 2,700 sockeye (Table 3).

For comparison, the smolt power model explained 18% less variation in recruitment than the jack-smolt model. Interestingly, the 2006 forecast for the smolt power model is also 5,800 sockeye with a slightly more skewed forecast distribution. We conclude that the added information from the jack data is not very informative. This could be due to measurement error in jack and sibling abundance estimates and poorly understood biological processes affecting jacking rates.

Cultus sockeye were designated as "Endangered" in 2002 by the Committee of the Status of Endangered Wildlife in Canada (COSEWIC 2003). The 2006 median forecast is 21% of the 1974-2004 cycle line and all-year mean return (Table 3). The median 2006 return forecast of 5,800 compares to a brood return of 6,000 fish or a population growth rate of near zero.

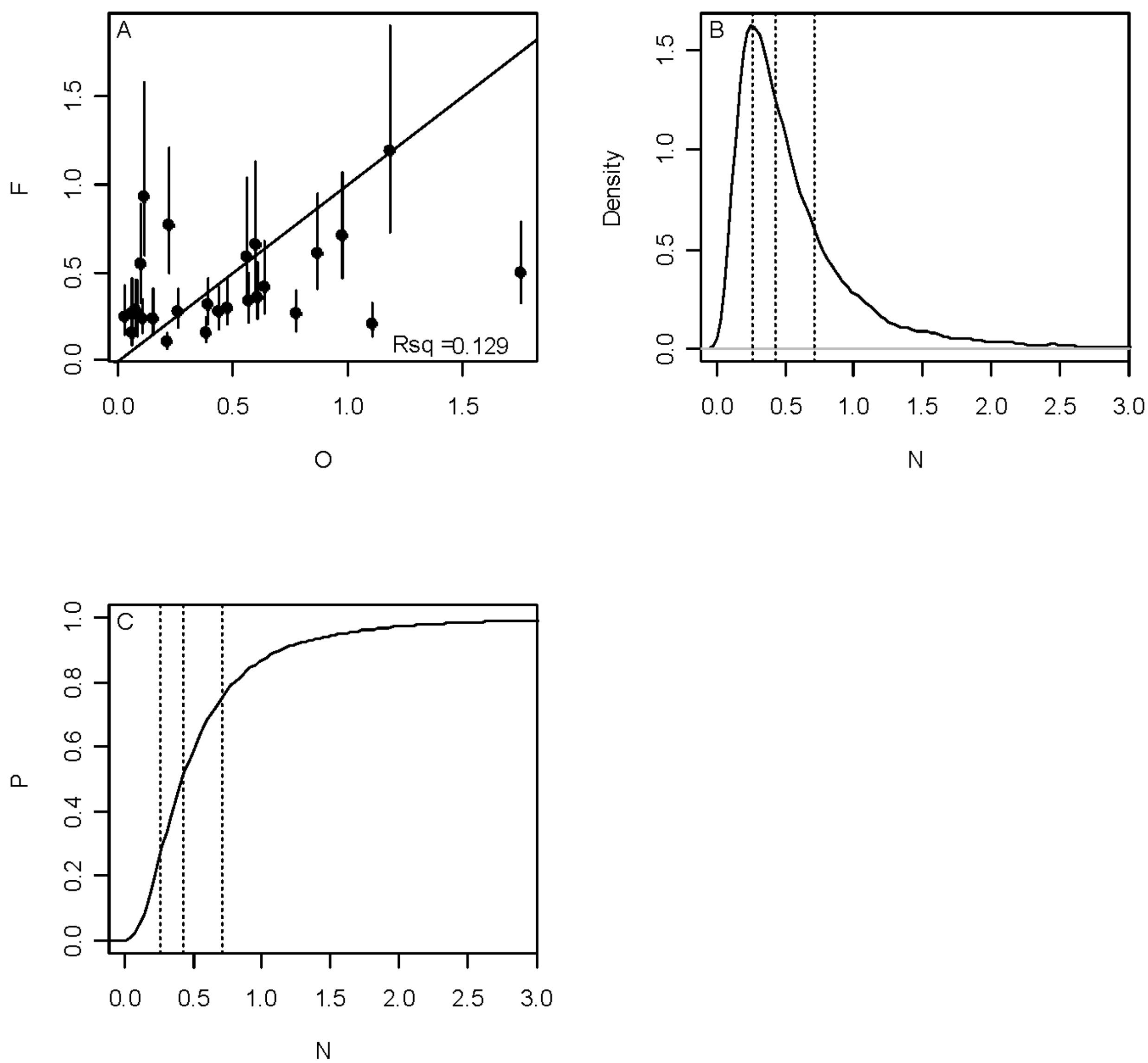

Figure 17. A) Retrospective forecasts (F) in millions for fish versus observed recruits (O) for the "best" performing candidate model (fry-based power model). Error bars are centred on the median (50%) estimate and show the 25% and 75% percentiles. The diagonal line is the 1:1 line. B) Probability density of the "posterior" distribution for the 2006 return forecast (N) in millions of fish. Vertical lines show the 25%, 50% and 75% percentiles. C) The probability distribution of the 2006 return forecast.

Portage

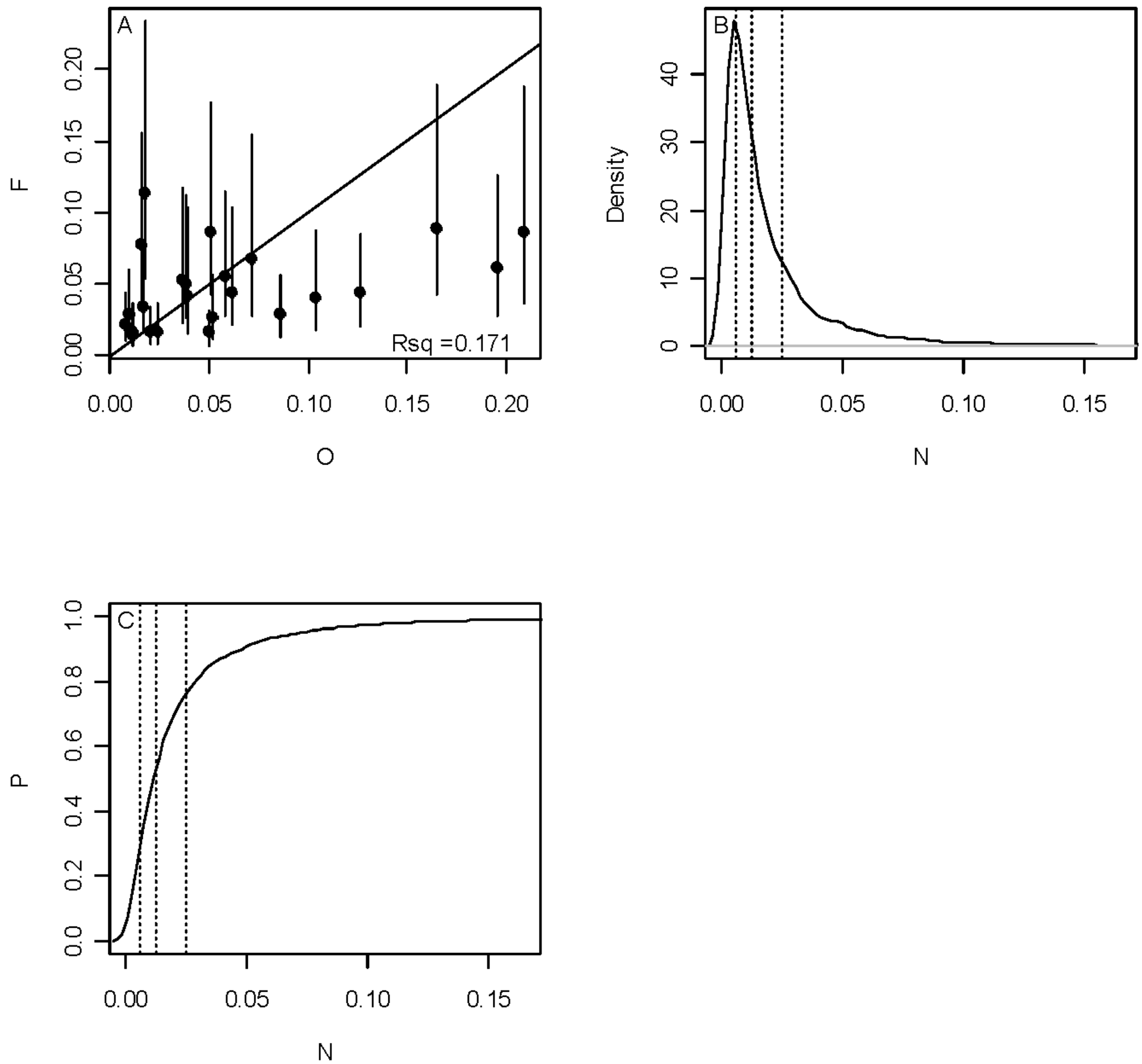

Figure 18. A) Retrospective forecasts (F) in millions for fish versus observed recruits (O) for the “best” performing candidate model (escapement-based power model). Error bars are centred on the median (50%) estimate and show the 25% and 75% percentiles. The diagonal line is the 1:1 line. B) Probability density of the “posterior” distribution for the 2006 return forecast (N) in millions of fish. Vertical lines show the 25%, 50% and 75% percentiles. C) The probability distribution of the 2006 return forecast.

Late Shuswap

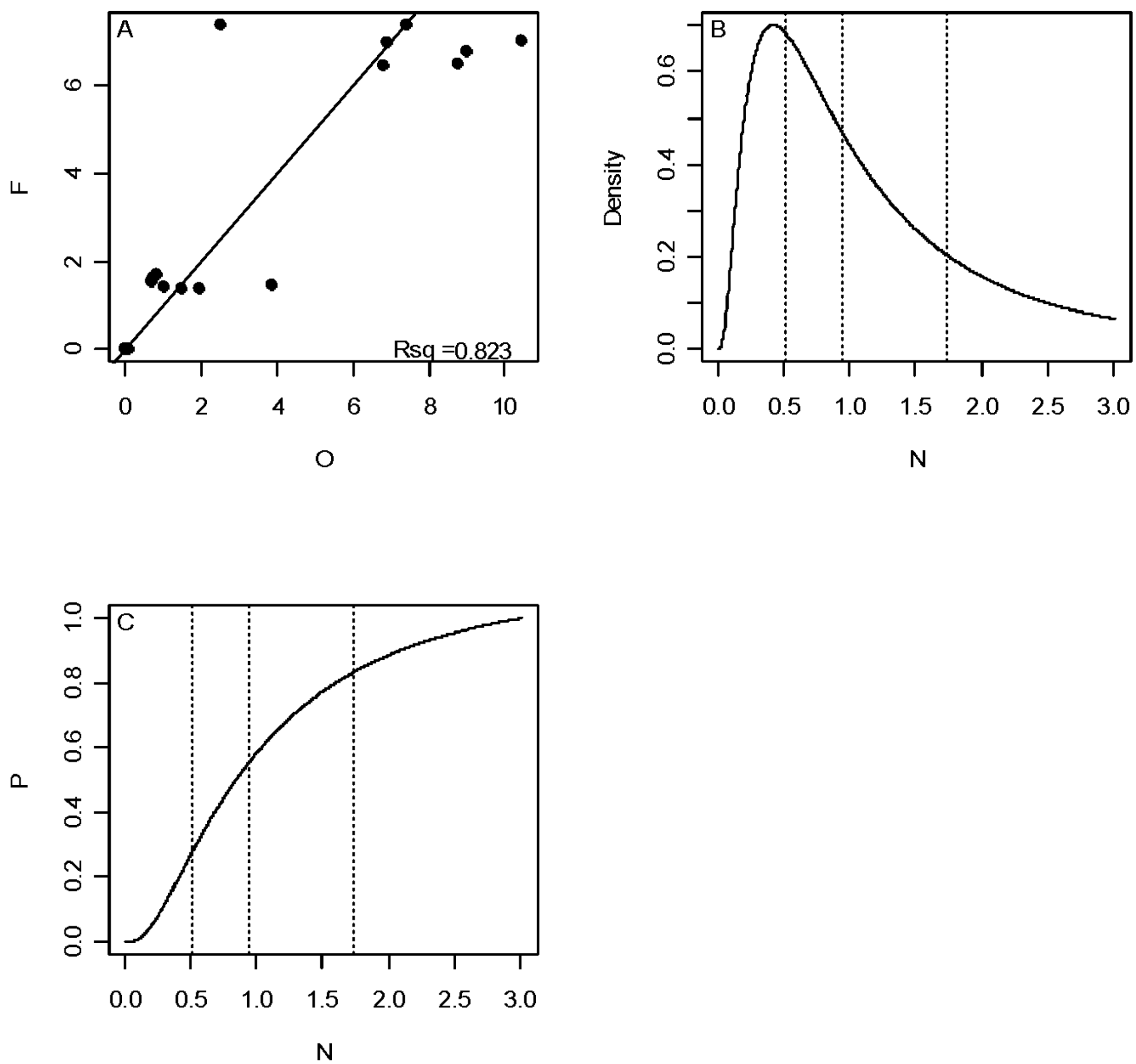

Figure 19. A) Retrospective forecasts (F) in millions for fish versus observed recruits (O) for the "best" performing candidate model (RAC naive model). The diagonal line is the 1:1 line. B) Probability density of the "posterior" distribution for the 2006 return forecast (N) in millions of fish. Vertical lines show the 25%, 50% and 75% percentiles. C) The probability distribution of the 2006 return forecast. Note error bars in (A) are not computed for naïve models.

Weaver

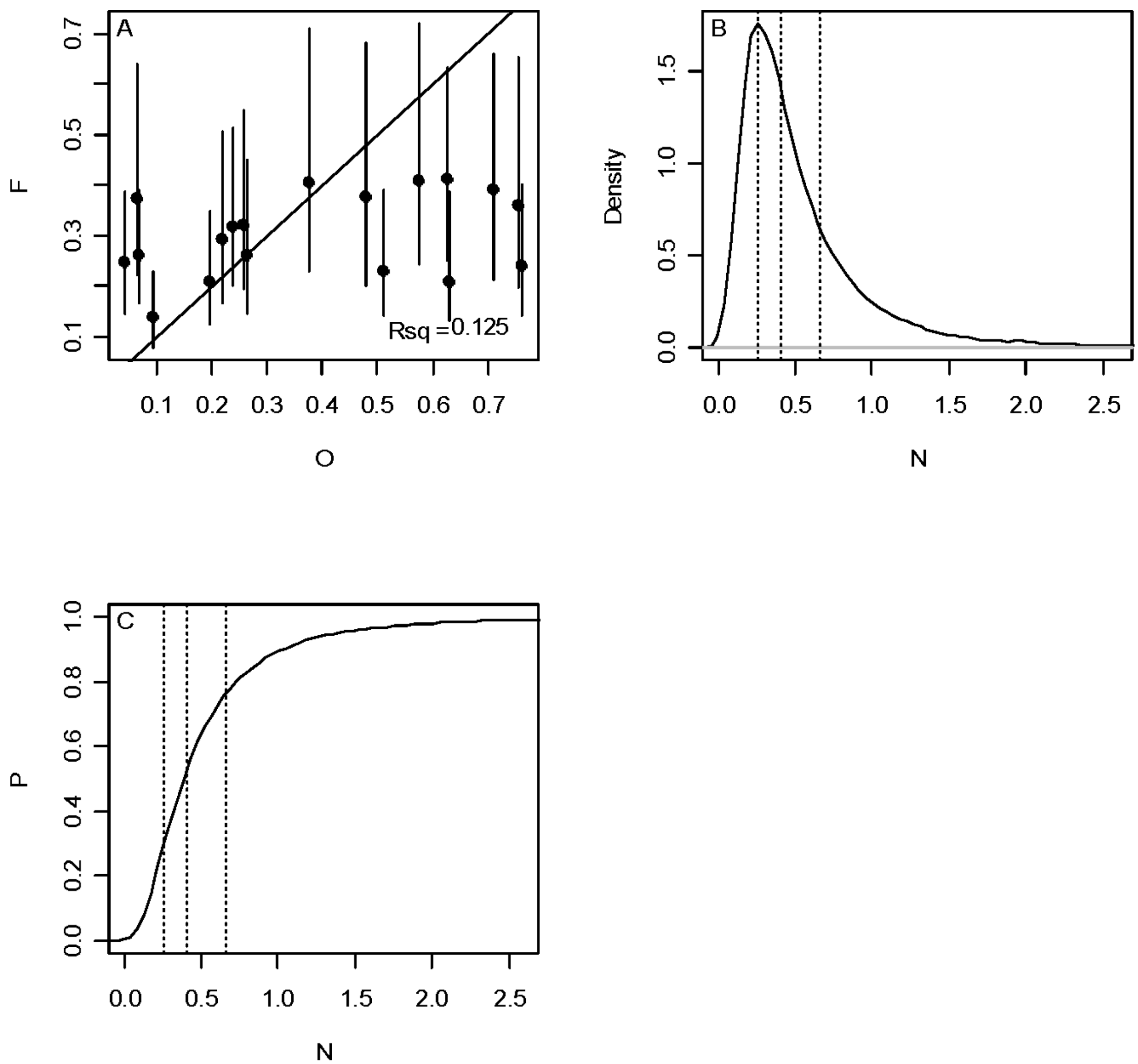

Figure 20. A) Retrospective forecasts (F) in millions for fish versus observed recruits (O) for the "best" performing candidate model (fry-based power model). Error bars are centred on the median (50%) estimate and show the 25% and 75% percentiles. The diagonal line is the 1:1 line. B) Probability density of the "posterior" distribution for the 2006 return forecast (N) in millions of fish. Vertical lines show the 25%, 50% and 75% percentiles. C) The probability distribution of the 2006 return forecast.

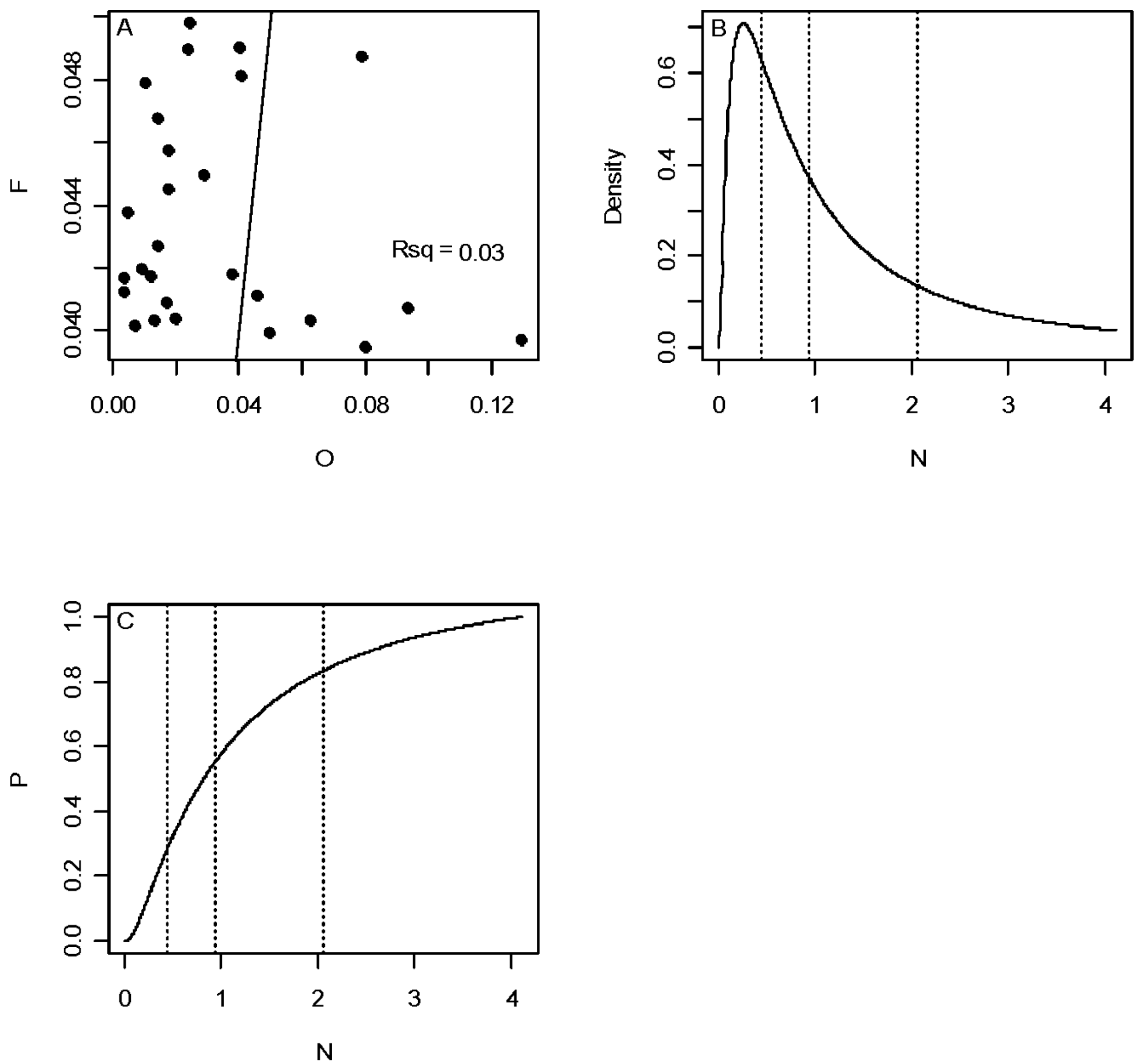

Figure 21. A) Retrospective forecasts (F) in millions for fish versus observed recruits (O) for the "best" performing candidate model (fry-based power model). Error bars are centred on the median (50%) estimate and show the 25% and 75% percentiles. The diagonal line is the 1:1 line. B) Probability density of the "posterior" distribution for the 2006 return forecast (N) in millions of fish. Vertical lines show the 25%, 50% and 75% percentiles. C) The probability distribution of the 2006 return forecast.

