PRE-SEASON RUN SIZE FORECASTS FOR FRASER RIVER SOCKEYE *(ONCORHYNCHUS NERKA)* AND PINK (*ONCORHYNCHUS GORBUSCHA*) SALMON IN 2025

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ABSTRACT

Dionne, K., Gao, J., and Lilly, J. 2025. Pre-season run size forecasts for Fraser River Sockeye (*Oncorhynchus nerka*) and Pink (*Oncorhynchus gorbuscha*) Salmon in 2025. Can. Tech. Rep. Fish. Aquat. Sci. 3731: v + 36 p. https://doi.org/10.60825/hrtt-0c28

Forecasts for the 2025 Fraser River Sockeye and Pink salmon returns were prepared with Bayesian statistical models and presented as cumulative probability distributions. The total Fraser River Sockeye return for 2025 has a median estimate of 2,947,000 (80% PI: 736,000 to 13,140,000), which is less than half the long term average of 7.0 million. The return is expected mainly from the Chilko and Late Stuart River stocks in the Summer run timing group. Out of 27 forecasts for Sockeye, six stocks included environmental covariates and 12 stocks used sibling models to calculate the age-5 return. Warmer nearshore sea surface temperatures (SST) suggested the potential for reduced salmon productivity, while the Pacific Decadal Oscillation (PDO) suggested that SSTs offshore were more favorable for salmon production. The 2025 forecast for Fraser River Pink salmon is 26,965,000 (12,585,000 to 57,854,000) and represents the highest possible return on record, which is largely driven by the high abundance of juvenile outmigration observed in 2024 (1.35 billion). However, Pink returns in 2023 were underestimated and highlights the uncertainty in Pink population dynamics not captured in our current model infrastructure. The 2025 Fraser Pink forecast should be considered highly uncertain.

RÉSUMÉ

Dionne, K., Gao, J., and Lilly, J. 2025. Pre-season run size forecasts for Fraser River Sockeye (*Oncorhynchus nerka*) and Pink (*Oncorhynchus gorbuscha*) Salmon in 2025. Can. Tech. Rep. Fish. Aquat. Sci. 3731: v + 36 p. https://doi.org/10.60825/hrtt-0c28

Les prévisions pour les retours de saumons rouges et roses du fleuve Fraser en 2025 ont été établies à l'aide de modèles statistiques bayésiens et présentées sous forme de distributions de probabilité cumulatives. Le total prévu des retours de saumons rouges du fleuve Fraser pour 2025 a une estimation médiane de 2,947,000 (intervalle de prévision à 80 % : 736,000 à 13,140,000), moins de la moitié de la moyenne à long-terme de 7 millions. Cette montaison provient principalement des stocks de la rivière Chilko et le stock tardif de la rivière Stuart, ces deux appartenant au groupe de montaison estival. Parmi les 27 prévisions des stocks de saumon rouge produites, 6 incluent des covariables environnementales, et 12 utilisent des modèles d'espèces jumelles pour calculer la prévision des poissons d'âge 5. Les températures superficielles marines (TSM) plus élevées dans les eaux littorales du Pacifique suggérent une réduction dans la productivité des saumons, tandis que l'oscillation décennale du Pacifique (ODP) indique que les TSM au large leur sont plus favorables. La prévision pour les saumons roses du fleuve Fraser en 2025 est de 29,965,000 (12,585,000 to 57,854,000): ce chiffre représenterait la montaison la plus élevée jamais enregistrée. Cependant, les retours de saumons roses en 2023 ont été sous-estimés, ce qui met en évidence l'incertitude entourant la dynamique des populations de saumons roses qui n'est pas encore pleinement prise en compte dans notre infrastructure actuelle de modélisation. Par conséquent, la prévision de 2025 pour le saumon rose du Fraser doit être considérée comme hautement incertaine.

1. BACKGROUND

1.1 FRASER SOCKEYE SALMON

The Fraser River is the largest watershed entirely contained in British Columbia and home to all species of Pacific Salmon found in the Eastern Pacific Ocean. Fraser River Sockeye salmon (*Oncorhynchus nerka*) typically demonstrate a four year, lake-type life cycle where juveniles rear in a lake for one full year prior to migrating to the marine environment. There they spend two or three years at sea before returning to spawn in their natal streams. The exception to this life history strategy are the river-type Harrison Sockeye that migrate to the Strait of Georgia shortly after egg emergence and return as 3- and age-4 adults. Several stocks also display cyclic dominance with one return year being more abundant than the remaining three cycle lines (Grant et al. 2020).

Fraser River Sockeye salmon have historically supported large commercial, recreational, and First Nations harvests (Gilhousen 1992). However, recent productivity trends have become more variable, resulting in both the largest (2010) and lowest (2020) Fraser Sockeye returns in recorded history (Figure 1; Pacific Salmon Commission 2021). In 2017, a Wild Salmon Policy (WSP) status evaluation, and a Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status report both identified persistent patterns of decline in many of the Conservation Units (CUs) or Designatable Units (DUs), which are the discrete and evolutionary distinct constituent populations of the Fraser River Sockeye aggregate. The WSP process identified seven of the 19 forecasted CUs as being in a state of significant conservation concern, while the COSEWIC status report recommends that seven of these stocks be listed as endangered (Grant et al. 2020, COSEWIC 2017).

The increased variability of returns of Fraser River Sockeye beginning in the 1990s has resulted in reduced predictability by forecast models. Since this time, returns have been lower on average than forecasts based on long-term average survival (with the exception of several years of larger than expected returns). Several studies have linked ocean warming and environmental volatility associated with climate change to low survival of Fraser Sockeye salmon (Mueter et al. 2002; Connors et al. 2020; MacDonald et al. 2020). Environmental covariates are included in the forecasting process and show mixed signals for the 2025 return. Nearshore sea surface temperature (SST) measured at Entrance Island and Pine Island in the spring of 2023 (at the time of early marine entry for the 2025 return) show warmer than average conditions (Figure 3). , However the Pacific Decadal Oscillation (PDO) was cooler than average in 2023 (Figure 3) indicating offshore SSTs have been more favorable for salmon production. Additionally, a summary of ocean ecosystem indicators used to characterize juvenile salmon marine survival in the Northern California Current put 2023 in the middle of all years of data with respect to overall condition ranks (1998-2023) (Figure 9).

Escapement data is collected by DFO staff using a variety of methods. In general, higher accuracy methods with estimated precision (sonar or mark-recapture studies) are used to enumerate larger populations, while lower accuracy methods with no accompanying precision (e.g., visual surveys, peak count via aerial or ground-based surveys, carcass recovery surveys) are used to enumerate smaller populations (Welch and Grant 2018). The specifics of the escapement programs as well as the escapement estimates are provided annually for the forecasting process by DFO Stock Assessment and are the primary driver of the forecasts (Macdonald and Grant 2012).

The 2025 Fraser River Sockeye salmon forecast of 2,947,000 (736,000 – 13,140,000) is lower than the long term and cycle line average return. However, both freshwater and marine survival have been showing an increasing trend in the last several cycle lines (Figure 2), and environmental conditions in the marine environment are near average for salmon production (Figure 9).

1.2 FRASER PINK SALMON

Fraser River Pink salmon (*O, gorbuscha*) are the largest run of pink salmon in British Columbia and exhibit a two-year life cycle. Adults spawn in the fall, fry emerge in the spring, and migrate immediately to sea. Adults return a year later to spawn at age two. Fraser River Pink salmon have a strong bi-annual pattern with significant returns of adult pink salmon occurring only on odd years. The last three returns (2019, 2021, and 2023) have been below the long-term average of 12.3 million. Fry (or sub-yearling smolts) are enumerated during their downstream migration in the spring on even years and these values are used to forecast the return for the fall of the next odd year (with the exception of 2020 when the program was unable to run due to the COVID-19 pandemic). These metrics are favored for forecasting Fraser Pink salmon returns as the data have been consistently collected and are a better predictor of subsequent adult returns than the adult escapement estimates where methodologies have varied through time. The methods, time series, and the history of data collection for Fraser River Pink salmon are detailed in Grant et al. (2014).