Cultus

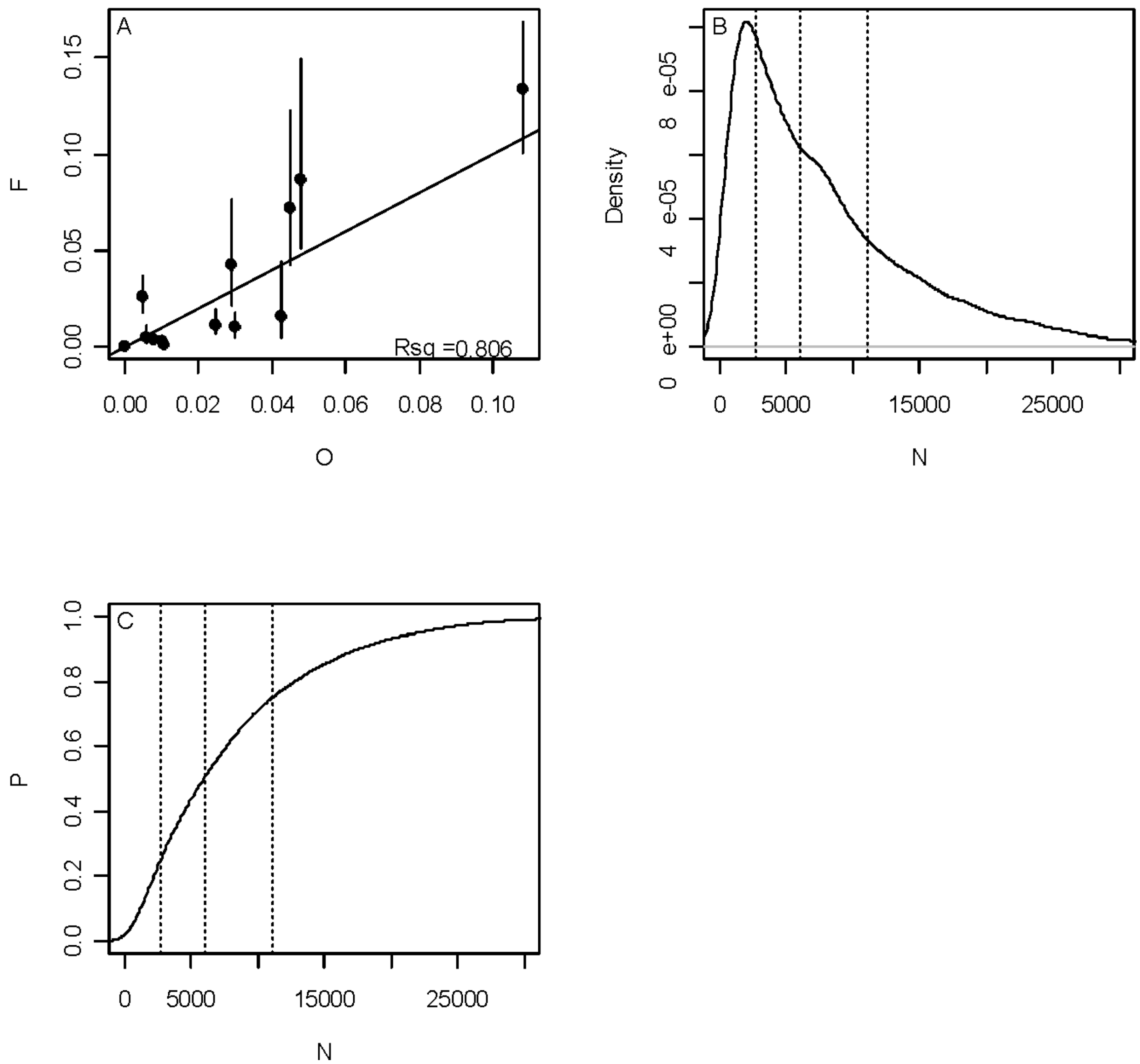

Figure 22. A) Retrospective forecasts (F) (x1000) for fish versus observed recruits (O) for the "best" performing candidate model (fry-jack model). Error bars are centred on the median (50%) estimate and show the 25% and 75% percentiles. The diagonal line is the 1:1 line. B) Probability density of the "posterior" distribution for the 2006 return forecast (N) (x1000). Vertical lines show the 25%, 50% and 75% percentiles. C) The probability distribution of the 2006 return forecast (x1000).

5. Discussion

One of the data choices made in this analysis is the method of pooling data. Data inputs were aggregated by cycle-line and by pooling the entire data series. Restricting models to cycle-line years theoretically should out perform alternative models based on data for the entire data series if the relationship between returns and predictor the variable varies among the four cycle lines. The performance of cyclic escapement-based models was an overall poor performer. The retrospective analysis could be a biased test due to small sample sizes or because we cannot detect a difference in productivity among cycles.

We tested whether productivity estimated by log (R/S) and/or stocks density effects estimated by a Ricker model can be better explained by data aggregated by cycle line data. We used classical analysis of variance (ANOVA) to answer the specific questions:

1) Does cycle line productivity expressed as log(R/S) in the absence of density dependence explain more of the variation in productivity compared to data aggregated across the entire data series?

2) Do distinct Ricker models for each cycle better explain the stock-recruitment relationship compared to a common Ricker model fit to the entire data series?

For Question 1, suppose that $\log(R/S)_i$ varies randomly around a mean level μ_i within each cycle *i*:

$\log(R_{it}/S_{it}) = \mu_i + \varepsilon_{it}$.. We tested the null hypothesis

H_0: $\mu_1 = \mu_2 = \mu_3 = \mu_4$

Was tested against the alternative

H_1: $\mu_1 \neq \mu_2 \neq \mu_3 \neq \mu_4$. For all 19 stocks, without exception, we could not reject H_0 for a common productivity in favour of statistically different productivities among cycle lines (F-test; $P<0.05$).

For Question 2, we tested whether the Ricker *a* or *b* parameters varies among cycle lines. Here the null hypothesis

H_0: $a_1 = a_2 = a_3 = a_4$

$b_1 = b_2 = b_3 = b_4$

was tested against the alternative

H_1: $a_1 \neq a_2 \neq a_3 \neq a_4$

$b_1 \neq b_2 \neq b_3 \neq b_4$.

We could not reject the null hypothesis for a common Ricker model for any of the non-cyclic stocks (F-test; $P<0.05$) but could reject H_0 for the highly cyclic stocks. On the basis of the ANOVA tests, aggregating data for the entire data series for at least the non-cyclic stocks appears justified. We acknowledge, however, that alternative data treatments (and models) are potentially tenable particularly for cyclic populations given the complexity of the dynamics in cyclic populations.

Most of the forecasts presented here are associated with large uncertainty. This is consistent with previous Fraser sockeye forecasts PSARC reviews and recent research on coast-wide salmon stocks ranging from Alaska to BC (Haeseker et al. 2005; Randall Perterman, Simon Fraser University, personal communication).

A recent study of forecasting model performance with 16 Fraser sockeye stocks, but excluding juvenile models, suggests naïve models were the best performers for the majority (10:6) (Personal communication, Steve Haeseker, U.S. Fish & Wildlife Service, Vancouver, Washington). Further, within the naïve group, the R1C model (i.e. like last generation) was the most common (7 of 10 cases). The differences in the choice of candidate models between the two studies could explain the different strengths of biological versus naïve model. Nevertheless, it is clear that no single model performs optimally across stocks and data sets. The best performing model is often stock dependent and varies according to performance criteria. Even for the best performing model assessed here, the recruitment variation among stocks explained by models spans a large ranged (3-83%) from extremely uncertain to informative.

Notwithstanding the Bayesian smolt-jack model used for Cultus sockeye, our choice of models was less inclusive compared to Haeseker (2005). We did not include a mixed-effects model that potentially increases parameter precision and inference about environmental effects. Nor did we consider Kalman filter models. Peterman et al (2003) applied a Kalman filtering technique to reconstruct historical productivity changes in Bristol Bay sockeye. Their work showed large swings in productivity for most of the stocks on a scale of 5-10 years. All studies to date indicated that all the test models are highly uncertain.

Our choice of biological data for Fraser River sockeye was more inclusive than other multi-stock studies in that we included a full suite of juvenile data. The performance of juvenile-based models was however also mixed. We selected environmental data that has been linked to salmon survival patterns in other studies. These include coastal SST (Mueter et al. 2002) and winter PDO (Beamish et al. 2004). Consistent with other studies, there was no noticeable improvement in forecast performance explained by the selected environmental variables including the addition of Fraser River discharge data. Admittedly our treatment of environmental effects is cursory. We recommend a more exhaustive assessment of hierarchical Bayesian mixed-stock effects model (Su et al. 2004), for example, to more fully consider environment/climate impacts.

Coast-wide high abundances of sockeye jack returns, including to the Fraser River in 2005, and large trawl catches of Fraser sockeye juveniles from the 2002 brood in Strait of Georgia (Dick Beamish, Fisheries and Oceans Canada, personal communication) have been reported. Qualitatively, these perhaps are suggestive of above average survival of the brood. On the other hand, the warm ocean conditions of the past few years (Anon. 2005) (http://www.pac.dfo-mpo.gc.ca/sci/psarc/OSRs/2004OSR_e.htm) and the anomalously late migratory timing and small body size of returning adults in 2005 perhaps are indicative of large-scale negative oceanographic effects. Whether these signals are short-term or indicative of long-term climate change impacts are unknown. There is consensus among members of the North Pacific Science Organization (PICES) that 1998 marked the change to another climate regime in the North Pacific http://www.pices.int/publications/brochures/PICES%20Advisory%20Report.pdf . Again, the short-term and long-term impact of that event on Fraser sockeye productivity and returns is unknown. The impact of global warming on the productivity of salmon, such as Fraser sockeye, that geographically are at the southern limit of the species range will increase forecast uncertainty. It is important to note that jack-based (sibling) regression forecasts of Fraser sockeye have not performed well in the past. The high ranking of the retrospective performance of the Bayesian smolt-jack model for Cultus Lake sockeye is encouraging but was not very informative in terms of the 2006 forecast compared to the next-best smolt model. Unfortunately, because sibling model perform poorly, the impacts of oceanographic factors on early life stages cannot reliably be estimated using the standard data sets and forecast models.

6. References

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Appendix Table 1. Biological data by stock.

A Effective females for all stocks except Cultus, which is represented by adult count at fence minus captive brood removals.

Stock	Brood Year	Cycle Year	Recruitment (Millions) Age 2	Age 3	Age 4	Age 5	Total	Spawners (Millions) [A]	Juveniles (fry, fall fry age 1 smolts) (Millions)
E.Stuart	1948	4	0	0.000000	0.179412	0.018741	0.198153	0.010859	NA
E.Stuart	1949	1	0	0.006218	1.029437	0.001271	1.030708	0.168471	NA
E.Stuart	1950	2	0	0.000579	0.240545	0.000542	0.241087	0.025658	NA
E.Stuart	1951	3	0	0.000009	0.158428	0.015217	0.173645	0.029787	NA
E.Stuart	1952	4	0	0.000028	0.078012	0.010560	0.088572	0.015483	NA
E.Stuart	1953	1	0	0.000294	0.537711	0.002886	0.540597	0.078332	NA
E.Stuart	1954	2	0	0.000341	0.154781	0.000701	0.155482	0.018010	NA
E.Stuart	1955	3	0	0.000011	0.025824	0.001632	0.027456	0.001397	NA
E.Stuart	1956	4	0	0.000000	0.101035	0.006393	0.107428	0.016662	NA
E.Stuart	1957	1	0	0.000730	1.215763	0.003272	1.219035	0.119278	NA
E.Stuart	1958	2	0	0.000755	0.102112	0.000240	0.102352	0.022196	NA
E.Stuart	1959	3	0	0.000000	0.014682	0.006153	0.020835	0.001297	NA
E.Stuart	1960	4	0	0.000022	0.069925	0.004202	0.074127	0.007401	NA
E.Stuart	1961	1	0	0.000630	0.252123	0.002208	0.254331	0.087809	NA
E.Stuart	1962	2	0	0.000000	0.067661	0.005992	0.073653	0.014075	NA
E.Stuart	1963	3	0	0.000332	0.090397	0.001825	0.092222	0.002590	NA
E.Stuart	1964	4	0	0.001027	0.025940	0.012949	0.038889	0.001300	NA
E.Stuart	1965	1	0	0.000432	0.415253	0.001526	0.416779	0.011242	NA
E.Stuart	1966	2	0	0.001746	0.083040	0.000000	0.083040	0.005959	NA
E.Stuart	1967	3	0	0.000423	0.326142	0.013128	0.339270	0.011167	NA
E.Stuart	1968	4	0	0.000011	0.010412	0.000000	0.010412	0.000793	NA
E.Stuart	1969	1	0	0.000648	1.366181	0.004452	1.370633	0.048687	NA
E.Stuart	1970	2	0	0.001212	0.178232	0.001312	0.179544	0.015806	NA
E.Stuart	1971	3	0	0.000311	0.423510	0.006993	0.430503	0.045612	NA
E.Stuart	1972	4	0	0.000025	0.032207	0.000000	0.032207	0.002253	NA
E.Stuart	1973	1	0	0.004591	1.342456	0.003951	1.346407	0.153870	NA
E.Stuart	1974	2	0	0.001242	0.141307	0.001849	0.143156	0.021603	NA
E.Stuart	1975	3	0	0.000150	0.220974	0.002852	0.223826	0.026248	NA
E.Stuart	1976	4	0	0.000020	0.028800	0.003034	0.031834	0.006792	NA
E.Stuart	1977	1	0	0.000572	0.752467	0.008655	0.761122	0.053381	NA
E.Stuart	1978	2	0	0.000202	0.071470	0.001180	0.072650	0.020005	NA
E.Stuart	1979	3	0	0.000034	0.089807	0.017889	0.107696	0.036172	NA
E.Stuart	1980	4	0	0.000010	0.037950	0.025541	0.063491	0.007361	NA
E.Stuart	1981	1	0	0.000046	0.331290	0.018805	0.350095	0.067227	NA
E.Stuart	1982	2	0	0.000013	0.026796	0.001007	0.027803	0.002158	NA
E.Stuart	1983	3	0	0.000423	0.176760	0.010949	0.187709	0.013121	NA
E.Stuart	1984	4	0	0.000240	0.209867	0.029536	0.239403	0.021868	NA
E.Stuart	1985	1	0	0.002414	1.179879	0.026057	1.205936	0.116610	NA
E.Stuart	1986	2	0	0.000056	0.128280	0.017603	0.145883	0.015219	NA
E.Stuart	1987	3	0	0.000008	0.494847	0.031065	0.525912	0.075970	NA
E.Stuart	1988	4	0	0.000033	0.319342	0.059894	0.379236	0.088069	NA

Stock	Brood Year	Cycle Year	Recruitment (Millions) Age 2	Age 3	Age 4	Age 5	Total	Spawners (Millions) [A]	Juveniles (fry, fall fry age 1 smolts) (Millions)
E.Stuart	1989	1	0	0.000420	1.091749	0.045958	1.137707	0.211039	NA
E.Stuart	1990	2	0	0.000002	0.156963	0.009133	0.166096	0.047063	27.908219
E.Stuart	1991	3	0	0.000514	0.129370	0.014581	0.143951	0.085454	53.050896
E.Stuart	1992	4	0	0.000010	0.080797	0.019569	0.100366	0.036293	12.328016
E.Stuart	1993	1	0	0.000847	1.652166	0.161770	1.813936	0.385694	628.116848
E.Stuart	1994	2	0	0.000006	0.027990	0.001034	0.029024	0.014544	16.049888
E.Stuart	1995	3	0	0.000020	0.170595	0.018985	0.189580	0.057322	37.445340
E.Stuart	1996	4	0	0.000000	0.359206	0.103232	0.462438	0.041063	30.934483
E.Stuart	1997	1	0	0.000001	0.107475	0.038120	0.145595	0.073053	25.642477
E.Stuart	1998	2	0	0.000002	0.024341	0.005137	0.029478	0.009375	4.837449
E.Stuart	1999	3	0	0.000000	0.030628	0.000000	0.030628	0.008397	4.428665
E.Stuart	2000	4	0	0.000000	0.132370	0.000000	0.132370	0.035315	32.807366
E.Stuart	2001	1	NA	NA	NA	NA	NA	0.082833	51.804034
E.Stuart	2002	2	NA	NA	NA	NA	NA	0.012939	11.603591
L.Stuart	1948	4	0	0.000000	0.000327	0.000000	0.000327	NA	NA
L.Stuart	1949	1	0	0.003433	1.526554	0.000000	1.526554	0.039085	NA
L.Stuart	1950	2	0	0.000591	0.036671	0.002419	0.039090	0.001834	NA
L.Stuart	1951	3	0	0.000000	0.056085	0.007559	0.063644	0.001247	NA
L.Stuart	1952	4	0	0.000086	0.003858	0.000029	0.003887	0.000016	NA
L.Stuart	1953	1	0	0.000830	1.548072	0.001470	1.549542	0.078689	NA
L.Stuart	1954	2	0	0.000150	0.135111	0.002704	0.137815	0.002687	NA
L.Stuart	1955	3	0	0.000029	0.050196	0.001120	0.051316	0.003274	NA
L.Stuart	1956	4	0	0.000000	0.013472	0.032630	0.046102	0.000466	NA
L.Stuart	1957	1	0	0.000874	1.327094	0.001916	1.329010	0.300029	NA
L.Stuart	1958	2	0	0.000672	0.053044	0.000961	0.054005	0.013152	NA
L.Stuart	1959	3	0	0.000067	0.006092	0.001233	0.007325	0.004090	NA
L.Stuart	1960	4	0	0.000027	0.006658	0.002932	0.009590	0.001307	NA
L.Stuart	1961	1	0	0.000143	0.770385	0.007535	0.777920	0.194469	NA
L.Stuart	1962	2	0	0.000045	0.043107	0.001917	0.045024	0.009073	NA
L.Stuart	1963	3	0	0.000025	0.011911	0.000113	0.012024	0.001092	NA
L.Stuart	1964	4	0	0.000060	0.001806	0.001235	0.003041	0.000824	NA
L.Stuart	1965	1	0	0.000228	1.102448	0.021752	1.124200	0.122789	NA
L.Stuart	1966	2	0	0.000274	0.071954	0.001851	0.073805	0.004164	NA
L.Stuart	1967	3	0	0.000224	0.006294	0.010038	0.016332	0.000897	NA
L.Stuart	1968	4	0	0.000000	0.027393	0.003906	0.031299	0.000179	NA
L.Stuart	1969	1	0	0.002756	1.602892	0.019888	1.622780	0.114306	NA
L.Stuart	1970	2	0	0.000318	0.070520	0.000000	0.070520	0.008027	NA
L.Stuart	1971	3	0	0.001243	0.065527	0.000000	0.065527	0.000725	NA
L.Stuart	1972	4	0	0.000000	0.016180	0.002586	0.018766	0.003411	NA
L.Stuart	1973	1	0	0.000290	0.658158	0.005807	0.663965	0.116706	NA
L.Stuart	1974	2	0	0.000855	0.048593	0.000947	0.049540	0.007371	NA
L.Stuart	1975	3	0	0.000541	0.196371	0.000478	0.196849	0.005679	NA
L.Stuart	1976	4	0	0.000000	0.003339	0.000000	0.003339	0.001674	NA
L.Stuart	1977	1	0	0.000104	1.313861	0.043776	1.357637	0.075890	NA
L.Stuart	1978	2	0	0.000699	0.069820	0.008928	0.078748	0.007115	NA
L.Stuart	1979	3	0	0.000000	0.006854	0.000000	0.006854	0.016711	NA