There are few studies on Fraser River Pink salmon and how environmental conditions at sea affect returns and productivity. Although evaluation of the inclusion of environmental covariates for the purposes of forecasting Fraser River Pink salmon has been limited, sea surface salinity (SSS) has been determined to be an appropriate covariate to include. Sea surface salinity values for the 2025 cohort suggest reduced upwelling and therefore less favorable conditions for Fraser River Pink salmon.

The 2025 Pink salmon forecast of 27 million is more than double the long-term average (12.3 million), and the 2024 fry outmigration of 1.3 billion is the highest observed since the method for enumerating outmigrating fry was standardized in 1968, and is approximately three times the long-term average of 460 million. Although the fry estimate standardizes to river discharge, it should be noted that the freshet in 2024 was the lowest on record. It is unclear if the low discharge levels have affected the catchability of pink fry in the survey and as such, the data should be considered uncertain.

1.3 SPECIAL CONSIDERATIONS: FRASER RIVER WATER TEMPERATURES

In 2021, Sockeye experienced above average water temperatures in the Fraser River during their upstream migration. At the end of June, a very strong high-pressure ridge set up over most of BC resulting in all-time record high temperatures (>40°C) in many southern areas of the province. Fraser River water temperatures at Hope were above average (15°C to 19°C) from late June to the end of July, reaching 21°C in early August (DFO Fraser River Environmental Watch 2021). Fraser Sockeye are known to experience decreased swimming performance when water temperature exceed 18°C, and suffer significant mortality when water temperatures exceed 20°C (DFO Fraser River Environmental Watch 2021). In addition, warm water conditions along the migration route can also impact reproductive success and contribute to intergenerational effects on the survival and development of offspring (Braun et al. 2013). In addition, an atmospheric river resulted in heavy precipitation and widespread flooding throughout the Lower Fraser River in November of 2021. The impact of this event on incubating sockeye salmon eggs is unclear.

1.4 FORECASTING

Forecasting salmon returns has been an area of study for generations of fisheries scientists (see Haeseker et al. 2008 for an overview of salmon forecasting methods). Although forecast methods have not changed dramatically over time, there have been innovations both in the modeling frameworks applied and the sophistication of computation (e.g. Cass et al 2006, MacDonald and Grant 2012; Akenhead et al. 2016). The recent low, yet highly variable productivity for most Fraser Sockeye stocks has added additional challenges to forecasting returns, with many years falling at the low end of the forecast distributions. In 2022, the retrospective analysis was updated using a one-step-ahead approach to replace the previous jackknife retrospective analysis that was conducted in 2012. (MacDonald and Grant 2012; Liu and Xu, 2024; Xu et al., 2024).

The Fraser River Sockeye and Pink salmon preseason forecast is required to inform pre-season planning of First Nations, recreational, and commercial fisheries and stock assessment programs, and provides informative priors for the in-season run-size assessment programs. It also supports planning decisions of the bilateral Fraser River Panel and provides advice to DFO fisheries managers regarding in-season harvest management of Sockeye salmon (Pacific Salmon Treaty 1985).

2. DATA AND METHODS

2.1 DATA

2.1.1 Sockeye Data

Fraser Sockeye data used in the forecast process includes the following:

Spawners

- Effective Female Spawners (EFS) data are included up to the 2021 brood year for all stocks, except Harrison (2022 brood year), following previous forecasts (DFO 2021; 2022; Appendix D).

Juveniles

- Fry data for the 2021 brood year are available for Nadina and Weaver. Each stock typically has a large proportion of fry production originating from a spawning channel with a monitoring program in place, along with a smaller proportion of fry originating from the adjacent natural spawning grounds. Fry data were available for the channels and natural rivers/creeks historically, but limited to the channels in 2020 and 2021 brood years. Fry data gaps in the historic time series were infilled using the average historical fry/EFS production by stream multiplied by the relevant brood-year EFS. This infilling approach is consistent with previous model settings (Grant et al. 2010; MacDonald and Grant 2012). Gates channel fry surveys have not occurred since the 2018 brood year (1968-2018) due to the termination of channel operation in 2019.

• Juvenile smolt data (2023) for the 2021 brood year are available for Cultus and Chilko.

Recruitment

• The most recent brood year for which adult recruitment data are available (2024) is 2019, 2020, and 2021 for age-5, age-4, and age-3 returns (Harrison), respectively. . However, these values are still considered to be preliminary. There were changes in recruitment data between current and previous forecasts due to the run-size adjustment process (return year: 2021 and 2022) and recalculation of age composition (return year 2019-2020).

• The time series (by brood year) of EFS, juveniles, and recruitment data used to run the models are from 1948-2021 for all stocks except for Nadina (1973-2021), Gates (1968-2021), Scotch (1980-2021), Fennell (1967-2021), Weaver (1966-2021), Portage (1953-2021) and Chilliwack (1998-2021).

2.1.2 Pink Data

Adult returns are estimated by the Pacific Salmon Commission's (PSC) hydroacoustic program in the lower Fraser River (aggregated with catch estimates), while outmigrating juvenile abundance (smolt) data are collected by Fisheries and Oceans Canada (DFO) through a downstream trapping project (incline plane and rotary screw traps). Fry abundance is used exclusively as the predictor variable in the relevant non-parametric and biological models for Fraser Pink salmon forecasts. Escapement is not used as a predictor variable for Pink salmon forecast given the considerable changes in escapement methods used over the historic time-span, lack of calibration work to account for differences between methodologies (Figure 5; Grant et al. 2014), and discontinuation of escapement monitoring after 2001). In addition, catch estimation methods have varied over time, owing to differences in run-reconstruction methods between 1959-1977 and 1979-1985, differences in genetic stock identification methods between 1987-2005 and 2007-present (Grant et al. 2014; DFO 2015; 2021).

2.1.3 Environmental Data

The following environmental data were collected and incorporated in several biological models (used in 2006-2022; See Cass et al. 2006 and MacDonald and Grant 2012 for further details; DFO 2021):

• Pacific Decadal Oscillation (PDO) in the winter preceding outmigration (November to March), with a below average (colder Sea Surface Temperatures (SST)) phase for the smolt entry year of 2023 (BY 2021) (Zhang et al. 1997, Mantua et al. 1997; data available online; Figure 3). When the PDO is in a negative or below average condition, it is considered to be favourable for Sockeye salmon productivity.

• The average of average monthly SST from Entrance Island lighthouse (Ei; Strait of Georgia, near Nanaimo, B.C.) from April to June, and Pine Island (Pi; Northeast corner of Vancouver Island) from April to July (data available online; Jennifer Jackson, DFO, Sidney, BC, pers. comm.; Figure 3) of the year of outmigration. The SST variables show warmer than average conditions at the Entrance Island and the Pine Island location in 2023.

• Peak Fraser Discharge (FrD-peak) and average Fraser Discharge (FrD-average) from April to June of the outmigration year was measured at Hope, BC, with a higher peak and a lower average discharge during the smolt entry year compared with the time series average (David Patterson, DFO, Vancouver, BC, pers. comm.; Figure 4).

2.2 METHODS

The 2025 Fraser Sockeye forecasts followed recent forecasting methods using a Bayesian statistical approach to estimate parameters from biological models and MCMC (Markov Chain Monte Carlo) to assess the uncertainties (Cass et al. 2006; MacDonald and Grant 2012; DFO 2013; DFO 2014; DFO 2015; DFO 2016; DFO 2017; DFO 2018; Hawkshaw et al. 2020a; Hawkshaw et al. 2020b; DFO 2021; Xu and Liu 2023; Dionne and Liu 2024; Dionne and Gao 2025). Visualization tools including Taylor diagrams and an R markdown HTML Viewer that were developed in the 2022 forecast season were presented during the 2025 forecast meetings.