Stock	Brood Year	Cycle Year	Recruitment (Millions)					Spawners (Millions) [A]	Juveniles (fry, fall fry age 1 smolts) (Millions)
			Age 2	Age 3	Age 4	Age 5	Total		
L.Stuart	1980	4	0	0.000000	0.021440	0.000000	0.021440	0.000286	NA
L.Stuart	1981	1	0	0.000000	1.978010	0.055891	2.033901	0.120124	NA
L.Stuart	1982	2	0	0.000193	0.052097	0.008699	0.060796	0.008681	NA
L.Stuart	1983	3	0	0.000000	0.014195	0.003717	0.017912	0.001451	NA
L.Stuart	1984	4	0	0.000222	0.014522	0.000000	0.014522	0.000672	NA
L.Stuart	1985	1	0	0.007755	3.367086	0.132788	3.499874	0.159101	NA
L.Stuart	1986	2	0	0.000264	0.725126	0.091171	0.816297	0.015044	NA
L.Stuart	1987	3	0	0.000984	0.283932	0.095155	0.379087	0.002393	NA
L.Stuart	1988	4	0	0.001552	0.207234	0.000000	0.207234	0.003638	NA
L.Stuart	1989	1	0	0.020256	5.162734	0.144134	5.306868	0.327096	NA
L.Stuart	1990	2	0	0.000440	0.372685	0.016069	0.388754	0.111747	NA
L.Stuart	1991	3	0	0.000354	0.089247	0.017786	0.107033	0.040200	NA
L.Stuart	1992	4	0	0.000000	0.128970	0.006429	0.135399	0.012422	NA
L.Stuart	1993	1	0	0.004082	3.249145	0.511029	3.760174	0.744565	NA
L.Stuart	1994	2	0	0.000000	0.108011	0.007429	0.115440	0.040717	NA
L.Stuart	1995	3	0	0.001366	0.092713	0.039358	0.132071	0.017181	NA
L.Stuart	1996	4	0	0.000607	0.809646	0.214682	1.024328	0.027297	NA
L.Stuart	1997	1	0	0.000081	0.353577	0.017033	0.370610	0.415149	NA
L.Stuart	1998	2	0	0.000017	0.264055	0.013629	0.277684	0.067836	NA
L.Stuart	1999	3	0	0.000023	0.127524	0.016039	0.143563	0.033801	NA
L.Stuart	2000	4	0	0.001827	0.858113	0.000000	0.858113	0.226267	NA
L.Stuart	2001	1	NA	NA	NA	NA	NA	0.179527	NA
L.Stuart	2002	2	NA	NA	NA	NA	NA	0.017820	NA
Stellako	1948	4	0	0.000000	0.185175	0.022002	0.207177	0.009242	NA
Stellako	1949	1	0	0.000133	0.173402	0.006341	0.179743	0.040228	NA
Stellako	1950	2	0	0.004630	0.903768	0.030719	0.934487	0.077415	NA
Stellako	1951	3	0	0.000026	0.354049	0.101292	0.455341	0.051412	NA
Stellako	1952	4	0	0.000023	0.093984	0.016694	0.110678	0.019920	NA
Stellako	1953	1	0	0.000030	0.156192	0.018023	0.174215	0.020388	NA
Stellako	1954	2	0	0.003311	1.140205	0.067783	1.207988	0.072273	NA
Stellako	1955	3	0	0.000028	0.602677	0.027091	0.629768	0.029937	NA
Stellako	1956	4	0	0.000092	0.220400	0.026243	0.246643	0.022276	NA
Stellako	1957	1	0	0.000008	0.143835	0.008000	0.151835	0.018044	NA
Stellako	1958	2	0	0.001156	0.323089	0.016215	0.339304	0.061581	NA
Stellako	1959	3	0	0.000017	0.514918	0.026485	0.541403	0.041872	NA
Stellako	1960	4	0	0.000019	0.143340	0.021155	0.164495	0.022718	NA
Stellako	1961	1	0	0.000288	0.137046	0.010068	0.147114	0.018136	NA
Stellako	1962	2	0	0.000100	0.572029	0.017376	0.589405	0.044532	NA
Stellako	1963	3	0	0.000977	0.713487	0.013462	0.726949	0.041535	NA
Stellako	1964	4	0	0.000194	0.170674	0.006969	0.177643	0.016182	NA
Stellako	1965	1	0	0.000179	0.231100	0.012372	0.243472	0.020479	NA
Stellako	1966	2	0	0.000833	0.336316	0.022757	0.359073	0.051509	NA
Stellako	1967	3	0	0.000288	0.531886	0.018350	0.550236	0.032467	NA
Stellako	1968	4	0	0.000085	0.125900	0.003837	0.129737	0.013680	NA
Stellako	1969	1	0	0.000131	0.235729	0.017385	0.253114	0.025629	NA
Stellako	1970	2	0	0.001170	0.228808	0.004130	0.232938	0.026727	NA

Stock	Brood Year	Cycle Year	Recruitment (Millions)					Spawners (Millions) [A]	Juveniles (fry, fall fry age 1 smolts) (Millions)
			Age 2	Age 3	Age 4	Age 5	Total		
Stellako	1971	3	0	0.000496	0.508759	0.000000	0.508759	0.020147	NA
Stellako	1972	4	0	0.000204	0.711226	0.044784	0.756010	0.020386	NA
Stellako	1973	1	0	0.000011	0.075813	0.010077	0.085890	0.015424	NA
Stellako	1974	2	0	0.001823	0.281752	0.014082	0.295834	0.023718	NA
Stellako	1975	3	0	0.003852	1.682571	0.064645	1.747216	0.068451	NA
Stellako	1976	4	0	0.000170	0.216701	0.027506	0.244207	0.065299	NA
Stellako	1977	1	0	0.000074	0.209138	0.056488	0.265626	0.010894	NA
Stellako	1978	2	0	0.000860	0.388505	0.048040	0.436545	0.032528	NA
Stellako	1979	3	0	0.000031	0.478737	0.145156	0.623893	0.152583	NA
Stellako	1980	4	0	0.000207	0.535944	0.219255	0.755199	0.028477	NA
Stellako	1981	1	0	0.000028	0.234136	0.051734	0.285870	0.012030	NA
Stellako	1982	2	0	0.001900	0.309369	0.046504	0.355873	0.034888	NA
Stellako	1983	3	0	0.001129	1.097744	0.158607	1.256351	0.061357	NA
Stellako	1984	4	0	0.000170	0.744589	0.266430	1.011019	0.032672	NA
Stellako	1985	1	0	0.000087	0.097659	0.030996	0.128655	0.021968	NA
Stellako	1986	2	0	0.000023	0.445398	0.116424	0.561822	0.044611	NA
Stellako	1987	3	0	0.000014	0.353471	0.082191	0.435662	0.098179	NA
Stellako	1988	4	0	0.000158	0.566227	0.425114	0.991341	0.200541	NA
Stellako	1989	1	0	0.000028	0.127212	0.095047	0.222259	0.015926	NA
Stellako	1990	2	0	0.001145	0.861027	0.099889	0.960916	0.056536	NA
Stellako	1991	3	0	0.000259	0.336974	0.037271	0.374245	0.054400	65.558880
Stellako	1992	4	0	0.000338	0.734393	0.133793	0.868186	0.055190	53.022000
Stellako	1993	1	0	0.000013	0.068158	0.241673	0.309831	0.042858	49.770000
Stellako	1994	2	0	0.000127	0.593409	0.088649	0.682058	0.064353	39.866000
Stellako	1995	3	0	0.000075	0.127344	0.056515	0.183859	0.041176	21.233000
Stellako	1996	4	0	0.000016	0.635220	0.178242	0.813462	0.167624	36.942000
Stellako	1997	1	0	0.000000	0.069200	0.056248	0.125448	0.023245	24.851000
Stellako	1998	2	0	0.000073	0.500776	0.144775	0.645551	0.097011	79.020000
Stellako	1999	3	0	0.000000	0.156491	0.029891	0.186382	0.066140	24.681000
Stellako	2000	4	0	0.000000	0.635186	0.000000	0.635186	0.195386	75.156000
Stellako	2001	1	NA	NA	NA	NA	NA	0.061590	48.435000
Stellako	2002	2	NA	NA	NA	NA	NA	0.177618	60.290000
Bowron	1948	4	0	0.000000	0.080266	0.000000	0.080266	0.012826	NA
Bowron	1949	1	0	0.000045	0.062746	0.000000	0.062746	0.010721	NA
Bowron	1950	2	0	0.000550	0.065365	0.009633	0.074998	0.007298	NA
Bowron	1951	3	0	0.000378	0.103443	0.000000	0.103443	0.010039	NA
Bowron	1952	4	0	0.000008	0.036992	0.006304	0.043296	0.008568	NA
Bowron	1953	1	0	0.000003	0.070599	0.004977	0.075576	0.005734	NA
Bowron	1954	2	0	0.000652	0.062971	0.003293	0.066264	0.004566	NA
Bowron	1955	3	0	0.000043	0.092623	0.004289	0.096912	0.004471	NA
Bowron	1956	4	0	0.000000	0.027586	0.010160	0.037746	0.003639	NA
Bowron	1957	1	0	0.000000	0.041008	0.000958	0.041966	0.006416	NA
Bowron	1958	2	0	0.000043	0.017945	0.000167	0.018112	0.008297	NA
Bowron	1959	3	0	0.000011	0.056454	0.005400	0.061854	0.014614	NA
Bowron	1960	4	0	0.000004	0.017278	0.000451	0.017729	0.003506	NA
Bowron	1961	1	0	0.000000	0.026835	0.001313	0.028148	0.003675	NA

Stock	Brood Year	Cycle Year	Recruitment (Millions) Age 2	Age 3	Age 4	Age 5	Total	Spawners (Millions) [A]	Juveniles (fry, fall fry age 1 smolts) (Millions)
Bowron	1962	2	0	0.000006	0.018822	0.002499	0.021321	0.003219	NA
Bowron	1963	3	0	0.000028	0.204973	0.009315	0.214288	0.011468	NA
Bowron	1964	4	0	0.000000	0.025416	0.002091	0.027507	0.000690	NA
Bowron	1965	1	0	0.000050	0.016770	0.001029	0.017799	0.001170	NA
Bowron	1966	2	0	0.000000	0.021196	0.001053	0.022249	0.001151	NA
Bowron	1967	3	0	0.000124	0.193857	0.012513	0.206370	0.013991	NA
Bowron	1968	4	0	0.000000	0.037393	0.006150	0.043543	0.001710	NA
Bowron	1969	1	0	0.000000	0.016003	0.001208	0.017211	0.001936	NA
Bowron	1970	2	0	0.000371	0.015826	0.000000	0.015826	0.000497	NA
Bowron	1971	3	0	0.000000	0.124161	0.000346	0.124507	0.010761	NA
Bowron	1972	4	0	0.000000	0.016860	0.000111	0.016971	0.001969	NA
Bowron	1973	1	0	0.000000	0.010538	0.000124	0.010662	0.002012	NA
Bowron	1974	2	0	0.000000	0.015702	0.003458	0.019160	0.001046	NA
Bowron	1975	3	0	0.000122	0.169441	0.000634	0.170075	0.014735	NA
Bowron	1976	4	0	0.000000	0.007112	0.000000	0.007112	0.001069	NA
Bowron	1977	1	0	0.000000	0.005875	0.009521	0.015396	0.001214	NA
Bowron	1978	2	0	0.000000	0.039903	0.000724	0.040627	0.001678	NA
Bowron	1979	3	0	0.000000	0.015714	0.014270	0.029984	0.016178	NA
Bowron	1980	4	0	0.000000	0.039381	0.005789	0.045170	0.001376	NA
Bowron	1981	1	0	0.000000	0.014724	0.001808	0.016532	0.000562	NA
Bowron	1982	2	0	0.000000	0.003066	0.002211	0.005277	0.000990	NA
Bowron	1983	3	0	0.000017	0.036597	0.001535	0.038132	0.003484	NA
Bowron	1984	4	0	0.000012	0.044712	0.005879	0.050591	0.004909	NA
Bowron	1985	1	0	0.000000	0.016449	0.002728	0.019177	0.003030	NA
Bowron	1986	2	0	0.000000	0.020562	0.000636	0.021198	0.001396	NA
Bowron	1987	3	0	0.000132	0.018171	0.004289	0.022460	0.005660	NA
Bowron	1988	4	0	0.000000	0.011669	0.001381	0.013050	0.007405	NA
Bowron	1989	1	0	0.000000	0.004945	0.007897	0.012842	0.001367	NA
Bowron	1990	2	0	0.000000	0.018847	0.013002	0.031849	0.005065	NA
Bowron	1991	3	0	0.000114	0.049865	0.001083	0.050948	0.002460	NA
Bowron	1992	4	0	0.000014	0.010556	0.002313	0.012869	0.001117	NA
Bowron	1993	1	0	0.000000	0.016961	0.003506	0.020467	0.000592	NA
Bowron	1994	2	0	0.000000	0.006743	0.004106	0.010849	0.001845	NA
Bowron	1995	3	0	0.000040	0.025092	0.002258	0.027350	0.013487	NA
Bowron	1996	4	0	0.000000	0.020689	0.006608	0.027297	0.004054	NA
Bowron	1997	1	0	0.000000	0.001451	0.003734	0.005185	0.002119	NA
Bowron	1998	2	0	0.000000	0.011410	0.003849	0.015259	0.002830	NA
Bowron	1999	3	0	0.000000	0.013258	0.000000	0.013258	0.003295	NA
Bowron	2000	4	0	0.000000	0.025379	0.000000	0.025379	0.006720	NA
Bowron	2001	1	NA	NA	NA	NA	NA	0.002752	NA
Bowron	2002	2	NA	NA	NA	NA	NA	0.004505	NA
Raft	1948	4	0	0.000000	0.062653	0.000684	0.063337	0.005524	NA
Raft	1949	1	0	0.000000	0.036748	0.002878	0.039626	0.002109	NA
Raft	1950	2	0	0.000017	0.039549	0.005990	0.045539	0.001917	NA
Raft	1951	3	0	0.000008	0.034636	0.013009	0.047645	0.003365	NA
Raft	1952	4	0	0.000005	0.046167	0.005010	0.051177	0.005116	NA

Stock	Brood Year	Cycle Year	Recruitment (Millions) Age 2	Age 3	Age 4	Age 5	Total	Spawners (Millions) [A]	Juveniles (fry, fall fry age 1 smolts) (Millions)
Raft	1953	1	0	0.000000	0.030285	0.001839	0.032124	0.003600	NA
Raft	1954	2	0	0.000231	0.038964	0.011293	0.050257	0.005352	NA
Raft	1955	3	0	0.000007	0.052497	0.007860	0.060357	0.002905	NA
Raft	1956	4	0	0.000000	0.017335	0.008029	0.025364	0.005180	NA
Raft	1957	1	0	0.000072	0.018932	0.002011	0.020943	0.003314	NA
Raft	1958	2	0	0.000023	0.022591	0.000512	0.023103	0.006235	NA
Raft	1959	3	0	0.000000	0.020417	0.003167	0.023584	0.005232	NA
Raft	1960	4	0	0.000064	0.014715	0.002049	0.016764	0.002690	NA
Raft	1961	1	0	0.000032	0.022139	0.002154	0.024293	0.003014	NA
Raft	1962	2	0	0.000000	0.037568	0.002981	0.040549	0.004197	NA
Raft	1963	3	0	0.000018	0.009090	0.000265	0.009355	0.002693	NA
Raft	1964	4	0	0.000081	0.040283	0.008228	0.048511	0.002666	NA
Raft	1965	1	0	0.000073	0.018867	0.001686	0.020553	0.002669	NA
Raft	1966	2	0	0.000320	0.020483	0.002736	0.023219	0.002666	NA
Raft	1967	3	0	0.000037	0.008226	0.001395	0.009621	0.000358	NA
Raft	1968	4	0	0.000098	0.100888	0.005411	0.106299	0.003455	NA
Raft	1969	1	0	0.000381	0.010279	0.003710	0.013989	0.002577	NA
Raft	1970	2	0	0.000037	0.008300	0.000523	0.008823	0.001205	NA
Raft	1971	3	0	0.000033	0.009570	0.002116	0.011686	0.000223	NA
Raft	1972	4	0	0.000087	0.056973	0.000761	0.057734	0.004507	NA
Raft	1973	1	0	0.000022	0.001616	0.007723	0.009339	0.001345	NA
Raft	1974	2	0	0.000206	0.011541	0.000774	0.012315	0.001479	NA
Raft	1975	3	0	0.000007	0.006963	0.000797	0.007760	0.001391	NA
Raft	1976	4	0	0.000044	0.018539	0.001331	0.019870	0.003976	NA
Raft	1977	1	0	0.000000	0.002728	0.003189	0.005917	0.000198	NA
Raft	1978	2	0	0.000253	0.011888	0.006562	0.018450	0.001343	NA
Raft	1979	3	0	0.000000	0.001183	0.001856	0.003039	0.000693	NA
Raft	1980	4	0	0.000112	0.047827	0.003784	0.051611	0.002056	NA
Raft	1981	1	0	0.000029	0.007366	0.001244	0.008610	0.000312	NA
Raft	1982	2	0	0.000000	0.002509	0.001233	0.003742	0.001533	NA
Raft	1983	3	0	0.000038	0.002855	0.001196	0.004051	0.001821	NA
Raft	1984	4	0	0.000325	0.032692	0.014038	0.046730	0.006701	NA
Raft	1985	1	0	0.000007	0.002830	0.001591	0.004421	0.001922	NA
Raft	1986	2	0	0.000000	0.002902	0.000111	0.003013	0.001080	NA
Raft	1987	3	0	0.000000	0.001399	0.002421	0.003820	0.000723	NA
Raft	1988	4	0	0.000000	0.041783	0.008304	0.050087	0.009207	NA
Raft	1989	1	0	0.000007	0.007357	0.003935	0.011292	0.000925	NA
Raft	1990	2	0	0.000000	0.001610	0.000973	0.002583	0.000412	NA
Raft	1991	3	0	0.000000	0.000937	0.000553	0.001490	0.000264	NA
Raft	1992	4	0	0.000006	0.065321	0.002024	0.067345	0.004112	NA
Raft	1993	1	0	0.000024	0.022386	0.010727	0.033113	0.002934	NA
Raft	1994	2	0	0.000000	0.004738	0.022745	0.027483	0.000800	NA
Raft	1995	3	0	0.000041	0.022745	0.004482	0.027227	0.000682	NA
Raft	1996	4	0	0.000593	0.089288	0.023399	0.112687	0.021381	NA
Raft	1997	1	0	0.000000	0.026803	0.025591	0.052394	0.002367	NA
Raft	1998	2	0	0.000008	0.004965	0.007631	0.012596	0.003585	NA

Stock	Brood Year	Cycle Year	Recruitment (Millions) Age 2	Age 3	Age 4	Age 5	Total	Spawners (Millions) [A]	Juveniles (fry, fall fry age 1 smolts) (Millions)
Raft	1999	3	0	0.000079	0.017806	0.034226	0.052032	0.003499	NA
Raft	2000	4	0	0.000053	0.106411	0.000000	0.106411	0.027668	NA
Raft	2001	1	NA	NA	NA	NA	NA	0.016025	NA
Raft	2002	2	NA	NA	NA	NA	NA	0.008402	NA
Quesnel	1948	4	0	0.000000	0.000618	0.000000	0.000618	0.000047	NA
Quesnel	1949	1	0	0.022969	0.463409	0.000000	0.463409	0.019208	NA
Quesnel	1950	2	0	0.000034	0.002014	0.000000	0.002014	0.000264	NA
Quesnel	1951	3	0	0.000000	0.000413	0.000000	0.000413	0.000009	NA
Quesnel	1952	4	0	0.000000	0.000562	0.000000	0.000562	0.000051	NA
Quesnel	1953	1	0	0.005902	0.604123	0.000220	0.604343	0.047564	NA
Quesnel	1954	2	0	0.000000	0.010692	0.000000	0.010692	0.000146	NA
Quesnel	1955	3	0	0.000000	0.000180	0.000000	0.000180	0.000030	NA
Quesnel	1956	4	0	0.000018	0.001115	0.000000	0.001115	0.000038	NA
Quesnel	1957	1	0	0.009779	0.989580	0.000144	0.989724	0.134562	NA
Quesnel	1958	2	0	0.000027	0.003362	0.000023	0.003385	0.001269	NA
Quesnel	1959	3	0	0.000000	0.000165	0.000000	0.000165	0.000029	NA
Quesnel	1960	4	0	0.000006	0.001469	0.000000	0.001469	0.000123	NA
Quesnel	1961	1	0	0.044481	1.195807	0.000509	1.196316	0.069938	NA
Quesnel	1962	2	0	0.000030	0.007257	0.000000	0.007257	0.000566	NA
Quesnel	1963	3	0	0.000000	0.000956	0.000000	0.000956	0.000040	NA
Quesnel	1964	4	0	0.000000	0.002812	0.000000	0.002812	0.000077	NA
Quesnel	1965	1	0	0.014161	1.652107	0.000821	1.652928	0.105350	NA
Quesnel	1966	2	0	0.000028	0.007038	0.000396	0.007434	0.001040	NA
Quesnel	1967	3	0	0.000011	0.001750	0.000000	0.001750	0.000024	NA
Quesnel	1968	4	0	0.000000	0.000428	0.000000	0.000428	0.000333	NA
Quesnel	1969	1	0	0.006482	1.626582	0.007768	1.634350	0.078639	NA
Quesnel	1970	2	0	0.000000	0.020339	0.000000	0.020339	0.000388	NA
Quesnel	1971	3	0	0.000000	0.000747	0.000000	0.000747	0.000016	NA
Quesnel	1972	4	0	0.000009	0.000856	0.000000	0.000856	0.000046	NA
Quesnel	1973	1	0	0.005641	2.167745	0.002641	2.170386	0.112413	NA
Quesnel	1974	2	0	0.000080	0.021208	0.001143	0.022351	0.002587	NA
Quesnel	1975	3	0	0.000000	0.001713	0.000000	0.001713	0.000105	NA
Quesnel	1976	4	0	0.000000	0.001233	0.000000	0.001233	0.000209	0.114400
Quesnel	1977	1	0	0.008446	3.810786	0.054029	3.864815	0.160492	49.600000
Quesnel	1978	2	0	0.000142	0.186073	0.010473	0.196546	0.004349	NA
Quesnel	1979	3	0	0.000000	0.002103	0.003908	0.006011	0.000238	NA
Quesnel	1980	4	0	0.000000	0.002446	0.000000	0.002446	0.000098	NA
Quesnel	1981	1	0	0.019608	9.553856	0.212953	9.766809	0.329550	67.584371
Quesnel	1982	2	0	0.000000	0.498387	0.056312	0.554699	0.020034	NA
Quesnel	1983	3	0	0.000033	0.031515	0.008864	0.040379	0.001098	NA
Quesnel	1984	4	0	0.000085	0.006868	0.000000	0.006868	0.000551	NA
Quesnel	1985	1	0	0.031005	12.057631	0.326398	12.384029	0.690676	46.515454
Quesnel	1986	2	0	0.000041	2.349593	0.168115	2.517708	0.094701	14.683961
Quesnel	1987	3	0	0.000009	0.119437	0.057144	0.176581	0.011238	11.009225
Quesnel	1988	4	0	0.000000	0.026563	0.000000	0.026563	0.004180	NA
Quesnel	1989	1	0	0.012318	10.221562	0.277957	10.499519	0.931813	58.013355

Stock	Brood Year	Cycle Year	Recruitment (Millions)					Spawners (Millions) [A]	Juveniles (fry, fall fry age 1 smolts) (Millions)
			Age 2	Age 3	Age 4	Age 5	Total		
Quesnel	1990	2	0	0.000567	2.917338	0.347207	3.264545	0.256866	5.244447
Quesnel	1991	3	0	0.000026	0.103127	0.050671	0.153798	0.024862	12.291054
Quesnel	1992	4	0	0.000000	0.029213	0.000000	0.029213	0.003046	NA
Quesnel	1993	1	0	0.001924	6.446036	0.392499	6.838535	1.489912	62.550416
Quesnel	1994	2	0	0.000248	2.226039	0.212418	2.438457	0.352034	16.753374
Quesnel	1995	3	0	0.000000	0.116084	0.048206	0.164290	0.116916	NA
Quesnel	1996	4	0	0.000000	0.067872	0.019598	0.087470	0.021720	NA
Quesnel	1997	1	0	0.001383	3.890388	0.308976	4.199364	0.853267	55.546172
Quesnel	1998	2	0	0.000053	4.397304	0.268217	4.665521	0.523136	42.867369
Quesnel	1999	3	0	0.000000	0.573851	0.220692	0.794543	0.105688	15.864029
Quesnel	2000	4	0	0.000000	0.036617	0.000000	0.036617	0.036927	5.159686
Quesnel	2001	1	NA	NA	NA	NA	NA	1.538258	65.965060
Quesnel	2002	2	NA	NA	NA	NA	NA	1.312599	51.300000
Chilko	1948	4	0	0.032000	1.643062	0.011182	1.654244	0.364597	NA
Chilko	1949	1	0	0.003732	0.560635	0.010368	0.571003	0.033029	3.146830
Chilko	1950	2	0	0.001489	0.183278	0.004705	0.187983	0.006555	1.170491
Chilko	1951	3	0	0.003925	0.644911	0.020763	0.665674	0.057564	11.504581
Chilko	1952	4	0	0.018732	1.763929	0.035975	1.799904	0.233628	24.491079
Chilko	1953	1	0	0.001172	0.514554	0.014004	0.528558	0.094471	7.690383
Chilko	1954	2	0	0.012234	0.632132	0.004415	0.636547	0.021247	2.853403
Chilko	1955	3	0	0.032418	1.407963	0.031011	1.438974	0.075834	9.159120
Chilko	1956	4	0	0.013905	2.379854	0.016684	2.396538	0.368607	28.242157
Chilko	1957	1	0	0.000076	0.117362	0.003149	0.120511	0.083128	9.458468
Chilko	1958	2	0	0.004055	0.278320	0.013613	0.291933	0.070433	6.894577
Chilko	1959	3	0	0.023792	2.080497	0.018659	2.099156	0.272891	32.164794
Chilko	1960	4	0	0.005472	0.958877	0.005980	0.964857	0.244864	33.780351
Chilko	1961	1	0	0.000256	0.052713	0.011583	0.064296	0.015038	1.592073
Chilko	1962	2	0	0.010657	0.960609	0.013582	0.974191	0.042125	8.813395
Chilko	1963	3	0	0.037579	1.112861	0.004045	1.116906	0.057163	9.269764
Chilko	1964	4	0	0.007252	1.818921	0.055810	1.874731	0.131590	23.664571
Chilko	1965	1	0	0.001787	0.138555	0.002360	0.140915	0.020813	2.346223
Chilko	1966	2	0	0.026456	0.744469	0.027636	0.772105	0.107541	17.354774
Chilko	1967	3	0	0.028734	1.933329	0.023351	1.956680	0.090006	9.148004
Chilko	1968	4	0	0.046952	2.335183	0.021925	2.357108	0.181912	31.541800
Chilko	1969	1	0	0.004126	0.369954	0.015839	0.385793	0.025519	3.586283
Chilko	1970	2	0	0.016775	0.627337	0.001084	0.628421	0.050923	3.832910
Chilko	1971	3	0	0.024353	0.571260	0.000000	0.571260	0.084109	5.671900
Chilko	1972	4	0	0.037001	1.861092	0.034424	1.895516	0.331140	20.270000
Chilko	1973	1	0	0.007640	0.195187	0.006807	0.201994	0.030231	4.300000
Chilko	1974	2	0	0.024416	0.641497	0.004748	0.646245	0.070790	7.246000
Chilko	1975	3	0	0.022821	1.406022	0.007375	1.413397	0.102022	14.145000
Chilko	1976	4	0	0.007798	1.572025	0.025168	1.597193	0.211581	26.011000
Chilko	1977	1	0	0.002708	0.189574	0.002743	0.192317	0.019832	2.268000
Chilko	1978	2	0	0.008307	1.125918	0.077743	1.203661	0.082726	16.490000
Chilko	1979	3	0	0.005962	1.459307	0.067538	1.526845	0.134853	21.152000
Chilko	1980	4	0	0.008842	3.496336	0.473961	3.970297	0.276057	35.038000

Stock	Brood Year	Cycle Year	Recruitment (Millions)					Spawners (Millions) [A]	Juveniles (fry, fall fry age 1 smolts) (Millions)
			Age 2	Age 3	Age 4	Age 5	Total		
Chilko	1981	1	0	0.001220	0.177561	0.004547	0.182108	0.020084	1.697240
Chilko	1982	2	0	0.047921	1.300458	0.131741	1.432199	0.135971	13.325670
Chilko	1983	3	0	0.043205	1.289276	0.036418	1.325694	0.178374	19.715000
Chilko	1984	4	0	0.004770	0.324216	0.002890	0.327106	0.220003	9.843000
Chilko	1985	1	0	0.000331	0.308815	0.184400	0.493215	0.034739	5.588000
Chilko	1986	2	0	0.021355	4.413216	0.279555	4.692771	0.158632	18.885000
Chilko	1987	3	0	0.011552	4.032356	0.316979	4.349335	0.139496	21.695000
Chilko	1988	4	0	0.002697	2.979547	0.157913	3.137460	0.135021	20.901000
Chilko	1989	1	0	0.011841	3.015024	0.086942	3.101966	0.034894	NA
Chilko	1990	2	0	0.013262	2.412516	0.183563	2.596079	0.497975	34.168374
Chilko	1991	3	0	0.004495	1.154894	0.128342	1.283236	0.597558	39.721810
Chilko	1992	4	0	0.004956	1.773513	0.078754	1.852267	0.319943	12.866432
Chilko	1993	1	0	0.018173	3.380892	0.548667	3.929559	0.322283	27.257811
Chilko	1994	2	0	0.010606	1.331935	0.072717	1.404652	0.253982	16.976927
Chilko	1995	3	0	0.002778	1.045307	0.179069	1.224376	0.298077	39.826473
Chilko	1996	4	0	0.000359	1.176197	0.159432	1.335629	0.504519	18.700496
Chilko	1997	1	0	0.000222	0.664301	0.204157	0.868458	0.509295	21.837625
Chilko	1998	2	0	0.000988	0.422769	0.070440	0.493209	0.467725	11.078244
Chilko	1999	3	0	0.002323	1.383937	0.107056	1.490993	0.432593	19.985332
Chilko	2000	4	0	0.003679	0.416330	0.000000	0.416330	0.395550	19.475377
Chilko	2001	1	NA	NA	NA	NA	NA	0.331244	35.710945
Chilko	2002	2	NA	NA	NA	NA	NA	0.215118	19.625177
Seymour	1948	4	0	0.000000	0.029658	0.000000	0.029658	0.001280	NA
Seymour	1949	1	0	0.000733	0.025617	0.000000	0.025617	0.003476	NA
Seymour	1950	2	0	0.000909	0.161081	0.000000	0.161081	0.004696	NA
Seymour	1951	3	0	0.000125	0.067964	0.000731	0.068695	0.011505	NA
Seymour	1952	4	0	0.000093	0.011156	0.000000	0.011156	0.002780	NA
Seymour	1953	1	0	0.000150	0.044870	0.000000	0.044870	0.002907	NA
Seymour	1954	2	0	0.023882	0.428958	0.003444	0.432402	0.012852	NA
Seymour	1955	3	0	0.000372	0.308775	0.000550	0.309325	0.005178	NA
Seymour	1956	4	0	0.000026	0.010971	0.001766	0.012737	0.001102	NA
Seymour	1957	1	0	0.000262	0.011959	0.000000	0.011959	0.007416	NA
Seymour	1958	2	0	0.006184	0.188824	0.000510	0.189334	0.044285	NA
Seymour	1959	3	0	0.000409	0.175192	0.000368	0.175560	0.025773	NA
Seymour	1960	4	0	0.000051	0.008697	0.000000	0.008697	0.001862	NA
Seymour	1961	1	0	0.000055	0.025649	0.000000	0.025649	0.001957	NA
Seymour	1962	2	0	0.002939	0.169778	0.000572	0.170350	0.028664	NA
Seymour	1963	3	0	0.000147	0.112265	0.001674	0.113939	0.026742	NA
Seymour	1964	4	0	0.000000	0.017994	0.000504	0.018498	0.001321	NA
Seymour	1965	1	0	0.000183	0.034707	0.000000	0.034707	0.002550	NA
Seymour	1966	2	0	0.000658	0.139745	0.001425	0.141170	0.012943	NA
Seymour	1967	3	0	0.000066	0.216733	0.002954	0.219687	0.007264	NA
Seymour	1968	4	0	0.000000	0.021963	0.000145	0.022108	0.002064	NA
Seymour	1969	1	0	0.000258	0.014617	0.000000	0.014617	0.003276	NA
Seymour	1970	2	0	0.000470	0.223705	0.000000	0.223705	0.003603	NA
Seymour	1971	3	0	0.001341	0.132035	0.001934	0.133969	0.009463	NA

Stock	Brood Year	Cycle Year	Recruitment (Millions) Age 2	Age 3	Age 4	Age 5	Total	Spawners (Millions) [A]	Juveniles (fry, fall fry age 1 smolts) (Millions)
Seymour	1972	4	0	0.000320	0.056465	0.000000	0.056465	0.001418	NA
Seymour	1973	1	0	0.000419	0.024381	0.000000	0.024381	0.001150	NA
Seymour	1974	2	0	0.001353	0.247377	0.000000	0.247377	0.025868	NA
Seymour	1975	3	0	0.001665	0.217627	0.004007	0.221634	0.016844	NA
Seymour	1976	4	0	0.000050	0.018193	0.000191	0.018384	0.004898	NA
Seymour	1977	1	0	0.000135	0.053835	0.001444	0.055279	0.002883	NA
Seymour	1978	2	0	0.000730	0.256211	0.004984	0.261195	0.030757	NA
Seymour	1979	3	0	0.000085	0.092992	0.042223	0.135215	0.024866	NA
Seymour	1980	4	0	0.000010	0.045127	0.007711	0.052838	0.004616	NA
Seymour	1981	1	0	0.000000	0.026268	0.000000	0.026268	0.005354	NA
Seymour	1982	2	0	0.002737	0.492244	0.013474	0.505718	0.027219	NA
Seymour	1983	3	0	0.003003	0.261161	0.007562	0.268723	0.014014	NA
Seymour	1984	4	0	0.000174	0.035743	0.000100	0.035843	0.009148	NA
Seymour	1985	1	0	0.000332	0.032018	0.011226	0.043244	0.002684	NA
Seymour	1986	2	0	0.001132	0.811714	0.011322	0.823036	0.057069	NA
Seymour	1987	3	0	0.000314	0.416101	0.025805	0.441906	0.041081	NA
Seymour	1988	4	0	0.000000	0.009027	0.001816	0.010843	0.007989	NA
Seymour	1989	1	0	0.000068	0.018809	0.000000	0.018809	0.002864	NA
Seymour	1990	2	0	0.000136	0.272278	0.006890	0.279168	0.108279	NA
Seymour	1991	3	0	0.000000	0.089769	0.011139	0.100908	0.060845	NA
Seymour	1992	4	0	0.000005	0.011139	0.002778	0.013917	0.003586	NA
Seymour	1993	1	0	0.000000	0.006251	0.002465	0.008716	0.004948	NA
Seymour	1994	2	0	0.000000	0.169885	0.002662	0.172547	0.016783	NA
Seymour	1995	3	0	0.000017	0.064323	0.001699	0.066022	0.023928	NA
Seymour	1996	4	0	0.000000	0.032981	0.007313	0.040294	0.009590	NA
Seymour	1997	1	0	0.000000	0.002194	0.000000	0.002194	0.000836	NA
Seymour	1998	2	0	0.000182	0.209960	0.003688	0.213648	0.014548	NA
Seymour	1999	3	0	0.000027	0.106038	0.027757	0.133795	0.010072	NA
Seymour	2000	4	0	0.000000	0.058038	0.000000	0.058038	0.011860	NA
Seymour	2001	1	NA	NA	NA	NA	NA	0.003743	NA
Seymour	2002	2	NA	NA	NA	NA	NA	0.055465	NA
Late Shuswap	1948	4	0	0.000000	0.022876	0.005454	0.028330	0.008502	NA
Late Shuswap	1949	1	0	0.005415	0.021384	0.000000	0.021384	0.002011	NA
Late Shuswap	1950	2	0	0.596974	9.303676	0.012645	9.316321	0.583045	NA
Late Shuswap	1951	3	0	0.007290	0.519779	0.002251	0.522030	0.082097	NA
Late Shuswap	1952	4	0	0.001481	0.014320	0.002131	0.016451	0.004211	NA
Late Shuswap	1953	1	0	0.001456	0.029571	0.000000	0.029571	0.001623	NA
Late Shuswap	1954	2	0	0.714720	15.095741	0.012060	15.107801	1.067603	NA
Late Shuswap	1955	3	0	0.011116	0.853267	0.000609	0.853876	0.044632	NA
Late Shuswap	1956	4	0	0.000555	0.006961	0.000458	0.007419	0.002103	NA
Late Shuswap	1957	1	0	0.000016	0.002206	0.000000	0.002206	0.001651	NA
Late Shuswap	1958	2	0	0.124446	2.076776	0.004097	2.080873	1.644152	NA
Late Shuswap	1959	3	0	0.007679	0.374501	0.000106	0.374607	0.089271	NA
Late Shuswap	1960	4	0	0.000201	0.002333	0.000000	0.002333	0.001322	NA
Late Shuswap	1961	1	0	0.000204	0.006996	0.000000	0.006996	0.000854	NA
Late Shuswap	1962	2	0	0.090548	2.740250	0.010891	2.751141	0.651863	NA