Model selection for the 19 major stocks is completed through consensus by expert opinion where a shortlist of top-ranked models from the retrospective analysis are considered. Model performance and ranking for Fraser Sockeye salmon are presented on Taylor diagrams and ranking tables based on the one-step-ahead retrospective analyses developed in the 2022 forecast season (Liu and Xu, 2024, Xu et al., 2024). The updated analysis hindcasts the run size for the last three generations between 2009 and 2020 for all 27 stocks (19 major, 8 miscellaneous), and is more reflective of recent population dynamics, current productivities, and environmental conditions than analyses incorporating the entire time series. The total and age-specific forecast results from the top-ranked models, including their implied productivities, are presented and compared to the historical time-series of observed recruits and productivity. Preference was given to models that captured the dynamics of recent productivity. Detailed descriptions of all models are listed in Table 4. For miscellaneous stocks with no recruitment data available, forecasts are generally based on brood year escapements and ‘recent’ observed survival rates from proxy stocks (See Appendix A).

Since 2019, sibling models have often been used forecast productivity for older age classes, using return data from their brood-year mates that returned the previous year. A description of the sibling model can be found in the 2019 forecast document (Hawkshaw et al. 2020a), and a description of the recently updated sibling model selection criteria can be found in the 2020 forecast document (Hawkshaw et al. 2020b). In the context of 2025, the goal of using a sibling model is to forecast returns of older age classes by using data from the 2024 return to align the forecast of age-5 fish to the recent productivity trend observed for many stocks in 2024.

3. RESULTS

3.1 SOCKEYE

The 2025 total p50 Fraser River Sockeye return forecast is 2,947,000 (80 %PI: 736,000 - 13,140,000). This return is forecasted to be lower than the cycle line average return (7.5 million) and the all-years average return (7.0 million; Table 1B).

The 2025 forecast for Early Stuart sockeye is 116,000 (42,000 to 319,000) and was generated using a Ricker model with sea surface temperature at Entrance Island (Ei) as a covariate (Ricker Ei). The forecasted proportion of age-4 returns is 100% (Table 3). For the Early Stuart return, the Ricker(Ei) model is the highest ranked model followed by the Ricker (PDO). The sibling model was not selected for the age-5 component as the 2020 return was very near 0 and not expected to contribute to the 2025 return When considering the top performing models for the total forecast, Ricker(Ei) and Ricker (PDO) rank highly. Preference is given to the more conservative biological model (Ricker Ei) as it has performed well in previous years.

The total forecasted return for the Early Summer aggregate is 220,000 (54,000 to 820,000) including miscellaneous stocks and 187,000 (49,000 to 684,000) excluding miscellaneous stocks. The primary contributing stocks to the Early Summer return at the p50 forecast are the Scotch (47,000) and Pitt stocks (46,000). Scotch was forecasted using a Larkin model for the age-4 return and a sibling model for the age-5 return, and is expected to be dominated by age-4 returns (99%). Based on the Taylor diagram, the sibling model performed well for forecasting age-5 returns and was selected. It was also highly ranked in the retrospective ranking table. Two Larkin models performed well for forecasting the age-4 component and produced similar forecasts (± 4.8%). However, because a basic Larkin model has been selected in the past and has performed well, it was chosen again for this forecast. The Pitt was also forecasted using a Larkin model for the age-4 return and a sibling model for the age-5 return, and is expected to be dominated by age-5 returns (72%). The sibling model demonstrated high performance on the Taylor diagram for forecasting age-5 fish and it was the top ranked model in the retrospective ranking table. A basic Larkin model and a like last year (LLY) were both highly ranked in the Taylor diagram for forecasting age-4 fish. Larkin models were used in previous years; however, they tended to overestimate returns slightly. The Larkin model was still selected because the forecast generated by the LLY was even greater than the Larkin forecast.

The Summer run timing group is expected to be the largest contributor to the 2025 forecast with a forecasted return of 2,137,000 (522,000 to 10,004,000). Chilko is predicted to be the largest contributing stock with a p50 forecast of 928,000 (250,000 to 4,153,000). Chilko was forecasted using a Ricker model with a cycle line covariate (RickerCyc) for the age-4 return and a sibling model for the age-5 return. Although Chilko is a data-rich stock with a robust smolt enumeration program, models that include the juvenile abundance covariate have tended to be overly optimistic in recent years due to increasing freshwater survival but below average smolt-to-adult survival. The sibling model performed well for the age-5 component of the Chilko forecasts in both the Taylor diagrams, and is the top ranked model in the age-specific retrospective ranking table. Top models for the age-4 Chilko forecast included Larkin and RickerCyc. Larkin models have historically been favored for forecasting Chilko sockeye as they were highly ranked in the previous retrospective analysis (MacDonald 2012) but have had a tendency to over forecast in recent years. Observations of the raw stock-recruit data for Chilko showed that there was a high degree of variability in the number of recruits for spawner abundances in the range of that observed in 2021, where some of the highest and lowest recruitment events for the stock have occurred. The implied productivity using the RickerCyc more closely aligned with recent observations and with the precautionary approach, and was therefore selected for 2025. Late Stuart is expected to be the second most abundant stock in 2025 with a p50 forecast of 608,000 (107,000 to 3,466,000). Late Stuart sockeye were the second most abundant stock in 2021, and this is the dominant cycle line for Late Stuart. Their age-4 forecast was generated using a naïve model where the estimated returns was the product of average survival from four years before the forecast year and the forecast brood year EFS (RS1). In addition, a sibling model was used to estimate five-year-old returns. Stellako is expected to be the third most abundant stock in 2025 with a p50 forecast of 281,000 (100,000 to 810,000). This forecast was generated using a Larkin model for the age-4 return and a sibling model for the age-5 return. The sibling model performs very well for age-5 forecasts for Stellako as is evident in the Taylor diagram as well as in the age-specific ranking table. The Larkin Basic model was selected for the age-4 component as it ranked highly in the retrospective analysis. Model selection for the remaining stocks in the Summer run timing aggregate can be found in Table 1A.

The aggregate forecast for the Late Run timing group is 474,000 (118,000 to 1,997,000), with most expected to be Weaver Sockeye (297,000; 88,000 to 1,119,000). The Weaver forecast was generated using the combined cycle-line Ricker (RickerCyc) model for age-4 returns and sibling model for (age-5) returns. The sibling model performed well as is evident in the Taylor diagram as well as in the age-specific ranking table. Other top models include RS1 for naïve model, RickerCyc and Ricker(Ei) models. The RickerCyc model was chosen as it has performed well in previous years and the implied productivity aligned well with recent observations. Birkenhead is expected to be the second most abundant Late Run stock in 2025, with a p50 forecast of 92,000 (31,000 to 269,000). The Birkenhead age-4 forecast was generated using a Ricker model with an Pine Island (Pi) SST covariate. The sibling model was ranked highly for the age-5 component of the Birkenhead sockeye forecast and was therefore selected. When considering the age-4 component of the forecast, several models were highly ranked including the Ricker(Pi), which had an implied productivity that was more aligned with recent observations than other models. Late Shuswap and Portage are forecasted to contribute 60,000 and 13,000 Sockeye, respectively, at the p50 level. The forecast for Cultus Sockeye is 700 (200 to 3,000).

For further details on model selection rationale at the stock level, see Appendix B.