Stock	Brood Year	Cycle Year	Recruitment (Millions) Age 2	Age 3	Age 4	Age 5	Total	Spawners (Millions) [A]	Juveniles (fry, fall fry age 1 smolts) (Millions)
Late Shuswap	1963	3	0	0.078928	3.047429	0.003663	3.051092	0.080244	NA
Late Shuswap	1964	4	0	0.002346	0.017103	0.000177	0.017280	0.000345	NA
Late Shuswap	1965	1	0	0.000496	0.024312	0.000000	0.024312	0.001332	NA
Late Shuswap	1966	2	0	0.101052	3.914887	0.022138	3.937025	0.660849	NA
Late Shuswap	1967	3	0	0.065955	3.108302	0.008076	3.116378	0.402411	NA
Late Shuswap	1968	4	0	0.000222	0.020709	0.000074	0.020783	0.002713	NA
Late Shuswap	1969	1	0	0.001625	0.027967	0.000000	0.027967	0.003166	NA
Late Shuswap	1970	2	0	0.173713	5.373956	0.002667	5.376623	0.785282	NA
Late Shuswap	1971	3	0	0.021467	0.680311	0.000128	0.680439	0.158976	NA
Late Shuswap	1972	4	0	0.004098	0.038342	0.005054	0.043396	0.002155	NA
Late Shuswap	1973	1	0	0.003817	0.063843	0.000000	0.063843	0.002460	NA
Late Shuswap	1974	2	0	0.144388	6.812861	0.009369	6.822230	0.608202	90.475861
Late Shuswap	1975	3	0	0.002976	1.016326	0.001078	1.017404	0.085418	21.208499
Late Shuswap	1976	4	0	0.000550	0.013049	0.000000	0.013049	0.003072	12.460947
Late Shuswap	1977	1	0	0.000620	0.093025	0.000000	0.093025	0.006027	3.901516
Late Shuswap	1978	2	0	0.119355	8.661579	0.115757	8.777336	1.008834	172.618632
Late Shuswap	1979	3	0	0.006915	1.475536	0.015681	1.491217	0.161747	51.295653
Late Shuswap	1980	4	0	0.001513	0.021350	0.000444	0.021794	0.001816	NA
Late Shuswap	1981	1	0	0.000004	0.009466	0.000000	0.009466	0.005950	NA
Late Shuswap	1982	2	0	0.079877	8.891360	0.104069	8.995429	1.561248	137.424814
Late Shuswap	1983	3	0	0.017088	1.946978	0.016259	1.963237	0.100240	34.362244
Late Shuswap	1984	4	0	0.000103	0.032672	0.000399	0.033071	0.002403	NA
Late Shuswap	1985	1	0	0.000061	0.004319	0.000000	0.004319	0.000703	NA
Late Shuswap	1986	2	0	0.067599	10.257931	0.193212	10.451143	1.039119	141.256617
Late Shuswap	1987	3	0	0.008396	3.839503	0.054510	3.894013	0.319368	153.543643
Late Shuswap	1988	4	0	0.000001	0.006468	0.001608	0.008076	0.003556	15.103054
Late Shuswap	1989	1	0	0.000277	0.012858	0.000000	0.012858	0.000380	15.512714
Late Shuswap	1990	2	0	0.021882	7.287112	0.121820	7.408932	1.693350	89.263205
Late Shuswap	1991	3	0	0.000761	0.811822	0.018086	0.829908	0.615713	56.186507
Late Shuswap	1992	4	0	0.000000	0.010735	0.007669	0.018404	0.006550	10.687339
Late Shuswap	1993	1	0	0.000024	0.014671	0.000000	0.014671	0.000752	NA
Late Shuswap	1994	2	0	0.000581	2.497911	0.016443	2.514354	0.655631	63.883374
Late Shuswap	1995	3	0	0.000475	0.744571	0.020220	0.764791	0.206741	16.393377
Late Shuswap	1996	4	0	0.000000	0.031741	0.013203	0.044944	0.005407	NA
Late Shuswap	1997	1	0	0.000000	0.031409	0.000000	0.031409	0.000596	NA
Late Shuswap	1998	2	0	0.076908	6.879130	0.020356	6.899486	0.656440	30.030503
Late Shuswap	1999	3	0	0.000111	0.676705	0.025394	0.702099	0.137488	NA
Late Shuswap	2000	4	0	0.000000	0.001418	0.000000	0.001418	0.000158	NA
Late Shuswap	2001	1	NA	NA	NA	NA	NA	0.002061	NA
Late Shuswap	2002	2	NA	NA	NA	NA	NA	2.686809	122.876324
Birkenhead	1948	4	0	0.000000	0.179637	0.012353	0.191990	0.054755	NA
Birkenhead	1949	1	0	0.044548	0.228462	0.008696	0.237158	0.043328	NA
Birkenhead	1950	2	0	0.013166	0.183919	0.030830	0.214749	0.041370	NA
Birkenhead	1951	3	0	0.031161	0.107397	0.066404	0.173801	0.013590	NA
Birkenhead	1952	4	0	0.014902	0.180787	0.033154	0.213941	0.024744	NA
Birkenhead	1953	1	0	0.008205	0.102206	0.016671	0.118877	0.016287	NA

Stock	Brood Year	Cycle Year	Recruitment (Millions)					Spawners (Millions) [A]	Juveniles (fry, fall fry age 1 smolts) (Millions)
			Age 2	Age 3	Age 4	Age 5	Total		
Birkenhead	1954	2	0	0.012671	0.128222	0.017949	0.146171	0.008635	NA
Birkenhead	1955	3	0	0.035100	0.221160	0.007193	0.228353	0.008185	NA
Birkenhead	1956	4	0	0.020500	0.209127	0.042071	0.251198	0.027156	NA
Birkenhead	1957	1	0	0.003587	0.037495	0.005340	0.042835	0.007068	NA
Birkenhead	1958	2	0	0.021115	0.074626	0.011443	0.086069	0.005510	NA
Birkenhead	1959	3	0	0.026205	0.188393	0.036763	0.225156	0.011388	NA
Birkenhead	1960	4	0	0.028566	0.119526	0.010607	0.130133	0.019198	NA
Birkenhead	1961	1	0	0.021891	0.067104	0.017364	0.084468	0.010550	NA
Birkenhead	1962	2	0	0.021342	0.066117	0.008304	0.074421	0.014311	NA
Birkenhead	1963	3	0	0.095525	0.281641	0.048565	0.330206	0.020769	NA
Birkenhead	1964	4	0	0.039236	0.225898	0.085137	0.311035	0.027978	NA
Birkenhead	1965	1	0	0.030602	0.109033	0.014770	0.123803	0.009769	NA
Birkenhead	1966	2	0	0.056603	0.155016	0.061319	0.216335	0.013462	NA
Birkenhead	1967	3	0	0.054257	0.365358	0.045896	0.411254	0.017580	NA
Birkenhead	1968	4	0	0.021213	0.218223	0.035366	0.253589	0.031042	NA
Birkenhead	1969	1	0	0.073972	0.451184	0.239195	0.690379	0.014324	NA
Birkenhead	1970	2	0	0.119108	0.531214	0.030799	0.562013	0.019252	NA
Birkenhead	1971	3	0	0.062316	0.245897	0.046347	0.292244	0.016143	NA
Birkenhead	1972	4	0	0.042841	0.424942	0.046655	0.471597	0.026202	NA
Birkenhead	1973	1	0	0.044117	0.140353	0.024973	0.165326	0.028374	NA
Birkenhead	1974	2	0	0.054695	0.424633	0.208849	0.633482	0.085495	NA
Birkenhead	1975	3	0	0.009363	0.086517	0.018616	0.105133	0.023315	NA
Birkenhead	1976	4	0	0.041164	0.479356	0.084392	0.563748	0.050023	NA
Birkenhead	1977	1	0	0.015580	0.287020	0.097861	0.384881	0.012799	NA
Birkenhead	1978	2	0	0.042233	0.492209	0.117215	0.609424	0.048158	NA
Birkenhead	1979	3	0	0.013843	0.273583	0.120540	0.394123	0.035482	NA
Birkenhead	1980	4	0	0.010131	0.114956	0.362122	0.477078	0.032786	NA
Birkenhead	1981	1	0	0.004550	0.105179	0.156430	0.261609	0.027175	NA
Birkenhead	1982	2	0	0.048333	1.471487	0.281339	1.752826	0.072353	NA
Birkenhead	1983	3	0	0.015268	0.625519	0.149561	0.775080	0.021113	NA
Birkenhead	1984	4	0	0.005918	0.347631	0.086729	0.434360	0.023227	NA
Birkenhead	1985	1	0	0.012226	0.123208	0.093098	0.216306	0.005758	NA
Birkenhead	1986	2	0	0.024019	0.869228	0.315301	1.184529	0.197896	NA
Birkenhead	1987	3	0	0.005671	0.698300	0.279598	0.977898	0.089432	NA
Birkenhead	1988	4	0	0.029507	0.200724	0.664723	0.865447	0.075535	NA
Birkenhead	1989	1	0	0.036435	0.935181	0.173958	1.109139	0.015739	NA
Birkenhead	1990	2	0	0.010179	0.200407	0.024550	0.224957	0.097112	NA
Birkenhead	1991	3	0	0.000244	0.054369	0.061746	0.116115	0.152083	NA
Birkenhead	1992	4	0	0.003823	0.048099	0.046563	0.094662	0.093443	NA
Birkenhead	1993	1	0	0.008716	0.180208	0.380162	0.560370	0.151096	NA
Birkenhead	1994	2	0	0.001028	0.021899	0.035144	0.057043	0.022315	NA
Birkenhead	1995	3	0	0.000486	0.121812	0.029077	0.150889	0.018495	NA
Birkenhead	1996	4	0	0.000723	0.034188	0.038456	0.072644	0.028124	NA
Birkenhead	1997	1	0	0.000000	0.016825	0.010200	0.027025	0.023346	NA
Birkenhead	1998	2	0	0.000277	0.213323	0.388299	0.601622	0.173478	NA
Birkenhead	1999	3	0	0.000000	0.045583	0.035155	0.080738	0.026323	NA

Stock	Brood Year	Cycle Year	Recruitment (Millions)					Spawners (Millions) [A]	Juveniles (fry, fall fry age 1 smolts) (Millions)
			Age 2	Age 3	Age 4	Age 5	Total		
Birkenhead	2000	4	0	0.000652	0.062168	0.000000	0.062168	0.008742	NA
Birkenhead	2001	1	NA	NA	NA	NA	NA	0.028361	NA
Birkenhead	2002	2	NA	NA	NA	NA	NA	0.107481	NA
Cultus	1948	4	0	0.000000	0.037820	0.001256	0.039076	0.012746	NA
Cultus	1949	1	0	0.001662	0.037489	0.000000	0.037489	0.009055	NA
Cultus	1950	2	0	0.003623	0.101664	0.000000	0.101664	0.029928	NA
Cultus	1951	3	0	0.003498	0.166043	0.004527	0.170570	0.012677	0.388873
Cultus	1952	4	0	0.000159	0.032999	0.011266	0.044265	0.017833	0.620213
Cultus	1953	1	0	0.000497	0.062317	0.000855	0.063172	0.011543	NA
Cultus	1954	2	0	0.001631	0.061631	0.001933	0.063564	0.022036	1.903296
Cultus	1955	3	0	0.001610	0.274490	0.001184	0.275674	0.025922	2.688063
Cultus	1956	4	0	0.001273	0.035165	0.001067	0.036232	0.013718	0.976120
Cultus	1957	1	0	0.000095	0.026724	0.001264	0.027988	0.020375	0.319495
Cultus	1958	2	0	0.003547	0.046269	0.001097	0.047366	0.013324	1.427228
Cultus	1959	3	0	0.000114	0.050631	0.001449	0.052080	0.047779	1.327842
Cultus	1960	4	0	0.000483	0.022606	0.000414	0.023020	0.01764	1.025404
Cultus	1961	1	0	0.000194	0.005954	0.000000	0.005954	0.013396	1.200498
Cultus	1962	2	0	0.000524	0.035483	0.000000	0.035483	0.026997	NA
Cultus	1963	3	0	0.003825	0.131466	0.003157	0.134623	0.020303	NA
Cultus	1964	4	0	0.001357	0.067696	0.001550	0.069246	0.011067	NA
Cultus	1965	1	0	0.001380	0.019606	0.000000	0.019606	0.002455	0.131106
Cultus	1966	2	0	0.004551	0.040079	0.000435	0.040514	0.016919	2.101506
Cultus	1967	3	0	0.007716	0.096671	0.006114	0.102785	0.033198	2.441694
Cultus	1968	4	0	0.000036	0.042418	0.000000	0.042418	0.025314	1.005291
Cultus	1969	1	0	0.001446	0.005031	0.000000	0.005031	0.005942	0.186787
Cultus	1970	2	0	0.000910	0.044797	0.000150	0.044947	0.013941	0.799934
Cultus	1971	3	0	0.002673	0.047715	0.000313	0.048028	0.009128	1.086016
Cultus	1972	4	0	0.000337	0.030020	0.000003	0.030023	0.010366	0.167111
Cultus	1973	1	0	0.000044	0.000480	0.000189	0.000669	0.000641	NA
Cultus	1974	2	0	0.000636	0.027251	0.001831	0.029082	0.008984	0.986300
Cultus	1975	3	0	0.007700	0.107820	0.000267	0.108087	0.011349	1.219211
Cultus	1976	4	0	0.000020	0.006109	0.000000	0.006109	0.004435	0.167982
Cultus	1977	1	0	0.000114	0.001457	0.000000	0.001457	0.000082	NA
Cultus	1978	2	0	0.004837	0.069111	0.000000	0.069111	0.005076	NA
Cultus	1979	3	0	0.001662	0.106617	0.001627	0.108244	0.032031	NA
Cultus	1980	4	0	0.000186	0.004639	0.000000	0.004639	0.001657	NA
Cultus	1981	1	0	0.000579	0.000965	0.000000	0.000965	0.000256	NA
Cultus	1982	2	0	0.000883	0.012419	0.005529	0.017948	0.016725	NA
Cultus	1983	3	0	0.000423	0.095192	0.000711	0.095903	0.019944	NA
Cultus	1984	4	0	0.000215	0.009074	0.000032	0.009106	0.000994	NA
Cultus	1985	1	0	0.000329	0.001980	0.000122	0.002102	0.000424	NA
Cultus	1986	2	0	0.000210	0.010278	0.000000	0.010278	0.003256	NA
Cultus	1987	3	0	0.000019	0.064919	0.000917	0.065836	0.032184	NA
Cultus	1988	4	0	0.000099	0.006584	0.001142	0.007726	0.000861	0.065184
Cultus	1989	1	0	0.000004	0.009729	0.001012	0.010741	0.000418	0.052865
Cultus	1990	2	0	0.000236	0.022231	0.002300	0.024531	0.00186	0.178357

Stock	Brood Year	Cycle Year	Recruitment (Millions)					Spawners (Millions) [A]	Juveniles (fry, fall fry age 1 smolts) (Millions)
			Age 2	Age 3	Age 4	Age 5	Total		
Cultus	1991	3	0	0.000023	0.016722	0.000733	0.017455	0.020157	NA
Cultus	1992	4	0	0.000067	0.002150	0.000000	0.002150	0.001203	NA
Cultus	1993	1	0	0.000011	0.001600	0.000000	0.001600	0.001063	NA
Cultus	1994	2	0	0.000007	0.002297	0.000138	0.002435	0.004399	NA
Cultus	1995	3	0	0.000207	0.013690	0.000510	0.014200	0.010316	NA
Cultus	1996	4	0	0.000011	0.001497	0.000000	0.001497	0.002022	NA
Cultus	1997	1	0	0.000000	0.000617	0.000017	0.000634	0.000088	NA
Cultus	1998	2	0	0.000160	0.005664	0.000287	0.005951	0.001959	NA
Cultus	1999	3	0	0.000009	0.010325	0.000035	0.010360	0.012392	0.062807
Cultus	2000	4	0	0.000000	0.000077	0.000000	0.000077	0.001227	0.009637
Cultus	2001	1	NA	0.000000	0.000113	0.000000	0.000113	0.000515	0.012815
Cultus	2002	2	NA	0.000114	NA	NA	NA	0.004873	0.117306
Portage	1948	4	0	0.000000	NA	NA	NA	NA	NA
Portage	1949	1	0	0.000000	0.000296	0.000000	0.000296	NA	NA
Portage	1950	2	0	0.000426	0.028087	0.000000	0.028087	NA	NA
Portage	1951	3	0	0.000018	0.000226	0.000000	0.000226	0.000015	NA
Portage	1952	4	0	0.000002	0.000000	0.000000	0.000000	NA	NA
Portage	1953	1	0	0.000000	0.000394	0.000000	0.000394	0.000024	NA
Portage	1954	2	0	0.001898	0.035946	0.000000	0.035946	0.001729	NA
Portage	1955	3	0	0.000016	0.004376	0.000000	0.004376	0.000020	NA
Portage	1956	4	0	0.000000	0.000000	0.000000	0.000000	NA	NA
Portage	1957	1	0	0.000000	0.000047	0.000000	0.000047	0.000020	NA
Portage	1958	2	0	0.000895	0.024738	0.000012	0.024750	0.002749	NA
Portage	1959	3	0	0.000134	0.005431	0.000000	0.005431	0.000286	NA
Portage	1960	4	0	0.000000	0.000021	0.000000	0.000021	NA	NA
Portage	1961	1	0	0.000002	0.002721	0.000000	0.002721	0.000012	NA
Portage	1962	2	0	0.001878	0.070118	0.000184	0.070302	0.006326	NA
Portage	1963	3	0	0.002207	0.056214	0.000016	0.056230	0.001116	NA
Portage	1964	4	0	0.000042	0.000571	0.000000	0.000571	0.000005	NA
Portage	1965	1	0	0.000155	0.003308	0.000000	0.003308	0.000589	NA
Portage	1966	2	0	0.000332	0.030704	0.000303	0.031007	0.015201	NA
Portage	1967	3	0	0.000167	0.004005	0.000114	0.004119	0.001983	NA
Portage	1968	4	0	0.000000	0.001046	0.000000	0.001046	0.000050	NA
Portage	1969	1	0	0.003839	0.030773	0.000000	0.030773	0.000491	NA
Portage	1970	2	0	0.001317	0.056751	0.000000	0.056751	0.002139	NA
Portage	1971	3	0	0.002050	0.015812	0.000000	0.015812	0.000155	NA
Portage	1972	4	0	0.002127	0.013156	0.000000	0.013156	0.000098	NA
Portage	1973	1	0	0.010591	0.080696	0.000000	0.080696	0.001688	NA
Portage	1974	2	0	0.001645	0.040703	0.000209	0.040912	0.004843	NA
Portage	1975	3	0	0.007526	0.012592	0.000235	0.012827	0.001631	NA
Portage	1976	4	0	0.000570	0.007097	0.000000	0.007097	0.000753	NA
Portage	1977	1	0	0.000768	0.038060	0.001161	0.039221	0.003923	NA
Portage	1978	2	0	0.001315	0.099561	0.004769	0.104330	0.003963	NA
Portage	1979	3	0	0.000233	0.051559	0.000597	0.052156	0.002023	NA
Portage	1980	4	0	0.000675	0.011292	0.000184	0.011476	0.000996	NA
Portage	1981	1	0	0.000154	0.015829	0.000676	0.016505	0.002951	NA