3.2 PINK

The total forecast for Fraser River pink salmon is 27M (12.6M to 57.8M) and was forecasted using a power model with a juvenile abundance covariate (Powerjuv). This is the highest pink forecast on record. Although the power model with both a juvenile abundance and sea surface salinity (SSS) covariate were ranked higher in the retrospective analysis, the forecasts generated by these models were considered to be even more optimistic when considering recent return and productivity observations. Additionally, the power SSS model was the top-ranked model but the salinity data may not be accurate as it requires calibration (J. Jackson, pers. comm). Shifting enumeration methods through time for returning adult pink salmon and a lack of calibration between methodologies generates uncertainty for Fraser Pink forecasts in all years. Although the uncertainty range captured in the 80% probability interval is quite large, this range does not fully account for uncertainty in the escapement and juvenile fry data that inform the forecast models. The 2024 fry juvenile estimate is particularly uncertain owing to record low water levels and poorly understood effect of discharge on capture probability. Therefore it is likely that this probability interval does not capture the full range of potential outcomes for the 2025 Fraser Pink return.

4. DISCUSSION

The 2022 Fraser River Sockeye forecast was the first year that the updated retrospective analysis was used for model selection. From 2015 to 2020, forecast performance was exceptionally poor with post-season returns closer to the p10 forecast or lower for all years except 2018. Returns in 2021 were better than forecasted (p75) despite not having an updated retrospective analysis available. Forecast performance improved in 2022 and 2023 relative to the previous 10 years, with 2023 being the most accurate forecast on record. However, while the 2023 total return was very close to the pre-season p50 forecast, there was some variability at the MU and stock-level, and a need for additional retrospective work was identified, with a goal of further improving forecasts at the MU level. The updated retrospective analysis that informs the 2025 forecast uses a one-step-ahead approach that assesses model performance between 2009 and 2020. This ensures forecasting models are capturing recent relationships between abundance and covariates and are not based on historical correlations that are no longer relevant in the current environment. The strong forecast performance in 2023 can likely be attributed to updated methods and environmental conditions that were near the long term average.

In 2025, the expected proportion of age-4 fish is 95% which is higher than 2024 and above the long term average of 91% (Table 3). Environmental indicators are mixed for the 2021 brood year with nearshore temperatures above average at Pine Island and Entrance Island stations in the outmigration year of 2023. The PDO was below average, signifying cooler conditions, which is often better for offshore salmon production (Figure 3). A stoplight chart of ocean indicators generated by the National Oceanic and Atmospheric Administration (NOAA) suggests that overall marine conditions in 2023 returned to near average for salmon production (Figure 9). It

Fraser River Sockeye are forecasted to return in 2025 at less than half the long term average of 7.0 million. It is important to note that the 2021 brood year (which produces the age-4 Sockeye returning in 2025) ranked in the bottom 20% of all recorded brood year returns. The 2021 escapement may have been negatively impacted by the record high water temperatures in the Fraser during migration and spawning, and an atmospheric river that resulted in heavy precipitation in November. For potentially affected Sockeye stocks, a more conservative forecast was selected due to concerns that the severe flooding in November 2021 may have reduced survival of eggs recently deposited in stream substrates. Above average SST in the early marine environment during 2023 may have negatively impacted the early marine survival of all juveniles as well. However, during 2023 the PDO index was below average. Negative PDO indices have been associated with increased Sockeye prey abundances in the Northeast Pacific and increased Fraser Sockeye productivity (Grant et al. 2019, Peterman et al. 2010). Beginning in 2020, the development of sibling models has resulted in improved forecasts of the age-5 component of the run. These models should continue to be used when they are highly ranked and implied productivity aligns with recent observations.

Although some environmental indicators for Fraser River Sockeye suggest that environmental conditions were less favorable for Sockeye, environmental covariates used for forecasting Pink salmon are indicative of more favorable conditions. Fraser Pink salmon are forecasted to return at approximately double the long-term average of 12.3 million. Pink returns in 2023 were under-forecasted and highlights the uncertainty in Pink population dynamics not captured in our current model infrastructure. The 2025 Fraser Pink forecast should be considered highly uncertain.

5. CONCLUSIONS

The 2025 Fraser Sockeye forecast of 2,947,000 (736,000 to 13,140,000) is ranked in the bottom 20% of all recorded returns, due in large part to the low brood-year returns in 2020 and 2021 which are the main contributors (Figure 1). Forecast performance over the past decade has generally been poor and unable to capture recent patterns of low productivity that were observed over the past decade, with the exception of 2021. However, recent updates to the retrospective analysis, beginning in 2022, appear to be better capturing current productivity and population dynamics which has resulted in improvements in forecast accuracy.

It is important to note that while the below average PDO index suggests that offshore marine conditions may potentially contribute to higher productivity and marine survival, this may be offset by the negative impacts of above average SST on the early marine survival of juveniles. Moreover, the brood year EFS values for 2020 and 2021 are well below and close to average, respectively. This adds some uncertainty to the forecast as there is potential for higher productivity (in the absence of density-dependence in freshwater) but also for low productivity and associated low returns in 2025 due to depensation.

The 2025 Fraser Pink forecast of 26,965,000 (12,585,000 to 57,854,000) represents the highest potential return on record, largely driven by the high abundance of juvenile outmigration observed in 2024 (1.35 billion). Forecasting returns of Fraser River Pink salmon is always uncertain due to shifting enumeration methodologies through time. For the 2025 Pink forecast, the best preforming models in the retrospective analysis included the power and power SSS model. However, a precautionary approach was applied in selecting the Power model as the SSS model had the greatest uncertainty. Testing of additional model forms, incorporation of more environmental covariates, and a formalized retrospective analysis of models for forecasting the returns of Fraser River Pink salmon should be pursued in the future to improve the reliability of the forecast and to better capture the uncertainty around the forecast.

6. TABLES

Table 1A. The 2025 Fraser River Sockeye and Pink forecasts. Forecasts are presented from their 10% to 90% probability levels (probability that returns will be at or below the specified run size). At the median of the forecast distribution (50% probability level), there is a one in two chance the return will fall above or below the specified forecast value for each stock, based on the historical data. Results above 1,000 have been rounded to the nearest 1,000; between 100 and 1,000 to the nearest 100; and between 10 and 100 to the nearest 10.

Run timing group Stocks	**Forecast Model**	**Probability that Return will be at/or Below Specified Run Size**				
		10%	**25%**	**50%**	**75%**	**90%**
Early Stuart	*Ricker(Ei)*	42,000	72,000	116,000	202,000	319,000
Early Summer Total		54,000	103,000	220,000	449,000	820,000
Total excluding misc. stocks		49,000	95,000	187,000	368,000	684,000
Bowron	*R1C4Sibling5*	1,000	2,000	5,000	10,000	20,000
Upper Barriere (Fennell)	*LLY*	300	800	2,000	6,000	13,000
Gates	*R2C*	8,000	15,000	29,000	59,000	111,000
Nadina	*RickerCyc4Sibling5*	10,000	19,000	37,000	74,000	134,000
Pitt	*5*	14,000	25,000	46,000	84,000	142,000
Scotch	*Larkin4Sibling5*	10,000	22,000	47,000	97,000	192,000
Seymour	*Ricker(Pi)*	6,000	11,000	21,000	38,000	72,000
Misc (EShu)	*R/S*	1,000	2,000	10,000	18,000	22,000
Misc (Taseko)	*R/S*	300	400	1,000	3,000	3,000
Misc (Chilliwack)	*R/S*	2,000	4,000	15,000	41,000	76,000
Misc (Nahatlatch)	*R/S*	1,000	2,000	7,000	19,000	35,000
Summer Total		522,000	992,000	2,137,000	4,748,000	10,004,000
Total excluding misc. stocks		522,000	992,000	2,136,000	4,744,000	9,995,000
Chilko	*RickerCyc4Sibling5*	250,000	455,000	928,000	1,984,000	4,153,000
Late Stuart	*RS14Sibling5*	107,000	244,000	608,000	1,519,000	3,466,000
Quesnel	*Ricker(Ei)*	55,000	107,000	260,000	576,000	1,200,000
Stellako	*Larkin4Sibling5*	100,000	163,000	281,000	514,000	810,000
Harrison	*LLY3Sibling4*	7,000	17,000	46,000	124,000	307,000
Raft	*LLY4Sibling5*	3,000	6,000	13,000	27,000	59,000
Misc (N. Thomp. Tribs)	*R/S*	200	300	800	2,000	4,000
Misc (N. Thomp River)	*R/S*	100	100	400	1,000	2,000
Misc (Widgeon)	*R/S*	20	50	70	1,000	3,000
Late Total		118,000	237,000	474,000	993,000	1,997,000
Total excluding misc. stocks		117,000	236,000	473,000	967,000	1,945,000
Cultus	*PowerJuv(Pi)*	200	300	700	1,000	3,000
Late Shuswap	*Ricker(Pi)4Sibling5*	6,000	21,000	60,000	143,000	300,000
Portage	*Ricker(Ei)*	3,000	6,000	13,000	34,000	80,000
Weaver	*RickerCyc4Sibling5*	88,000	167,000	297,000	575,000	1,119,000
Birkenhead	*Ricker(Pi)Sibling5*	20,000	42,000	96,000	214,000	443,000
Misc Harrison/Lillooet	*R/S*	300	1,000	1,000	26,000	52,000
TOTAL SOCKEYE SALMON		736,000	1,404,000	2,947,000	6,392,000	13,140,000
Total Sockeye excluding misc. stocks		730,000	1,395,000	2,912,000	6,281,000	12,943,000
TOTAL PINK SALMON	*Power Fry*	12,585,000	17,738,000	26,965,000	39,168,000	57,854,000

Table 1B. Fraser Sockeye brood-year effective female spawners (EFS, except smolts for Cultus) for the four- and five-year-old recruits returning in 2025 (2021 and 2020 brood years). Brood year EFS are colour-coded by comparing to the **cycle-line average** from the historical time series (start years vary; "Mean EFS, Cyc. Years" column). Fraser Sockeye average run sizes are presented across all years and for the 2025 cycle-line for each stock. Median 2025 forecast returns for non-miscellaneous stocks are compared to cycle averages for colour-coding ("Mean Run Size, Cyc. Years" column). Red, yellow, and green shading represents below, near, and above average, respectively. With the near-average range defined as average +/- 0.5 standard deviation of historical time series. *For Harrison, 2022 EFS are presented in the 2020 EFS column.

Run Timing Group	2021 EFS	2020 EFS	Mean EFS		2025 FC Return	Mean Run Size	
Stocks			All Years	Cyc. Years		Stocks	Cyc. Years
Early Stuart	26,000	20	38,000	95,000	116,000	**Early Stuart**	267,000
Early Summer (excl.	46,000	24,000	63,000	40,000	187,000	**Early Summer**	675,000
Bowron	2,000	200	4,000	3,000	5,000	Bowron	244,000
Upper Barriere	500	600	3,000	1,000	2,000	Upper Barriere	21,000
Gates	16,000	3,000	4,000	5,000	29,000	Gates	10,000
Nadina	7,000	16,000	10,000	10,000	37,000	Nadina	42,000
Pitt	9,000	3,000	14,000	14,000	46,000	Pitt	57,000
Scotch	8,000	600	10,000	3,000	47,000	Scotch	70,000
Seymour	5,000	400	18,000	4,000	21,000	Seymour	20,000
Misc(EShu)	3,000	100	9,000	700	10,000	Misc(EShu)	24,000
Misc(Taseko)	700	30	1,000	400	1,000	Misc(Taseko)	NA
Misc(Chilliwack)	900	19,000	3,000	3,000	15,000	Misc(Chilliwack)	NA
Misc(Nahatlatch)	3,000	1,000	1,000	2,000	7,000	Misc(Nahatlatch)	NA
Summer (excl. misc.)	868,000	96,000	533,000	852,000	2,135,000	**Summer (excl.**	6,001,000
Chilko	540,000	27,000	229,000	178,000	928,000	Chilko	857,000
Late Stuart	191,000	2,000	67,000	209,000	608,000	Late Stuart	1,429,000
Quesnel	55,000	500	149,000	400,000	260,000	Quesnel	3,327,000
Stellako	62,000	22,000	54,000	33,000	281,000	Stellako	227,000
Harrison*	19,000	41,000	29,000	28,000	46,000	Harrison	138,000
Raft	2,000	3,000	4,000	4,000	13,000	Raft	24,000
Misc(N. Thomp. Tribs)	500	100	200	400	800	Misc(N. Thomp.	NA
Misc(N. Thomp. River)	200	100	2,000	6,000	400	Misc(N. Thomp.	NA
Misc (Widgeon)	60	90	300	300	70	Misc (Widgeon)	NA
Late (excl. misc.)	82,000	2,000	385,000	58,000	466,000	**Late (excl.**	622,000
Cultus	70	30	800	100	700	Cultus	11,000
Late Shuswap	20,000	10	323,000	9,000	60,000	Late Shuswap	51,000
Portage	2,000	10	3,000	3,000	13,000	Portage	41,000
Weaver	36,000	40	18,000	17,000	297,000	Weaver	274,000
Birkenhead	24,000	2000	40,000	28,000	96,000	Birkenhead	244,000
Misc(Non-Shuswap)	2,000	300	2,000	500	1,000	Misc(Non-	NA
Total Sockeye	1,022,000	121,000	1,018,000	1,045,000	2,904,000	**Total Sockeye**	7,542,000

Table 2. Geometric average four-year-old recruits-per-EFS for each of the forecast Fraser Sockeye stocks presented for the following: the entire time series of brood years: 1948-2018, peak generational (4-year) geometric average, the most recent three generations (2009-2020). Cultus is presented as four-year-old recruits-per-smolt. Forecast four-year-old recruits-per-EFS associated with the various probability levels of the 2025 forecast are presented for comparison. Red (< average), yellow (average) and green (>average), with the average range defined as average +/- 0.5 standard deviation of historical time series.