Stock	Brood Year	Cycle Year	Recruitment (Millions)					Spawners (Millions) [A]	Juveniles (fry, fall fry age 1 smolts) (Millions)
			Age 2	Age 3	Age 4	Age 5	Total		
Portage	1982	2	0	0.001276	0.198075	0.011246	0.209321	0.011734	NA
Portage	1983	3	0	0.000432	0.036858	0.000000	0.036858	0.004909	NA
Portage	1984	4	0	0.000517	0.024388	0.025188	0.049576	0.000941	NA
Portage	1985	1	0	0.001174	0.023668	0.000329	0.023997	0.000960	NA
Portage	1986	2	0	0.000255	0.067751	0.003588	0.071339	0.006212	NA
Portage	1987	3	0	0.000292	0.060858	0.001015	0.061873	0.003766	NA
Portage	1988	4	0	0.000394	0.015654	0.005040	0.020694	0.000797	NA
Portage	1989	1	0	0.000178	0.185837	0.009777	0.195614	0.005067	NA
Portage	1990	2	0	0.000000	0.050136	0.000821	0.050957	0.008415	NA
Portage	1991	3	0	0.000000	0.015547	0.000048	0.015595	0.007292	NA
Portage	1992	4	0	0.001049	0.005415	0.002057	0.007472	0.001378	NA
Portage	1993	1	0	0.000007	0.161197	0.004323	0.165520	0.009829	NA
Portage	1994	2	0	0.000023	0.123631	0.002935	0.126566	0.003890	NA
Portage	1995	3	0	0.000043	0.037059	0.000918	0.037977	0.004319	NA
Portage	1996	4	0	0.000234	0.083410	0.002572	0.085982	0.001759	NA
Portage	1997	1	0	0.000000	0.056839	0.001031	0.057870	0.005056	NA
Portage	1998	2	0	0.000009	0.017528	0.000114	0.017642	0.011873	NA
Portage	1999	3	0	0.000015	0.008595	0.000634	0.009229	0.002079	NA
Portage	2000	4	0	0.000086	0.011721	0.000000	0.011721	0.000671	NA
Portage	2001	1	NA	NA	NA	NA	NA	0.001851	NA
Portage	2002	2	NA	NA	NA	NA	NA	0.008001	NA
Weaver Ck	1965	1	0	0.001129	0.184488	0.019915	0.204403	0.007326	10.4710
Weaver Ck	1966	2	0	0.000660	0.073515	0.001939	0.075454	0.009860	14.4930
Weaver Ck	1967	3	0	0.001764	0.077288	0.008421	0.085709	0.010619	7.0020
Weaver Ck	1968	4	0	0.002976	0.141825	0.010577	0.152402	0.002202	3.5840
Weaver Ck	1969	1	0	0.003031	0.371636	0.038246	0.409882	0.030604	37.1320
Weaver Ck	1970	2	0	0.007393	0.371993	0.004652	0.376645	0.005004	9.8430
Weaver Ck	1971	3	0	0.010694	0.139569	0.002345	0.141914	0.002656	5.2330
Weaver Ck	1972	4	0	0.007439	0.331589	0.011114	0.342703	0.015027	19.4000
Weaver Ck	1973	1	0	0.004227	0.257812	0.011669	0.269481	0.024885	38.8170
Weaver Ck	1974	2	0	0.006714	0.252878	0.015653	0.268531	0.028099	43.6270
Weaver Ck	1975	3	0	0.002922	0.141661	0.001479	0.143140	0.016033	25.9610
Weaver Ck	1976	4	0	0.009489	0.271322	0.023704	0.295026	0.028243	57.5780
Weaver Ck	1977	1	0	0.002995	0.217049	0.015719	0.232768	0.028510	19.8590
Weaver Ck	1978	2	0	0.010226	1.184905	0.170418	1.355323	0.042315	43.0470
Weaver Ck	1979	3	0	0.001244	0.128249	0.011535	0.139784	0.025702	27.0360
Weaver Ck	1980	4	0	0.003167	0.331805	0.029742	0.361547	0.043285	53.0030
Weaver Ck	1981	1	0	0.002908	0.206879	0.060505	0.267384	0.022627	27.2130
Weaver Ck	1982	2	0	0.009112	1.275213	0.223634	1.498847	0.115031	58.6440
Weaver Ck	1983	3	0	0.002374	0.222270	0.018144	0.240414	0.027380	31.3750
Weaver Ck	1984	4	0	0.007491	0.575398	0.051913	0.627311	0.030435	45.9370
Weaver Ck	1985	1	0	0.001101	0.048781	0.019418	0.068199	0.022773	20.2690
Weaver Ck	1986	2	0	0.000045	0.039242	0.003417	0.042659	0.041837	21.7710
Weaver Ck	1987	3	0	0.000798	0.192151	0.027769	0.219920	0.030106	29.5290
Weaver Ck	1988	4	0	0.003179	0.334751	0.175848	0.510599	0.027623	22.2010
Weaver Ck	1989	1	0	0.002648	0.691640	0.070074	0.761714	0.010620	22.4938

Stock	Brood Year	Cycle Year	Recruitment (Millions)					Spawners (Millions) [A]	Juveniles (fry, fall fry age 1 smolts) (Millions)
			Age 2	Age 3	Age 4	Age 5	Total		
Weaver Ck	1990	2	0	0.005895	0.600890	0.028191	0.629081	0.008524	18.9087
Weaver Ck	1991	3	0	0.000070	0.049922	0.016663	0.066585	0.018710	43.7869
Weaver Ck	1992	4	0	0.000731	0.634217	0.122166	0.756383	0.028480	49.3286
Weaver Ck	1993	1	0	0.000449	0.362427	0.118151	0.480578	0.034019	43.6658
Weaver Ck	1994	2	0	0.000057	0.641176	0.069090	0.710266	0.035566	45.8319
Weaver Ck	1995	3	0	0.000114	0.170376	0.095345	0.265721	0.010905	22.7428
Weaver Ck	1996	4	0	0.000227	0.348740	0.028826	0.377566	0.043231	47.9098
Weaver Ck	1997	1	0	0.000010	0.172393	0.023347	0.195740	0.010724	14.0030
Weaver Ck	1998	2	0	0.000199	0.501965	0.071868	0.573833	0.029811	51.4682
Weaver Ck	1999	3	0	0.000029	0.198960	0.058585	0.257545	0.013106	31.5485
Weaver Ck	2000	4	0	0.000389	0.094934	0.000000	0.094934	0.002732	6.7104
Weaver Ck	2001	1	NA	NA	NA	NA	NA	0.008035	21.2809
Weaver Ck	2002	2	NA	NA	NA	NA	NA	0.036269	50.7548
Fennell Ck	1967	3	0	0.000000	0.015201	0.000000	0.015201	0.000294	NA
Fennell Ck	1968	4	0	0.000014	0.014846	0.000169	0.015015	0.000577	NA
Fennell Ck	1969	1	0	0.000000	0.000881	0.000000	0.000881	0.000022	NA
Fennell Ck	1970	2	0	0.000000	0.000740	0.000000	0.000740	0.000005	NA
Fennell Ck	1971	3	0	0.000263	0.015407	0.000819	0.016226	0.000306	NA
Fennell Ck	1972	4	0	0.000156	0.028193	0.000205	0.028398	0.001030	NA
Fennell Ck	1973	1	0	0.000000	0.001106	0.000000	0.001106	0.000083	NA
Fennell Ck	1974	2	0	0.000000	0.000536	0.000000	0.000536	0.000070	NA
Fennell Ck	1975	3	0	0.000569	0.068503	0.002143	0.070646	0.002181	NA
Fennell Ck	1976	4	0	0.000166	0.020252	0.001106	0.021358	0.002373	NA
Fennell Ck	1977	1	0	0.000000	0.007426	0.001704	0.009130	0.000174	NA
Fennell Ck	1978	2	0	0.000160	0.002230	0.000000	0.002230	0.000046	NA
Fennell Ck	1979	3	0	0.000008	0.009084	0.005145	0.014229	0.008046	NA
Fennell Ck	1980	4	0	0.000060	0.034268	0.001702	0.035970	0.004413	NA
Fennell Ck	1981	1	0	0.000000	0.002742	0.001205	0.003947	0.001069	NA
Fennell Ck	1982	2	0	0.000061	0.009104	0.001724	0.010828	0.000656	NA
Fennell Ck	1983	3	0	0.000124	0.035855	0.002395	0.038250	0.002596	NA
Fennell Ck	1984	4	0	0.000361	0.042781	0.004283	0.047064	0.006291	NA
Fennell Ck	1985	1	0	0.000005	0.023647	0.008179	0.031826	0.000696	NA
Fennell Ck	1986	2	0	0.000115	0.033093	0.001113	0.034206	0.003324	NA
Fennell Ck	1987	3	0	0.000036	0.065946	0.010502	0.076448	0.009211	NA
Fennell Ck	1988	4	0	0.000000	0.043984	0.004663	0.048647	0.013098	NA
Fennell Ck	1989	1	0	0.000104	0.013765	0.005689	0.019454	0.002813	NA
Fennell Ck	1990	2	0	0.000000	0.014471	0.008341	0.022812	0.006702	NA
Fennell Ck	1991	3	0	0.000000	0.011123	0.000771	0.011894	0.011944	NA
Fennell Ck	1992	4	0	0.000010	0.041211	0.007460	0.048671	0.005959	NA
Fennell Ck	1993	1	0	0.000052	0.028238	0.013201	0.041439	0.004928	NA
Fennell Ck	1994	2	0	0.000000	0.004865	0.008122	0.012987	0.003507	NA
Fennell Ck	1995	3	0	0.000000	0.031391	0.005356	0.036747	0.005986	NA
Fennell Ck	1996	4	0	0.000000	0.009406	0.003906	0.013312	0.015198	NA
Fennell Ck	1997	1	0	0.000017	0.004056	0.000000	0.004056	0.004326	NA
Fennell Ck	1998	2	0	0.000025	0.000000	0.000000	0.000000	0.004966	NA
Fennell Ck	1999	3	0	0.000000	0.000000	0.012441	0.012441	0.003333	NA

Stock	Brood Year	Cycle Year	Recruitment (Millions)					Spawners (Millions) [A]	Juveniles (fry, fall fry age 1 smolts) (Millions)
			Age 2	Age 3	Age 4	Age 5	Total		
Fennell Ck	2000	4	0	0.000000	0.055364	0.000000	0.055364	0.004623	NA
Fennell Ck	2001	1	NA	NA	NA	NA	NA	0.003302	NA
Fennell Ck	2002	2	NA	NA	NA	NA	NA	0.004847	NA
Scotch Ck (early)	1980	4	0	0.000000	0.001532	0.000000	0.001532	0.000062	NA
Scotch Ck (early)	1981	1	0	0.000071	0.025296	0.000000	0.025296	0.006887	NA
Scotch Ck (early)	1982	2	0	0.000192	0.103900	0.005475	0.109375	0.002544	NA
Scotch Ck (early)	1983	3	0	0.000000	0.002382	0.000250	0.002632	0.000133	NA
Scotch Ck (early)	1984	4	0	0.000012	0.002613	0.000000	0.002613	0.000265	NA
Scotch Ck (early)	1985	1	0	0.001471	0.042541	0.000000	0.042541	0.001422	NA
Scotch Ck (early)	1986	2	0	0.000000	0.250911	0.006148	0.257059	0.011299	NA
Scotch Ck (early)	1987	3	0	0.000049	0.020633	0.009762	0.030395	0.001149	NA
Scotch Ck (early)	1988	4	0	0.000000	0.003320	0.000000	0.003320	0.000723	NA
Scotch Ck (early)	1989	1	0	0.000578	0.016150	0.000000	0.016150	0.003928	NA
Scotch Ck (early)	1990	2	0	0.000265	0.311154	0.004813	0.315967	0.034459	NA
Scotch Ck (early)	1991	3	0	0.000010	0.022183	0.003644	0.025827	0.004540	NA
Scotch Ck (early)	1992	4	0	0.000001	0.002104	0.000349	0.002453	0.001385	NA
Scotch Ck (early)	1993	1	0	0.000059	0.011827	0.000000	0.011827	0.003259	NA
Scotch Ck (early)	1994	2	0	0.000196	0.181988	0.002267	0.184255	0.026711	NA
Scotch Ck (early)	1995	3	0	0.000011	0.012240	0.001925	0.014165	0.007811	NA
Scotch Ck (early)	1996	4	0	0.000000	0.003403	0.000839	0.004242	0.002206	NA
Scotch Ck (early)	1997	1	0	0.000004	0.002539	0.000000	0.002539	0.001440	NA
Scotch Ck (early)	1998	2	0	0.000148	0.190748	0.002272	0.193020	0.017024	NA
Scotch Ck (early)	1999	3	0	0.000001	0.015742	0.010610	0.026352	0.002060	NA
Scotch Ck (early)	2000	4	0	0.000002	0.040167	0.000000	0.040167	0.001754	NA
Scotch Ck (early)	2001	1	NA	NA	NA	NA	NA	0.001336	NA
Scotch Ck (early)	2002	2	NA	NA	NA	NA	NA	0.050374	NA
Gates	1968	4	0	0.003891	0.078371	0.000403	0.078774	0.003835	7.6450
Gates	1969	1	0	0.001042	0.003556	0.000168	0.003724	0.000359	0.3740
Gates	1970	2	0	0.000258	0.000154	0.000000	0.000154	0.000014	0.0250
Gates	1971	3	0	0.004926	0.007721	0.000000	0.007721	0.000115	0.2390
Gates	1972	4	0	0.004180	0.128111	0.000322	0.128433	0.003128	6.8310
Gates	1973	1	0	0.001344	0.009447	0.003794	0.013241	0.000351	0.9320
Gates	1974	2	0	0.001559	0.001413	0.000000	0.001413	0.000037	0.0840
Gates	1975	3	0	0.003841	0.018486	0.000000	0.018486	0.001246	2.2610
Gates	1976	4	0	0.003192	0.067835	0.002350	0.070185	0.008820	18.5290
Gates	1977	1	0	0.000690	0.017045	0.002975	0.020020	0.001174	2.1400
Gates	1978	2	0	0.000589	0.000860	0.000198	0.001058	0.000129	0.2250
Gates	1979	3	0	0.001866	0.015902	0.000000	0.015902	0.001648	3.0000
Gates	1980	4	0	0.001496	0.076467	0.001381	0.077848	0.011032	12.1710
Gates	1981	1	0	0.000412	0.014267	0.003085	0.017352	0.001908	4.1120
Gates	1982	2	0	0.003361	0.005472	0.000868	0.006340	0.000439	1.1710
Gates	1983	3	0	0.001542	0.026208	0.000348	0.026556	0.003055	5.7120
Gates	1984	4	0	0.001730	0.115017	0.021116	0.136133	0.009072	15.0570
Gates	1985	1	0	0.006340	0.114856	0.010766	0.125622	0.002031	3.7116
Gates	1986	2	0	0.006349	0.020390	0.000610	0.021000	0.001879	3.3748
Gates	1987	3	0	0.001683	0.022546	0.003604	0.026150	0.004105	6.0426

Stock	Brood Year	Cycle Year	Recruitment (Millions)					Spawners (Millions) [A]	Juveniles (fry, fall fry age 1 smolts) (Millions)
			Age 2	Age 3	Age 4	Age 5	Total		
Gates	1988	4	0	0.009599	0.305722	0.004031	0.309753	0.017840	15.8632
Gates	1989	1	0	0.005779	0.038792	0.008523	0.047315	0.009794	11.7207
Gates	1990	2	0	0.000826	0.013177	0.001725	0.014902	0.003304	3.6477
Gates	1991	3	0	0.001242	0.020071	0.001559	0.021630	0.004618	6.8523
Gates	1992	4	0	0.011639	0.175651	0.008143	0.183794	0.009224	20.0528
Gates	1993	1	0	0.000557	0.054410	0.034503	0.088913	0.009089	12.6403
Gates	1994	2	0	0.000815	0.057807	0.012510	0.070317	0.001706	2.6727
Gates	1995	3	0	0.001970	0.020949	0.000540	0.021489	0.004533	2.1791
Gates	1996	4	0	0.000413	0.189125	0.008229	0.197354	0.014150	14.2180
Gates	1997	1	0	0.000742	0.011028	0.000823	0.011851	0.001877	4.3728
Gates	1998	2	0	0.000634	0.002692	0.000944	0.003636	0.002442	6.0920
Gates	1999	3	0	0.002191	0.063225	0.002430	0.065655	0.001765	4.1792
Gates	2000	4	0	0.000624	0.088011	0.000000	0.088011	0.016571	15.1428
Gates	2001	1	NA	NA	NA	NA	NA	0.004008	6.4584
Gates	2002	2	NA	NA	NA	NA	NA	0.001144	2.8132
Nadina	1973	1	0	0.000146	0.067467	0.005741	0.073208	0.009638	12.1230
Nadina	1974	2	0	0.000195	0.020017	0.000000	0.020017	0.002074	2.0540
Nadina	1975	3	0	0.000383	0.301236	0.005729	0.306965	0.008359	13.8560
Nadina	1976	4	0	0.000010	0.007247	0.000000	0.007247	0.000846	1.9620
Nadina	1977	1	0	0.000172	0.125303	0.006374	0.131677	0.009260	14.5020
Nadina	1978	2	0	0.000083	0.028397	0.002767	0.031164	0.001527	2.9230
Nadina	1979	3	0	0.000005	0.083912	0.017456	0.101368	0.020415	22.0650
Nadina	1980	4	0	0.000004	0.016037	0.005331	0.021368	0.001518	1.9910
Nadina	1981	1	0	0.000005	0.073214	0.003530	0.076744	0.010924	17.0020
Nadina	1982	2	0	0.000000	0.005364	0.001411	0.006775	0.001423	1.4150
Nadina	1983	3	0	0.000032	0.138480	0.011219	0.149699	0.015400	19.3280
Nadina	1984	4	0	0.000000	0.020594	0.004323	0.024917	0.003501	4.4120
Nadina	1985	1	0	0.000000	0.041411	0.005442	0.046853	0.007722	6.7004
Nadina	1986	2	0	0.000000	0.016080	0.004758	0.020838	0.002048	3.9308
Nadina	1987	3	0	0.000016	0.170901	0.020119	0.191020	0.015150	19.8710
Nadina	1988	4	0	0.000000	0.048538	0.009201	0.057739	0.004304	8.5966
Nadina	1989	1	0	0.000000	0.015466	0.003221	0.018687	0.002653	1.9744
Nadina	1990	2	0	0.000000	0.014309	0.000769	0.015078	0.003404	2.3456
Nadina	1991	3	0	0.000112	0.048674	0.009005	0.057679	0.033360	18.3159
Nadina	1992	4	0	0.000009	0.054950	0.049754	0.104704	0.002355	4.2805
Nadina	1993	1	0	0.000000	0.051434	0.013979	0.065413	0.004797	2.2056
Nadina	1994	2	0	0.000000	0.026236	0.008471	0.034707	0.001076	1.9934
Nadina	1995	3	0	0.000025	0.065492	0.000000	0.065492	0.008403	1.8321
Nadina	1996	4	0	0.000000	0.451829	0.081360	0.533189	0.018093	20.2946
Nadina	1997	1	0	0.000000	0.002092	0.000520	0.002612	0.002681	1.5366
Nadina	1998	2	0	0.000009	0.002741	0.001603	0.004344	0.001983	3.3006
Nadina	1999	3	0	0.000000	0.019072	0.000000	0.019072	0.005026	4.1311
Nadina	2000	4	0	0.000000	0.240491	0.000000	0.240491	0.065444	51.6179
Nadina	2001	1	NA	NA	NA	NA	NA	0.017875	17.7878
Nadina	2002	2	NA	NA	NA	NA	NA	0.001031	1.8738
Upper Pitt R	1948	4	0	0.000000	0.026803	0.095917	0.122720	0.020340	NA

Stock	Brood Year	Cycle Year	Recruitment (Millions) Age 2	Age 3	Age 4	Age 5	Total	Spawners (Millions) [A]	Juveniles (fry, fall fry age 1 smolts) (Millions)
Upper Pitt R	1949	1	0	0.000000	0.006085	0.013251	0.019336	0.004449	NA
Upper Pitt R	1950	2	0	0.000062	0.091231	0.055044	0.146275	0.013312	NA
Upper Pitt R	1951	3	0	0.000000	0.041761	0.078541	0.120302	0.017922	NA
Upper Pitt R	1952	4	0	0.000000	0.039952	0.031890	0.071842	0.021904	NA
Upper Pitt R	1953	1	0	0.000000	0.012688	0.012372	0.025060	0.009303	NA
Upper Pitt R	1954	2	0	0.000042	0.037926	0.013126	0.051052	0.008332	NA
Upper Pitt R	1955	3	0	0.000005	0.078394	0.085616	0.164010	0.011221	NA
Upper Pitt R	1956	4	0	0.000015	0.028169	0.038686	0.066855	0.011107	NA
Upper Pitt R	1957	1	0	0.000000	0.003474	0.024544	0.028018	0.005130	NA
Upper Pitt R	1958	2	0	0.000012	0.012978	0.003157	0.016135	0.006658	NA
Upper Pitt R	1959	3	0	0.000010	0.021800	0.039932	0.061732	0.006096	NA
Upper Pitt R	1960	4	0	0.000000	0.005842	0.027406	0.033248	0.012493	NA
Upper Pitt R	1961	1	0	0.000074	0.026282	0.074479	0.100761	0.006525	NA
Upper Pitt R	1962	2	0	0.000046	0.024085	0.032679	0.056764	0.008460	NA
Upper Pitt R	1963	3	0	0.000068	0.088616	0.054052	0.142668	0.005749	NA
Upper Pitt R	1964	4	0	0.000068	0.048016	0.142584	0.190600	0.006313	NA
Upper Pitt R	1965	1	0	0.000000	0.014943	0.024041	0.038984	0.003368	NA
Upper Pitt R	1966	2	0	0.000065	0.024568	0.051336	0.075904	0.010723	NA
Upper Pitt R	1967	3	0	0.000029	0.024122	0.042747	0.066869	0.005236	NA
Upper Pitt R	1968	4	0	0.000045	0.038212	0.067282	0.105494	0.008189	NA
Upper Pitt R	1969	1	0	0.000000	0.009262	0.051821	0.061083	0.011710	NA
Upper Pitt R	1970	2	0	0.000081	0.021806	0.032749	0.054555	0.003098	NA
Upper Pitt R	1971	3	0	0.000462	0.091337	0.123848	0.215185	0.006663	NA
Upper Pitt R	1972	4	0	0.000031	0.078300	0.044584	0.122884	0.006569	NA
Upper Pitt R	1973	1	0	0.000011	0.011903	0.017262	0.029165	0.004744	NA
Upper Pitt R	1974	2	0	0.000178	0.053388	0.080679	0.134067	0.008854	NA
Upper Pitt R	1975	3	0	0.000081	0.044640	0.020578	0.065218	0.021369	NA
Upper Pitt R	1976	4	0	0.000032	0.013812	0.091485	0.105297	0.019467	NA
Upper Pitt R	1977	1	0	0.000057	0.015331	0.018676	0.034007	0.007791	NA
Upper Pitt R	1978	2	0	0.000000	0.010736	0.024013	0.034749	0.014109	NA
Upper Pitt R	1979	3	0	0.000022	0.003770	0.034444	0.038214	0.020307	NA
Upper Pitt R	1980	4	0	0.000008	0.010736	0.006169	0.016905	0.009169	NA
Upper Pitt R	1981	1	0	0.000000	0.002416	0.031641	0.034057	0.013224	NA
Upper Pitt R	1982	2	0	0.000037	0.004318	0.013910	0.018228	0.005086	NA
Upper Pitt R	1983	3	0	0.000022	0.011730	0.050301	0.062031	0.010074	NA
Upper Pitt R	1984	4	0	0.000107	0.018612	0.056977	0.075589	0.008755	NA
Upper Pitt R	1985	1	0	0.000026	0.006180	0.017002	0.023182	0.002088	NA
Upper Pitt R	1986	2	0	0.000000	0.006413	0.033585	0.039998	0.012283	NA
Upper Pitt R	1987	3	0	0.000003	0.007374	0.014591	0.021965	0.005503	NA
Upper Pitt R	1988	4	0	0.000000	0.002587	0.058490	0.061077	0.017876	NA
Upper Pitt R	1989	1	0	0.000007	0.004944	0.013159	0.018103	0.005583	NA
Upper Pitt R	1990	2	0	0.000018	0.001781	0.007845	0.009626	0.005701	NA
Upper Pitt R	1991	3	0	0.000001	0.001763	0.032177	0.033940	0.010867	NA
Upper Pitt R	1992	4	0	0.000000	0.029707	0.070846	0.100553	0.004335	NA
Upper Pitt R	1993	1	0	0.000185	0.016103	0.082072	0.098175	0.009040	NA
Upper Pitt R	1994	2	0	0.000081	0.004374	0.030016	0.034390	0.004365	NA

Stock	Brood Year	Cycle Year	Recruitment (Millions) Age 2	Age 3	Age 4	Age 5	Total	Spawners (Millions) [A]	Juveniles (fry, fall fry age 1 smolts) (Millions)
Upper Pitt R	1995	3	0	0.000000	0.008821	0.044177	0.052998	0.002352	NA
Upper Pitt R	1996	4	0	0.000018	0.021344	0.140569	0.161913	0.019451	NA
Upper Pitt R	1997	1	0	0.000011	0.013366	0.084956	0.098322	0.014996	NA
Upper Pitt R	1998	2	0	0.000020	0.034862	0.099103	0.133965	0.047612	NA
Upper Pitt R	1999	3	0	0.000000	0.024686	0.000000	0.024686	0.019390	NA
Upper Pitt R	2000	4	0	0.000015	0.041744	0.000000	0.041744	0.018584	NA
Upper Pitt R	2001	1	NA	NA	NA	NA	NA	0.072407	NA
Upper Pitt R	2002	2	NA	NA	NA	NA	NA	0.039416	NA
Harrison	1948	4	0	0.000000	0.043283	0.000000	0.043283	0.014577	NA
Harrison	1949	1	0	0.011423	0.025650	0.000000	0.037073	0.004372	NA
Harrison	1950	2	0	0.048269	0.029830	0.000000	0.078099	0.018216	NA
Harrison	1951	3	0.000903	0.103041	0.018078	0.000000	0.121119	0.013181	NA
Harrison	1952	4	0	0.018421	0.004633	0.000000	0.023054	0.017215	NA
Harrison	1953	1	0	0.002232	0.007552	0.000000	0.009784	0.007641	NA
Harrison	1954	2	0	0.006146	0.008651	0.000000	0.014797	0.016869	NA
Harrison	1955	3	0.000087	0.060115	0.080836	0.000000	0.140951	0.003405	NA
Harrison	1956	4	0	0.087258	0.009600	0.000114	0.096858	0.001266	NA
Harrison	1957	1	0.000043	0.025371	0.035140	0.000000	0.060511	0.001820	NA
Harrison	1958	2	0.000107	0.055305	0.004480	0.000000	0.059785	0.006404	NA
Harrison	1959	3	0.000014	0.010452	0.031079	0.000000	0.041531	0.017692	NA
Harrison	1960	4	0	0.026094	0.003357	0.000000	0.029451	0.007076	NA
Harrison	1961	1	0.000041	0.001634	0.011550	0.000000	0.013184	0.021725	NA
Harrison	1962	2	0	0.031134	0.019678	0.000000	0.050812	0.004197	NA
Harrison	1963	3	0	0.050277	0.037548	0.000000	0.087825	0.009803	NA
Harrison	1964	4	0.000047	0.043883	0.007247	0.000027	0.051130	0.001101	NA
Harrison	1965	1	0.000065	0.008237	0.012130	0.000000	0.020367	0.007779	NA
Harrison	1966	2	0.000019	0.042848	0.012577	0.000000	0.055425	0.009295	NA
Harrison	1967	3	0.000145	0.021814	0.028976	0.000000	0.050790	0.012672	NA
Harrison	1968	4	0.000126	0.013492	0.004220	0.000000	0.017712	0.002854	NA
Harrison	1969	1	0	0.002150	0.005152	0.000000	0.007302	0.007559	NA
Harrison	1970	2	0.000098	0.018810	0.020855	0.000000	0.039665	0.006471	NA
Harrison	1971	3	0	0.061283	0.023176	0.000000	0.084459	0.001970	NA
Harrison	1972	4	0	0.001153	0.000810	0.000000	0.001963	0.000794	NA
Harrison	1973	1	0	0.032256	0.005425	0.000000	0.037681	0.001571	NA
Harrison	1974	2	0	0.006133	0.034205	0.000000	0.040338	0.008709	NA
Harrison	1975	3	0	0.022979	0.056177	0.000000	0.079156	0.003381	NA
Harrison	1976	4	0	0.023597	0.001184	0.000000	0.024781	0.002933	NA
Harrison	1977	1	0	0.016076	0.007982	0.000000	0.024058	0.001374	NA
Harrison	1978	2	0	0.007016	0.034177	0.000000	0.041193	0.010488	NA
Harrison	1979	3	0	0.000470	0.010425	0.000000	0.010895	0.020234	NA
Harrison	1980	4	0	0.013416	0.000977	0.000000	0.014393	0.002262	NA
Harrison	1981	1	0	0.012466	0.005403	0.000000	0.017869	0.001788	NA
Harrison	1982	2	0	0.004275	0.024681	0.000000	0.028956	0.004686	NA
Harrison	1983	3	0	0.007855	0.009995	0.000000	0.017850	0.002132	NA
Harrison	1984	4	0.000069	0.003627	0.001569	0.000000	0.005196	0.000689	NA
Harrison	1985	1	0.000069	0.003694	0.010713	0.000000	0.014407	0.001825	NA

Stock	Brood Year	Cycle Year	Recruitment (Millions) Age 2	Age 3	Age 4	Age 5	Total	Spawners (Millions) [A]	Juveniles (fry, fall fry age 1 smolts) (Millions)
Harrison	1986	2	0	0.005680	0.003927	0.000000	0.009607	0.004145	NA
Harrison	1987	3	0	0.003482	0.042702	0.000000	0.046184	0.002686	NA
Harrison	1988	4	0.000185	0.002005	0.001823	0.000000	0.003828	0.000947	NA
Harrison	1989	1	0	0.000489	0.013075	0.000000	0.013564	0.001998	NA
Harrison	1990	2	0	0.061756	0.067746	0.000000	0.129502	0.001888	NA
Harrison	1991	3	0	0.004426	0.033655	0.000000	0.038081	0.007958	NA
Harrison	1992	4	0	0.000517	0.003363	0.000000	0.003880	0.000172	NA
Harrison	1993	1	0	0.015298	0.002284	0.000000	0.017582	0.002271	NA
Harrison	1994	2	0	0.000147	0.020219	0.000000	0.020366	0.006087	NA
Harrison	1995	3	0	0.001583	0.048276	0.000000	0.049859	0.006758	NA
Harrison	1996	4	0	0.003058	0.004486	0.000000	0.007544	0.008255	NA
Harrison	1997	1	0	0.010318	0.070070	0.000000	0.080388	0.001084	NA
Harrison	1998	2	0	0.017702	0.044978	0.000000	0.062680	0.003013	NA
Harrison	1999	3	0	0.016367	0.077400	0.000000	0.093767	0.005592	NA
Harrison	2000	4	0	0.008592	0.003850	0.000000	0.012442	0.001745	NA
Harrison	2001	1	NA	0.053648	NA	NA	NA	0.008335	NA
Harrison	2002	2	NA	NA	NA	NA	NA	0.024384	NA
Harrison	2003	3	NA	NA	NA	NA	NA	0.006043	NA

Appendix Table 2. Fraser River discharge, peak discharge, SST and PDO environmental data.

Year	Hope April mean discharge in smolt yr	Hope May mean discharge in smolt yr	Hope June mean discharge in juv yr	Hope annual peak discharge	Entrance Is April SST	Entrance Is May SST	Entrance Is June SST	Pine Is April SST	Pine Is May SST	Pine Is June SST	Pine Is July SST	Winter PDO (Nov-Mar)
1948	952	4,160	8,880	12,500	7.7	10.6	14.5	6.7	7.2	8.6	9.7	-1.56
1949	1,650	6,040	6,020	8,040	9.1	12.3	14.5	7.2	8.1	8.9	9.7	-1.544
1950	1,700	5,670	6,790	8,330	8.4	11.3	13.4	7.1	8	8.6	9.2	-1.012
1951	920	4,960	6,020	7,220	9.1	12.1	14.3	7.5	8.4	9.1	9.8	-0.496
1952	796	4,100	7,600	9,060	8.3	12.3	13.2	7.5	8.3	8.7	9.2	-0.682
1953	1,280	3,520	7,950	11,300	8.5	10.6	13	7.1	7.8	8.6	9.3	-0.472
1954	1,700	5,800	7,740	9,680	9.2	13.1	12.8	6.8	7.8	8.5	9.3	-2.722
1955	1,510	8,170	6,820	10,400	8.9	13	15.7	7.1	8.5	9	9.6	-1.172
1956	2,450	6,390	7,430	9,770	9.7	14.1	17.5	8.7	9.4	10.2	10.4	0.05
1957	1,560	4,830	7,460	8,470	9.2	12.5	14.8	8	8.7	9.6	10	-0.002
1958	2,530	4,390	6,980	9,340	9.1	11.4	14.4	7.8	9	9.2	9.7	0.356
1959	2,110	5,250	7,790	9,510	8.9	12.3	15.9	8.2	9	10	10.2	0.328
1960	2,380	4,150	6,970	8,210	9	11.7	14.8	7.6	8.4	9.1	9.9	-1.68
1961	2,130	4,420	6,670	7,700	9.3	13.2	15.5	8.3	9.3	9.7	10.1	-0.472
1962	1,490	3,990	10,200	11,600	8.7	11.8	14.3	7.9	8.2	9.4	9.9	-0.846
1963	2,100	5,220	7,400	8,580	8.7	11.2	15.1	7.6	8.3	9.2	9.8	-0.936
1964	2,450	5,290	7,030	7,900	9.2	11.9	13.4	7.8	8.2	8.9	9.7	-0.534
1965	1,340	5,420	9,960	10,800	8.5	12.1	16.6	7.7	8.7	9.4	10.1	-0.61
1966	1,760	5,230	7,890	8,830	8.8	12.3	14.3	7.6	8.7	9.6	10.4	-0.422
1967	2,330	5,150	6,520	7,820	8.2	12.3	16.1	7.4	8.3	9.4	9.9	-0.884
1968	1,410	3,630	6,560	8,670	9	12.1	16.3	7.9	8.3	9.1	9.2	0.78
1969	1,550	6,120	7,590	8,500	8.3	11.5	13	7	7.9	8.8	9.5	-1.418
1970	2,100	6,450	10,800	12,900	7.4	12.1	14.7	6.6	7.9	8.7	9.7	-1.806
1971	1,550	4,910	6,180	7,960	9.3	11.6	13.5	7.5	8.3	8.7	9.1	-0.266
1972	2,320	5,890	8,430	10,800	8.6	11.1	13.6	7.5	8.1	8.8	9.3	-1.268
1973	1,100	3,940	6,830	7,650	7.9	10.8	13.7	7	7.8	8.5	9.3	-0.35
1974	2,300	7,070	7,250	9,400	8.6	11	13.1	7.3	7.9	8.6	9.2	-1.528
1975	2,350	4,710	5,670	6,770	9.2	11.6	14.6	7.8	8.3	9	9.3	1.19
1976	1,960	3,950	5,730	6,970	9.2	11.6	15.1	8.5	9.1	10.1	10.2	0.344
1977	1,290	4,910	6,360	8,390	8.8	12	14.7	7.4	8.2	9	9.8	-0.422
1978	1,760	5,120	4,900	6,070	9.4	12.1	14.5	8.5	8.8	9.5	9.8	0.472
1979	1,880	4,950	6,260	8,370	9.2	12.2	13	8.5	9	9.4	9.9	0.662
1980	1,010	5,360	8,690	9,780	8.5	11.6	16.4	7.8	8.5	9.6	10.2	0.44
1981	1,990	4,090	6,060	7,280	10	13.2	15.6	9.1	9.8	10	10.6	0.764
1982	2,030	2,870	6,370	8,270	9.5	11.3	14.5	8.6	9.3	9.9	10.5	1.438
1983	2,070	5,300	7,390	9,770	8.9	11.8	14.6	7.9	8.6	9.7	10.4	0.862
1984	2,090	3,770	8,390	10,600	9.2	11.1	14.6	8	8.6	9.5	9.9	0.908
1985	2,280	5,120	5,840	7,180	9.8	12.3	15.4	8.9	9.4	9.9	10.6	1.854
1986	2,410	5,450	5,940	7,650	9.8	12	15.3	8.4	9.4	10.2	10.5	1.266
1987	1,780	4,860	6,020	7,110	10.2	14.3	15.8	7.9	9.1	9.7	10.6	-0.65
1988	3,000	5,050	8,760	10,100	10.6	13.4	15	8.6	9.1	10.1	11	-0.456
1989	2,690	5,810	6,910	8,010	10.2	12.7	14.6	8.1	9.1	9.8	10.6	-1.574
1990	2,950	4,800	5,940	6,670	10.5	14.1	17	9.2	10	10.6	10.9	0.308
1991	1,940	5,620	4,930	8,500	9.5	12.9	17.1	8.6	10	10.8	10.7	0.492
1992	3,600	5,970	5,960	7,000	10.4	14	15.5	8.7	9.5	10.3	10.4	0.982
1993	1,900	4,450	5,880	6,840	10.2	14.2	16.5	8.9	9.7	10.1	10.5	-0.606
1994	3,080	4,070	6,750	8,100	9.6	12.1	15.6	9.1	10	10.2	10.9	0.446
1995	2,580	7,420	9,580	11,300	9.6	13.3	15.4	8.4	9.8	10.9	11.3	0.244
1996	1,790	5,730	4,990	6,710	10.1	13.6	16	9.4	9.8	10.3	10.7	1.238
1997	2,390	5,220	8,910	11,000	9.4	12.1	14.7	7.8	8.4	9	9.4	-0.454
1998	1,980	4,270	6,740	8,000	10.3	11.6	14.6	7.9	8.8	9.5	9.8	-1.244
1999	1,220	3,620	5,740	7,140	9.3	12.2	15.4	8	8.8	9.5	9.5	0.266
2000	1,800	5,490	9,300	10,600	9.2	12.4	15.8	8.2	8.4	9.4	10.2	-0.598
2001	2,060	3,700	6,450	7,300	9.2	NA	16.2	8.7	9.5	10	10	1.792
2002	2,440	4,390	5,380	6,650	11.9	14.5	17.2	8.7	9.2	9.9	10.4	0.474

Appendix Table 3. BUGS model formulations.

A. The linear Ricker model (Equation 4)

```
model{
   for (i in 1:N) {                    #loop over N sample points
   R_Obs[i] ~ dlnorm(Y[i],tau_R)         #likelihood
   Y[i] <- RS[i] +log(S[i])              #calc log(R)
   RS[i] <- alpha - beta * S[i]          # ricker model
  }

   R4[N] <- R_Obs[N] * (p4)      # calc age 4 returns (age 3 for Harrison (use 1-p4 for t-3 brood))
   R5[N] <- R_Obs[N-1] * (1-p4)  # calc age 5 returns (age 3 for Harrison (use p4 for t-3 brood))
   Rall[N] <- R4[N]+R5[N]        # calc age 4 + age5 returns (a3+a4 for Harrison) in forecast year

   p4 ~ dbeta(a4.beta,b4.beta)                #probability of age 4 returns
   alpha ~ dnorm(p.alpha,tau_alpha)              #prior for alpha
   beta ~ dnorm(p.beta,tau_beta)              #prior for beta
   tau_R ~ dgamma(0.001,0.001)                   #prior for precision parameter
   sigma <- 1/pow(tau_R,2)                    #stand dev
}
```

B. The linear power model (Equation 5)

```
model{
   for (i in 1:N) {                                  #loop over N sample points
   R_Obs[i] ~ dlnorm(log_R[i],tau_R)                     #likelihood
   log_R[i] <- alpha + beta * log(S[i])               # linear power model
  }

   R4[N] <- R_Obs[N] * p4                            #calc age 4 returns (age 3 for Harrison)
   R5[N] <- R_Obs[N-1] * (1-p4)                      #calc age 5 returns (age 4 for Harrison)
   Rall[N] <- R4[N]+R5[N]                            #calc age 4 + age5 returns (a3+a4 for Harrison)
   p4 ~ dbeta(a4.beta,b4.beta)                       #probability of age 4 returns
   alpha ~ dnorm(0,1e-6             )                #prior for alpha
   beta ~ dnorm(0,1e-6)                              #prior for beta
   tau_R ~ dgamma(0.001,0.001)                       #prior for precision parameter
   sigma <- 1/pow(tau_R,2)                           #stand dev
}
```

Appendix Table 3 (continued). BUGS model formulations.