Run-timing Group, Stock	Geo. Average R_4/EFS	Peak Geo. Ave. R_4/EFS	Min. Geo. Ave. R_4/EFS	Recent Gen. R_4/EFS (2009-2020)	2025 Forecast R_4/EFS by Probability Level				
					10%	25%	50%	75%	90%
Early Stuart	5.9	24.5	1.4	4.1	1.62	2.79	4.48	7.81	12.32
Early Summer					NA	NA	NA	NA	NA
Bowron	5.7	20.4	0.4	3.3	0.59	1.18	2.51	5.37	10.64
Upper Barriere	5.1	53.5	0.5	2.3	0.52	1.23	3.21	8.37	19.83
Gates	8.0	41.0	1.1	9.4	0.41	0.76	1.54	3.1	5.82
Nadina	5.4	13.5	1.4	4.8	0.84	1.72	3.36	6.97	12.55
Pitt[a]	2.9	10.4	0.5	1.8	0.34	0.72	1.51	3.25	6.16
Scotch	5.6	21.5	1.2	5.3	1.32	2.89	6.17	12.63	25.36
Seymour	6.4	29.2	1.0	3.7	1.32	2.22	4.37	7.95	15.06
Misc (Early Shuswap) [b]	-	-	-	-	0.46	0.59	3.79	6.9	8.4
Misc (Taseko) [b]	-	-	-	-	0.47	0.58	2.22	4.4	5.1
Misc (Chilliwack) [b]	-	-	-	-	0.31	0.54	1.99	5.3	9.8
Misc (Nahatlatch) [b]	-	-	-	-	0.31	0.54	1.99	5.3	9.8
Summer					NA	NA	NA	NA	NA
Chilko	5.8	25.3	0.7	3.7	0.46	0.83	1.7	3.64	7.63
Late Stuart	7.8	57.2	2.1	3.2	0.55	1.26	3.15	7.9	18.06
Quesnel	7.2	31.4	0.6	2.1	0.96	1.89	4.73	10.46	21.91
Stellako	5.9	16.3	0.7	2.8	1.48	2.41	4.17	7.67	12.08
Harrison[c]	5.9	33.8	0.5	4.9	0.19	0.48	1.33	3.71	9.36
Raft	4.9	14.3	0.5	2.6	1.17	2.44	5.48	12.33	25.59
Misc (N. Thomp.Tribs) [b]	-	-		-	0.33	0.5	1.28	3.5	6.9
Misc (N. Thomp River) [b]	-	-		-	0.33	0.5	1.28	3.5	6.9
Misc (Widgeon) [b]	-	-		-	0.14	0.42	0.55	11.4	22.5
Late					NA	NA	NA	NA	NA
Cultus [d]	0.03	0.06	0.005	0.02	2.37	4.65	9.73	20.23	42.07
Late Shuswap	4.8	21.2	0.2	0.9	0.31	1.08	3.03	7.19	14.93
Portage	9.9	69.1	1.4	2.7	1.36	3	6.67	17.53	41.03
Weaver	9.5	41.8	0.8	6.1	2.42	4.59	8.14	15.77	30.68
Birkenhead	4.3	21.5	0.2	1.4	0.71	1.53	3.55	8.07	16.88
Misc Lillooet-Harrison [b]	-	-		-	0.01	0.04	0.06	1.2	2.3

a. Pitt displayed as Five-Year-Old survival, therefore recent generation is 2008-2019.
b. Naïve (non-biological) models do not have recruitment time series; so averages could not be compiled
c. Harrison is presented as total survival;.
d. Cultus survivals are presented as marine survival; recruits-per-juvenile.

Table 3. Four- and five-year-old and total 2025 Fraser Sockeye median (50% probability) forecasts for each stock. The four- and five-year-old proportions of the total median forecast are presented in the final two columns. Values below 1,000 were rounded to the nearest 100, and values below 100 were rounded to the nearest 10, rather than the nearest 1,000, in order to demonstrate age distributions. Harrison three-year-old returns are presented in the five-year-old column.

Sockeye stock/timing group	2025 Fraser Sockeye Forecasts				
	Four-year-old return 50%	Five-year-old Return 50%	Total Return 50%	Four-Year-Old Proportion	Five-Year-Old Proportion
Early Stuart	115,980	20	116,000	100%	0%
Early Summer					
Bowron	4,800	200	5,000	96%	4%
Upper Barriere (Fennell)	1,500	500	2,000	75%	25%
Gates	25,000	4,000	29,000	86%	14%
Nadina	23,000	14,000	37,000	62%	38%
Pitt	13,000	33,000	46,000	28%	72%
Scotch	46,600	400	47,000	99%	1%
Seymour	20,700	300	21,000	99%	1%
Misc (EShu)	9,960	40	10,000	100%	0%
Misc (Taseko)	990	10	1,000	99%	1%
Misc (Chilliwack)	2,000	13,000	15,000	13%	87%
Misc (Nahatlatch)	6,000	1,000	7,000	86%	14%
Summer					
Chilko	916,000	12,000	928,000	99%	1%
Late Stuart	602,000	6,000	608,000	99%	1%
Quesnel	259,300	700	260,000	100%	0%
Stellako	259,000	22,000	281,000	92%	8%
Harrison	21,000	25,000	46,000	46%	54%
Raft	9,000	4,000	13,000	69%	31%
Misc (N. Thomp. Tribs)	740	60	800	93%	8%
Misc (N. Thomp River)	350	50	400	88%	13%
Misc (Widgeon)	40	30	70	57%	43%
Late					
Cultus	680	20	700	97%	3%
Late Shuswap	59,700	300	60,000	100%	1%
Portage	12,910	90	13,000	99%	1%
Weaver	296,900	100	297,000	100%	0%
Birkenhead	84,000	12,000	96,000	88%	13%
Misc(Non-Shuswap)	900	100	1,000	90%	10%
Total	2,792,000	149,000	2,941,000	95%	5%

Table 4. List of candidate model acronyms, organized by their two broad categories (non-parametric/naïve and biological) with descriptions. Models are described in detail in Appendices 1 to 3 of Grant et al. (2010). Where applicable, models use effective female spawner data (EFS) as a predictor variable unless otherwise indicated by '(juv)' or '(smolt)' next to the model (Tables 1A), where fry or smolt data are used instead.

MODEL CATEGORY	DESCRIPTION
A. Non-Parametric (Naïve) Models	
LLY	Return from the previous year
R1C	Return from 4 years before to forecast year
R2C	Average return from 4 and 8 years before the forecast year
RAC	Average return on the forecast cycle line for all years
TSA	Average return across all years
RS1 (or RJ1)	Product of average survival from 4 years before the forecast year and the forecast brood year EFS (or juv/smolt)
RS2 (or RJ2)	Product of average survival from 4 and 8 years before the forecast year and the forecast brood year EFS (or juv/smolt)
RS4yr (or RJ4yr)	Product of average survival from the last 4 consecutive years and the forecast brood year EFS (or juv/smolt)
RS8yr (or RJ8yr)	Product of average survival from the last consecutive 8 years and the forecast brood year EFS (or juv/smolt)
MRS (or MRJ)	Product of average survival for all years and the forecast brood year EFS (or juv/smolt)
RSC (or RJC)	Product of average cycle-line survival (entire time series) and the forecast brood year EFS (or juv/smolt)
R/S (used for miscellaneous stocks)	Product of average survival on time series for specified stocks and the forecast brood year EFS
B. Biological Models	
Power	Bayesian power model, see Appendix 2 of Grant et al. 2010
Power-cyc	Same as above, using cycle line data only
Ricker	Bayesian Ricker model, see Appendix 2 of Grant et al. 2010
Ricker-cyc	Same as above, using cycle line data only
Larkin	Bayesian Larkin model, see Appendix 2 of Grant et al. 2010
Sibling	Bayesian sibling model, see 2.2.1 of Hawkshaw et al. 2020a
C. Biological Models Covariates	(e.g. Power (FrD-mean))
FrD-mean, AprFrD, MayFrD, JunFrD	Mean Fraser discharge (April - June), Mean April flow, May flow, June flow
FrD-peak	Peak Fraser Discharge
Ei, AprEi, MayEi, JunEi, JulEi	Mean Entrance Island spring-summer sea-surface temperature (SST) (April-July), Mean April SST, May SST, June SST, July SST
Pi, MayPi, JunPi, JulPi	Mean Pine Island spring-summer SST (May-July), Mean May SST, June SST, July SST
PDO	Pacific Decadal Oscillation

Table 5.Total Fraser Sockeye forecasts for 1998 to 2024 from the 10% to 90% p-levels, where available. The forecast value (or values) that corresponded most closely to the actual return is highlighted. For returns that fell above the 50% p-level, the cells are highlighted green. For returns that fell at the 50% p-level, cells are highlighted yellow. Returns falling below the 50% p-level are highlighted orange, and below the 25% p-level are highlighted red. *Returns for 2024 are preliminary based on in-season estimates only at the time of this publication.

Return Year	Forecast Probability Level						Actual Returns
	<10%	10%	25%	50%	75%	90%	
1998	NA	4,391,000	6,040,000	6,822,000	11,218,000	18,801,000	**10,870,000**
1999	NA	3,067,000	4,267,000	4,843,000	8,248,000	14,587,000	**3,640,000**
2000	NA	1,487,000	2,449,000	4,304,000	7,752,000	NA	**5,200,000**
2001	NA	3,869,000	6,797,000	12,864,000	24,660,000	NA	**7,190,000**
2002	NA	4,859,000	7,694,400	12,915,900	22,308,500	NA	**15,130,000**
2003	NA	1,908,000	2,742,000	3,141,000	5,502,000	9,744,000	**4,890,000**
2004	NA	1,858,000	2,615,000	2,980,000	5,139,000	9,107,000	**4,180,000**
2005	NA	5,149,000	8,734,000	16,160,000	30,085,000	53,191,000	**7,020,000**
2006	NA	5,683,000	9,530,000	17,357,000	31,902,000	56,546,000	**12,980,000**
2007	NA	2,242,500	3,602,000	6,247,000	11,257,000	19,706,000	**1,510,000**
2008	NA	1,258,000	1,854,000	2,899,000	4,480,000	7,057,000	**1,740,000**
2009	NA	3,556,000	6,039,000	10,578,000	19,451,000	37,617,000	**1,590,000**
2010	NA	5,360,000	8,351,000	13,989,000	23,541,000	40,924,000	**28,250,000**
2011	NA	1,700,000	2,693,000	4,627,000	9,074,000	15,086,000	**5,110,000**
2012	NA	743,000	1,203,000	2,119,000	3,763,000	6,634,000	**2,050,000**
2013	NA	1,554,000	2,655,000	4,765,000	8,595,000	15,608,000	**4,130,000**
2014	NA	7,237,000	12,788,000	22,854,000	41,121,000	72,014,000	**20,000,000**
2015	NA	2,364,000	3,824,000	6,778,000	12,635,000	23,580,000	**2,120,000**
2016	NA	814,000	1,296,000	2,271,000	4,227,000	8,181,000	**853,000**
2017	NA	1,315,000[R]	2,338,000	4,432,000	8,873,000	17,633,000	**1,641,000**
2018	NA	5,265,000	8,423,000	13,981,000	22,937,000	36,893,000	**10,675,000**
2019	NA	1,832,000	2,979,000	5,056,000	9,133,000	15,313,000	**564,000**
2020	NA	275,000	486,000	924,000	1,834,000	3,573,000	**288,000**
2021	NA	313,000	624,000	1,330,000	2,775,000	5,496,000	**2,549,000**
2022	NA	2,374,000	4,662,000	9,775,000	20,395,000	41,707,000	**6,886,000**
2023	NA	453,000	800,000	1,564,000	3,185,000	5,952,000	**1,653,000**
2024	NA	167,000	299,000	567,000	1,121,000	2,173,000	**474,000***

Table 6. Stock composition of 2019-2021 Brood Years and 2025 median forecast (excluding misc. stocks). The five largest stocks in each column are highlighted in bold font, and the largest stock marked in red.

Stock	2019 EFS	2020 EFS	2021 EFS	2025 Median Forecast Return
Early Stuart	0%	0%	2%	%
Early Summer				
Bowron	0%	0%	0%	0%
Upper Barriere (Fennell)	0%	1%	0%	0%
Gates	**3%**	**3%**	2%	1%
Nadina	**6%**	**12%**	1%	1%
Pitt	1%	**3%**	1%	2%
Scotch	1%	0%	1%	2%
Seymour	1%	0%	0%	1%
Summer				
Chilko	**52%**	**21%**	**51%**	**31%**
Late Stuart	2%	2%	**19%**	**21%**
Quesnel	**10%**	0%	**5%**	**9%**
Stellako	**19%**	**17%**	**6%**	**10%**
Harrison	1%	**39%**	**4%**	2%
Raft	0%	2%	0%	0%
Late				
Cultus	NA	NA	NA	NA
Late Shuswap	2%	0%	2%	2%
Portage	0%	0%	0%	0%
Weaver	1%	0%	3%	**10%**
Birkenhead	1%	1%	2%	3%
Total Number	144,000	132,000	1,059,000	2,947,000

Table 7. Overview of model selections for return-years 2021, 2024 and 2025 forecast. Models that changed from 2024 to 2025 are bolded. See Appendix 3 for stock-specific model choice rationales.

Year/Model	2021	2024	2025
Early Stuart	*Ricker(Pi)*	*Ricker(Ei)*	*Ricker(Ei)*
Early Summer			
Bowron	*Ricker(Pi)*	*RickerCyc*	***R1C4/Sibling5***
Upper Barriere	*Ricker(Pi)4/Sibling5*	*PowerBasic4/Sibling5*	***LLY***
Gates	*RS8yr*	*Ricker(Pi)*	***R2C***
Nadina	*PowerJuvFrD-peak4 /Sibling5*	*RickerFRDpeak4/Sibling5*	***RickerCyc4/****Sibling5*
Pitt	*Ricker(Ei)4 /Sibling5*	*LarkinBasicCyc*	***Larkin4/Sibling4***
Scotch	*Ricker(Pi)4 /Sibling5*	*Larkin*	***Larkin4/Sibling5***
Seymour	*Ricker(Ei)*	*Ricker(Pi)*	*Ricker(Pi)*
Misc (EShu)	*R/S*	*R/S*	*R/S*
Misc (Taseko)	*R/S*	*R/S*	*R/S*
Misc (Chilliwack)	*Power4/Sibling5*	*Ricker4/Sibling5*	***R/S***
Misc (Nahatlatch)	*R/S*	*R/S*	*R/S*
Summer			
Chilko	*RS8yr*	*RickerCyc4/Sibling5*	*RickerCyc4/Sibling5*
Late Stuart	*Power (Pi)*	*R1C*	***RS14/Sibling5***
Quesnel	*Ricker(Ei)*	*R2C*	***Ricker(Ei)***
Stellako	*Larkin4/Sibling5*	*R2C4/Sibling5*	***Larkin4/****Sibling5*
Harrison	*Ricker(Ei)Odd3/Sibling4*	*TSA3/Sibling4*	***LLY3/****Sibling4*
Raft	*Ricker(Pi)4/Sibling5*	*PowerBasicCyc*	***LLY4/Sibling5***
Misc (N. Thomp. Tribs)	*R/S*	*R/S*	*R/S*
Misc (N. Thomp River)	*R/S*	*R/S*	*R/S*
Misc (Widgeon)	*R/S*	*R/S*	*R/S*
Late			
Cultus	*PowerJuv (Pi)4/Sibling5*	*PowerJuvPi*	*PowerJuv(Pi)*
Late Shuswap	*Ricker(Ei)*	*Ricker(Pi)4/Sibling5*	*Ricker(Pi)4/Sibling5*
Portage	*RS8yr*	*Ricker(Pi)*	***Ricker(Ei)***
Weaver	*RS8yr*	*RickerCyc*	***RickerCyc4/Sibling5***
Birkenhead	*RS8yr*	*Ricker(Ei)*	***Ricker(Pi)/Sibling5***
Misc(Non-Shuswap)	*R/S*	*R/S*	*R/S*