C. Ricker model with added environmental data (Equation 7)

```
model{
   for (i in 1:N) {                          #loop over N sample points
   R_Obs[i] ~ dlnorm(Y[i],tau_R)               #likelihood
    Y[i] <- RS[i] + log(S[i])
    RS[i] <- alpha - beta *S[i] + g * env[i]   #Ricker model
   resid[i] <- R_Obs[i] - exp(Y[i])          #calculation of residual
   }

   R4[N] <- R_Obs[N] * p4                    #calc age 4 returns
   R5[N] <- R_Obs[N-1] * (1-p4)
   Rall[N] <- R4[N]+R5[N]                    #calc age 4 + age5 returns in forecast year

   prob <- step(beta)                        # probability of positive slope
   p4 ~ dbeta(a4.beta,b4.beta)               #probability of age 4 returns
   g ~ dnorm(p.env,tau_g)
   alpha ~ dnorm(p.alpha,tau_alpha)          #prior for alpha
   beta ~ dnorm(p.beta,tau_beta)             #prior for beta
  tau_R ~ dgamma(0.001,0.001)                #prior for precision parameter
  sigma <- 1/pow(tau_R,2)
```

Appendix Table 3 (continued). BUGS model formulations.

D. The smolt-jack model (Equation 8)

```
model{
  # age3 datum used to update priors for parameters survival and Page in age 4 forecast yr
 N_2age3 ~ dpois(m_2Page3)
 m_2Page3 <- juv2 * survival * Page3

  # age3 datum used to update priors for parameters survival and Page in age 5 forecast yr
  N_1age3 ~ dpois(m_1Page3)
  m_1Page3 <- survival * juv1 * Page3

  #priors for survival, Page3 and Page4
  survival  ~ dbeta(a1,b1)       #juvenile survival
  Page3 ~ dbeta(a2,b2)           #prortion age 3 (jacking rate)
  Page4 ~ dbeta(a3,b3)           #proportion age 4

  # compute age 4&5 recruitment forecast distributions in forecast year
  N_2age45 ~ dpois(m_2Page45)  #forecast year recruits
  m_2Page45 <- survival * juv2 * (1 - Page3)

  # compute age 4 recruitment forecast distributions in forecast year
  N_2age4 ~ dpois(m_2Page4)                    #forecast year recruits
  m_2Page4 <- survival * juv2 * (1 - Page3) * Page4          #forecast age 4

  # compute age 4&5 recruitment forecast distributions in forecast year - 1 to get age 5
 N_1age45 ~ dpois(m_1Page45)        #forecast year recruits
 m_1Page45 <- survival * juv1 * (1 - Page3)

  # compute age 5 recruitment forecast distributions in forecast year
 N_1age5 ~ dpois(m_1Page5)  #forecast year recruits
 m_1Page5 <- survival * juv1 * (1 - Page3) * (1-Page4)     #forecast age 5

 N_Tage45 <- N_2age4 +  N_1age5
```

Appendix Table 4. Model performance by performance criteria and stock.

	MRE	MAE & Model Rank	RMSE & Model Rank	Average Rank
Early Stuart				
Ricker	0.136	0.178 (3)	0.223 (3)	3.0
Power	0.086	0.149 (2)	0.173 (2)	2.0
Fry	-0.06	0.072 (1)	0.14 (1)	1.0
TSA	0.18	0.218 (4)	0.23 (4)	4.0
R1C	0.292	0.428 (7)	0.713 (7)	7.0
R2C	0.268	0.342 (6)	0.561 (6)	6.0
RAC	0.125	0.241 (5)	0.368 (5)	5.0
Bowron				
Ricker	0.008	0.021 (5)	0.029 (4)	4.5
power	0.007	0.019 (2)	0.028 (2)	2.0
Ricker-cyc	0.016	0.021 (5)	0.028 (2)	3.5
power-cyc	0.015	0.024 (11)	0.037 (11)	11.0
Ricker-disc	0.008	0.022 (10)	0.031 (9)	9.5
Ricker-peak	0.008	0.021 (5)	0.03 (5)	5.0
Ricker-ei	0.008	0.021 (5)	0.03 (5)	5.0
Ricker-pi	0.003	0.018 (1)	0.026 (1)	1.0
Ricker-PDO	0.006	0.021 (5)	0.03 (5)	5.0
TSA	0.024	0.032 (12)	0.038 (12)	12.0
R1C	0.004	0.02 (4)	0.033 (10)	7.0
R2C	0.008	0.019 (2)	0.03 (5)	3.5
RAC	0.026	0.032 (12)	0.044 (13)	12.5
Fennell				
Ricker	0.002	0.022 (4)	0.027 (4)	4.0
power	0.008	0.02 (2)	0.025 (3)	2.5
TSA	-0.008	0.019 (1)	0.023 (2)	1.5
R1C	0.001	0.023 (5)	0.028 (5)	5.0
R2C	0.015	0.027 (6)	0.033 (6)	6.0
RAC	-0.009	0.02 (2)	0.022 (1)	1.5
Gates				
Ricker	-0.02	0.059 (5)	0.076 (5)	5.0
power	-0.012	0.048 (1)	0.057 (1)	1.0
fry	-0.012	0.048 (1)	0.064 (2)	1.5
TSA	-0.039	0.065 (7)	0.094 (7)	7.0
R1C	-0.003	0.061 (6)	0.078 (6)	6.0
R2C	-0.011	0.051 (4)	0.071 (4)	4.0
RAC	-0.036	0.05 (3)	0.07 (3)	3.0

	MRE	MAE & Model Rank	RMSE & Model Rank	Average Rank
Nadina				
Ricker	-0.026	0.073 (2)	0.132 (2)	2.0
power	-0.003	0.084 (4)	0.144 (5)	4.5
fry	-0.047	0.062 (1)	0.118 (1)	1.0
TSA	-0.023	0.087 (5)	0.142 (4)	4.5
R1C	-0.002	0.087 (5)	0.147 (6)	5.5
R2C	-0.019	0.076 (3)	0.132 (2)	2.5
RAC	-0.017	0.089 (7)	0.149 (7)	7.0
Pitt				
Ricker	0.005	0.037 (5)	0.044 (2)	3.5
power	0.008	0.034 (1)	0.039 (1)	1.0
power-cyc	0.015	0.04 (8)	0.049 (9)	8.5
Ricker-disc	0.007	0.036 (2)	0.044 (2)	2.0
Ricker-peak	0.005	0.038 (7)	0.046 (6)	6.5
Ricker-ei	0	0.037 (5)	0.046 (6)	5.5
Ricker-pi	-0.004	0.036 (2)	0.046 (6)	4.0
Ricker-PDO	-0.001	0.036 (2)	0.044 (2)	2.0
TSA	0.017	0.041 (9)	0.045 (5)	7.0
R1C	0.005	0.043 (10)	0.059 (11)	10.5
R2C	0.035	0.055 (12)	0.076 (12)	12.0
RAC	0.019	0.045 (11)	0.052 (10)	10.5
Raft				
Ricker	-0.006	0.016 (5)	0.023 (5)	5.0
power	-0.001	0.013 (2)	0.016 (1)	1.5
Ricker-cyc	-0.023	0.027 (13)	0.037 (13)	13.0
power-cyc	-0.005	0.014 (3)	0.018 (3)	3.0
Ricker-disc	-0.006	0.017 (7)	0.023 (5)	6.0
Ricker-peak	-0.007	0.017 (7)	0.024 (8)	7.5
Ricker-ei	-0.007	0.016 (5)	0.023 (5)	5.0
Ricker-pi	-0.01	0.017 (7)	0.025 (10)	8.5
Ricker-PDO	-0.008	0.017 (7)	0.025 (10)	8.5
TSA	0.001	0.025 (12)	0.031 (12)	12.0
R1C	-0.005	0.012 (1)	0.017 (2)	1.5
R2C	-0.006	0.014 (3)	0.021 (4)	3.5
RAC	0.002	0.019 (11)	0.024 (8)	9.5
Scotch[A]				
Ricker	-0.004	0.045 (4)	0.062 (4)	4.0
power	-0.003	0.03 (3)	0.041 (1)	2.0
TSA	-0.011	0.085 (6)	0.107 (6)	6.0
R1C	0.004	0.025 (1)	0.045 (2)	1.5
R2C	0.041	0.048 (5)	0.092 (5)	5.0
RAC	-0.007	0.027 (2)	0.045 (2)	2.0

	MRE	MAE & Model Rank	RMSE & Model Rank	Average Rank
	Seymour			
Ricker	-0.018	0.097 (7)	0.156 (6)	6.5
power	-0.005	0.099 (8)	0.153 (4)	6.0
Ricker-cyc	0.015	0.058 (1)	0.081 (1)	1.0
power-cyc	-0.039	0.082 (3)	0.146 (3)	3.0
Ricker-disc	-0.02	0.111 (11)	0.174 (12)	11.5
Ricker-peak	-0.026	0.111 (11)	0.172 (11)	11.0
Ricker-ei	-0.034	0.089 (5)	0.155 (5)	5.0
Ricker-pi	-0.049	0.086 (4)	0.158 (8)	6.0
ricker-PDO	-0.025	0.102 (10)	0.17 (10)	10.0
TSA	-0.032	0.135 (13)	0.192 (13)	13.0
R1C	0.001	0.092 (6)	0.157 (7)	6.5
R2C	0.003	0.101 (9)	0.165 (9)	9.0
RAC	-0.028	0.079 (2)	0.142 (2)	2.0
	Chilko			
Ricker	-0.255	0.87 (6)	1.256 (5)	5.5
power	0.004	1.115 (11)	1.487 (11)	11.0
smolt	-0.247	0.763 (1)	1.201 (1)	1.0
smolt-cycle	-0.257	0.935 (9)	1.406 (9)	9.0
smolt-disc	-0.264	0.845 (5)	1.248 (4)	4.5
smolt-pi	-0.325	0.832 (4)	1.272 (6)	5.0
smolt-ei	-0.166	0.785 (2)	1.207 (2)	2.0
smolt-peak	-0.291	0.792 (3)	1.213 (3)	3.0
smolt-PDO	-0.297	0.874 (7)	1.34 (7)	7.0
TSA	-0.463	0.95 (10)	1.383 (8)	9.0
R1C	0.101	1.227 (13)	1.719 (13)	13.0
R2C	0.061	1.143 (12)	1.519 (12)	12.0
RAC	-0.43	0.903 (8)	1.416 (10)	9.0
	Late Stuart			
Ricker	-0.184	0.754 (10)	1.256 (9)	9.5
power	-0.3	0.577 (4)	1.049 (3)	3.5
Ricker-cyc	-0.132	0.737 (8)	1.295 (12)	10.0
power-cyc	-0.403	0.64 (5)	1.276 (10)	7.5
Ricker-disc	-0.153	0.711 (7)	1.189 (6)	6.5
Ricker-peak	-0.206	0.758 (11)	1.282 (11)	11.0
ricker-ei	-0.068	0.777 (12)	1.21 (7)	9.5
ricker-pi	-0.238	0.748 (9)	1.247 (8)	8.5
ricker-PDO	-0.177	0.673 (6)	1.06 (4)	5.0
TSA	-0.359	0.8 (13)	1.392 (13)	13.0
R1C	-0.033	0.523 (1)	0.924 (1)	1.0
R2C	-0.096	0.541 (2)	1.081 (5)	3.5
RAC	-0.41	0.551 (3)	1.04 (2)	2.5

	MRE	MAE & Model Rank	RMSE & Model Rank	Average Rank
	Quesnel Fry Based			
Ricker	1.061	1.117 (1)	1.355 (1)	1.0
power	2.378	2.401 (7)	4.334 (7)	7.0
fry	0.513	1.488 (3)	1.986 (3)	3.0
TSA	-1.506	2.213 (6)	2.724 (6)	6.0
R1C	0.394	1.318 (2)	1.756 (2)	2.0
R2C	0.572	1.64 (5)	2.287 (5)	5.0
RAC	-1.499	1.572 (4)	2.107 (4)	4.0
	Quesnel Escapement Based			
ricker	1.074	1.62 (7)	3.218 (6)	6.5
power	0.484	1.285 (3)	2.7 (4)	3.5
Ricker-cyc	3.135	3.518 (13)	6.57 (13)	13.0
power-cyc	0.963	1.609 (6)	3.434 (8)	7.0
ricker-disc	1.15	1.72 (8)	3.389 (7)	7.5
ricker-peak	0.852	1.347 (4)	2.512 (3)	3.5
ricker-ei	1.27	1.845 (9)	3.685 (10)	9.5
ricker-pi	1.389	1.997 (10)	4.065 (11)	10.5
ricker-PDO	1.549	2.202 (11)	5.059 (12)	11.5
TSA	-1.386	2.211 (12)	3.632 (9)	10.5
R1C	-0.265	0.909 (1)	1.592 (1)	1.0
R2C	-0.408	1.106 (2)	2.053 (2)	2.0
RAC	-1.531	1.552 (5)	2.924 (5)	5.0
	Stellako Fry Based			
Ricker	0.186	0.186 (3)	0.22 (3)	3.0
power	0.301	0.301 (7)	0.331 (7)	7.0
fry	0.026	0.197 (4)	0.234 (4)	4.0
TSA	0.001	0.263 (6)	0.276 (6)	6.0
R1C	0.09	0.091 (1)	0.118 (1)	1.0
R2C	0.146	0.146 (2)	0.152 (2)	2.0
RAC	0.003	0.221 (5)	0.275 (5)	5.0
	Stellako Escapement Based			
Ricker	-0.039	0.274 (3)	0.361 (3)	3.0
power	0.003	0.307 (12)	0.393 (9)	10.5
Ricker-cyc	0.141	0.293 (9)	0.335 (1)	5.0
power-cyc	-0.023	0.318 (13)	0.438 (13)	13.0
Ricker-disc	-0.042	0.267 (2)	0.372 (6)	4.0
Ricker-peak	-0.049	0.281 (6)	0.385 (7)	6.5
Ricker-ei	-0.041	0.277 (4)	0.369 (5)	4.5
Ricker-pi	-0.065	0.278 (5)	0.366 (4)	4.5
Ricker-PDO	-0.052	0.281 (6)	0.388 (8)	7.0
TSA	-0.115	0.303 (11)	0.409 (11)	11.0
R1C	0	0.283 (8)	0.429 (12)	10.0
R2C	-0.013	0.236 (1)	0.342 (2)	1.5

	MRE	MAE & Model Rank	RMSE & Model Rank	Average Rank
RAC	-0.102	0.298 (10)	0.399 (10)	10.0
	Cultus			
Ricker	-0.005	0.013 (3)	0.022 (3)	3.0
smolt	-0.004	0.011 (1)	0.019 (2)	1.5
smolt-jack	-0.001	0.011 (1)	0.016 (1)	1.0
TSA	0.03	0.037 (7)	0.039 (5)	6.0
R1C	0.005	0.017 (4)	0.025 (4)	4.0
R2C	0.023	0.026 (5)	0.04 (6)	5.5
RAC	0.029	0.029 (6)	0.04 (6)	6.0
	Harrison [B]			
Ricker	-0.002	0.021 (4)	0.031 (2)	3.0
power	-0.004	0.022 (6)	0.032 (4)	5.0
Ricker-cyc	-0.015	0.033 (11)	0.045 (11)	11.0
power-cyc	-0.003	0.027 (8)	0.036 (9)	8.5
Ricker-disc	-0.001	0.026 (7)	0.049 (12)	9.5
Ricker-peak	-0.006	0.02 (2)	0.033 (6)	4.0
Ricker-ei	-0.004	0.021 (4)	0.032 (4)	4.0
Ricker-pi	-0.007	0.02 (2)	0.031 (2)	2.0
Ricker-PDO	-0.009	0.016 (1)	0.026 (1)	1.0
TSA	0.01	0.028 (9)	0.033 (6)	7.5
R1C	-0.002	0.033 (11)	0.044 (10)	10.5
R2C	0.013	0.042 (13)	0.051 (13)	13.0
RAC	0.01	0.029 (10)	0.033 (6)	8.0
	Late Shuswap Fry Series			
Ricker	0.371	1.261 (2)	1.698 (1)	1.5
power	0.677	1.681 (3)	2.369 (3)	3.0
fry	-0.481	2.2 (6)	3.436 (7)	6.5
TSA	-0.28	2.409 (7)	2.847 (6)	6.5
R1C	0.528	1.936 (5)	2.699 (5)	5.0
R2C	0.926	1.84 (4)	2.623 (4)	4.0
RAC	0.464	1.017 (1)	1.855 (2)	1.5
	Late Shuswap [B]			
TSA	-0.234	2.693 (4)	3.4 (4)	4.0
R1C	-0.054	0.893 (2)	1.658 (2)	2.0
R2C	0.015	0.992 (3)	1.715 (3)	3.0
RAC	-0.134	0.728 (1)	1.419 (1)	1.0

	MRE	MAE & Model Rank	RMSE & Model Rank	Average Rank
	Portage [A]			
Ricker	-0.015	0.038 (1)	0.058 (2)	1.5
power	-0.016	0.038 (1)	0.054 (1)	1.0
TSA	-0.031	0.044 (4)	0.066 (4)	4.0
R1C	0.002	0.054 (5)	0.07 (5)	5.0
R2C	0.027	0.065 (6)	0.086 (6)	6.0
RAC	-0.032	0.041 (3)	0.064 (3)	3.0
	Weaver			
Ricker	-0.059	0.218 (4)	0.275 (5)	4.5
power	-0.102	0.214 (3)	0.272 (4)	3.5
fry	-0.123	0.203 (2)	0.263 (2)	2.0
TSA	-0.012	0.226 (5)	0.25 (1)	3.0
R1C	0.064	0.305 (7)	0.448 (7)	7.0
R2C	0.069	0.278 (6)	0.417 (6)	6.0
RAC	-0.029	0.202 (1)	0.266 (3)	2.0
	Birkenhead			
Ricker	-0.114	0.33 (3)	0.447 (3)	3.0
power	-0.063	0.285 (1)	0.405 (1)	1.0
Ricker-cyc	0.271	0.369 (11)	0.432 (2)	6.5
power-cyc	-0.017	0.369 (11)	0.469 (11)	11.0
Ricker-disc	-0.116	0.339 (6)	0.456 (7)	6.5
Ricker-peak	-0.117	0.335 (4)	0.449 (4)	4.0
Ricker-ei	-0.099	0.326 (2)	0.455 (6)	4.0
Ricker-pi	-0.096	0.336 (5)	0.465 (10)	7.5
Ricker-PDO	-0.133	0.34 (7)	0.458 (8)	7.5
TSA	-0.138	0.351 (9)	0.453 (5)	7.0
R1C	0.027	0.345 (8)	0.478 (12)	10.0
R2C	0.29	0.49 (13)	0.652 (13)	13.0
RAC	-0.145	0.358 (10)	0.46 (9)	9.5

[A] did not do all candidate models because of shorter data series of reliable data

[B] Can't use escapement based models given S is 1.6x record.