7. FIGURES

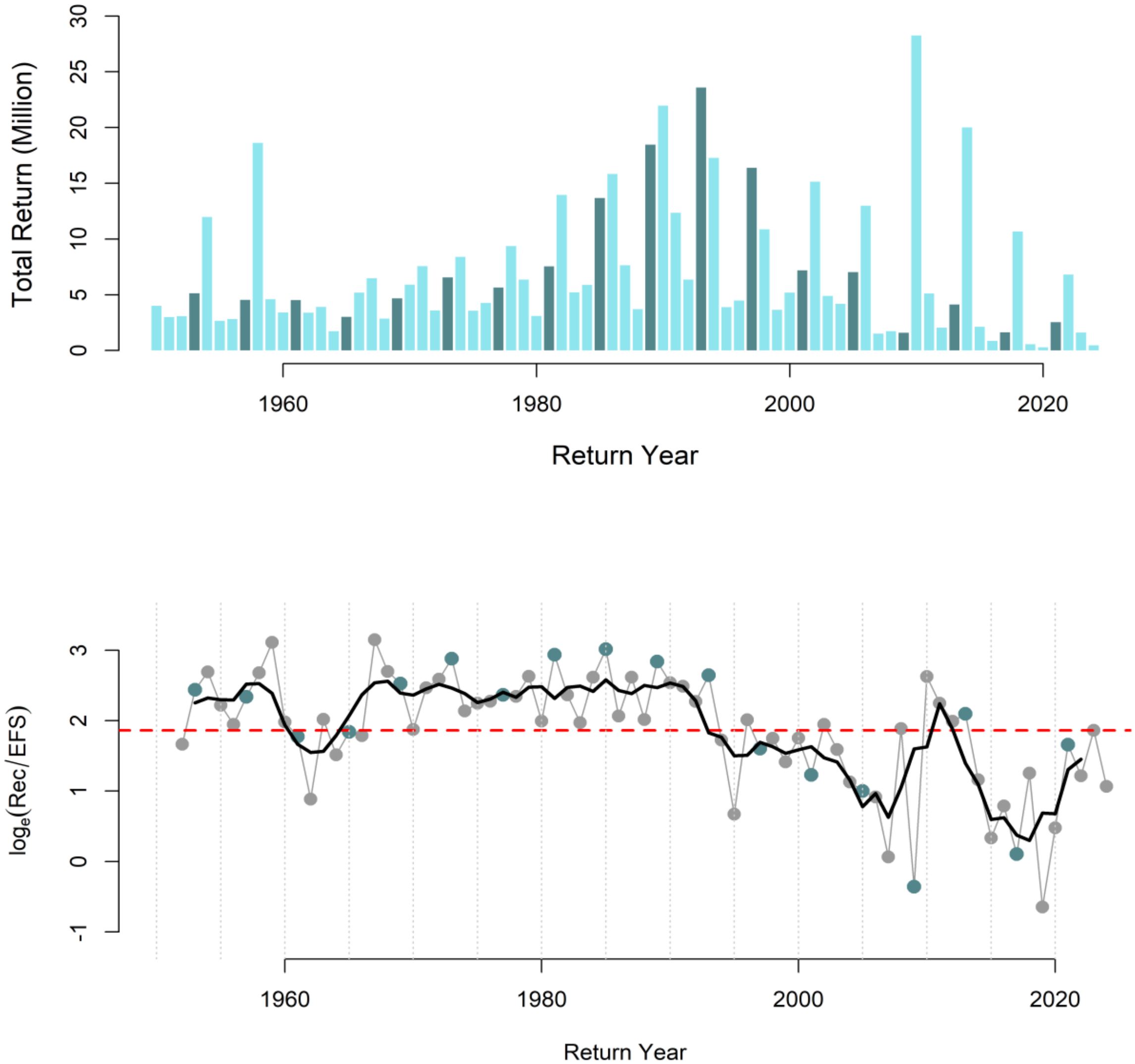
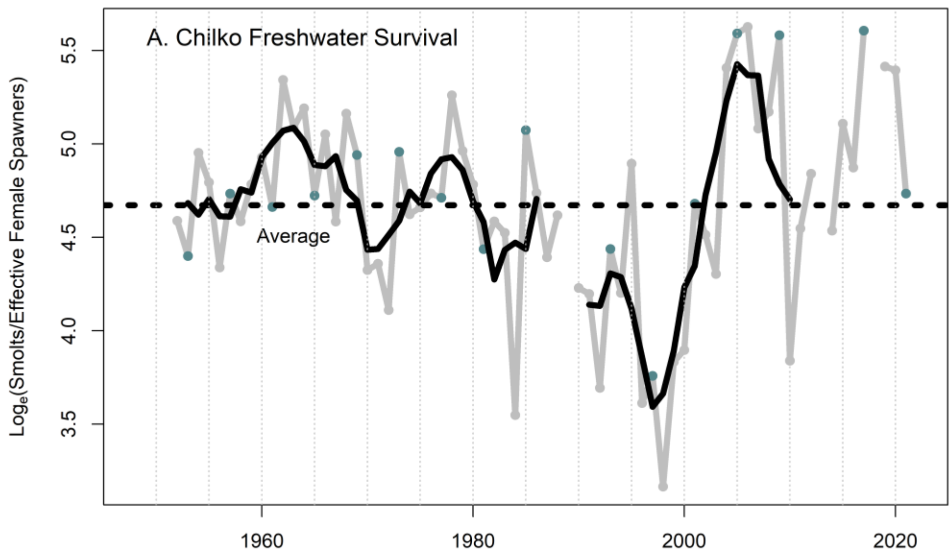


Figure 1. Total returns and overall productivity of Fraser Sockeye: Top panel shows total adult annual returns (note that adult returns in 2024 are preliminary); Bottom panel shows overall Fraser Sockeye productivity (loge(recruits / effective female spawners) up to the 2024 return year for the 19 major stocks with long time series of spawner and recruit estimates. Points represent annual productivity and the black line represents the smoothed four year running average. The dashed horizontal red line is the time-series average. In both panels, dark blue represents the 2025 cycle line.



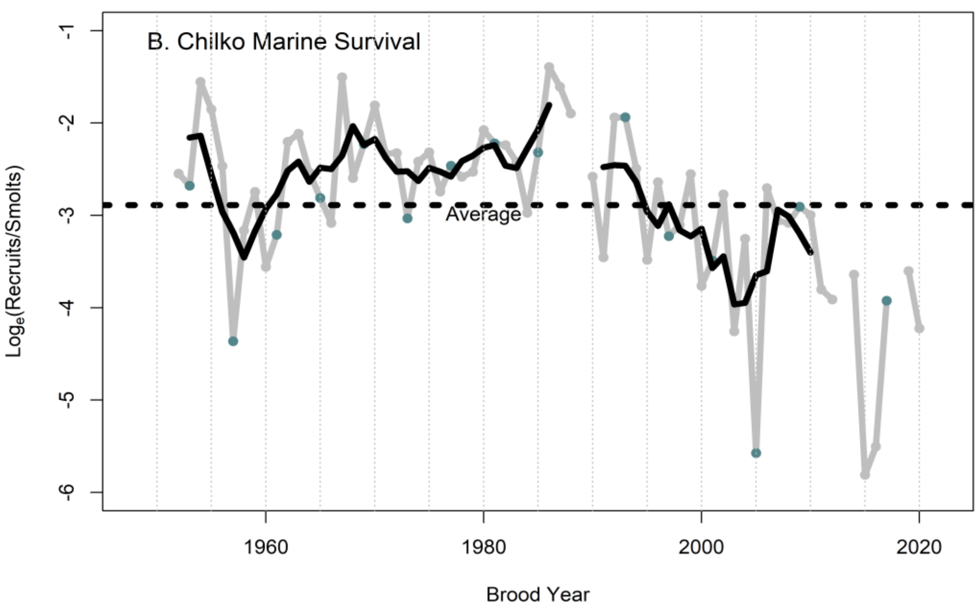


Figure 2. A. Annual freshwater survival (log smolts/effective female spawners; filled grey dots and lines); dark blue circle represents the 2025 cycle line. The black line represents the smoothed four-year running average survival and the black dashed lines indicate average survival. Note that no smolt assessment was conducted in the 2013 and 2018 brood year representing a gap. B. Annual 'marine' (log recruits/smolt) survival (filled grey circles and lines). Marine survival' includes the period of time smolts spend migrating from the outlet of Chilko Lake (where they are enumerated) to when they return as adults and includes their downstream migration in the Fraser River as smolts.

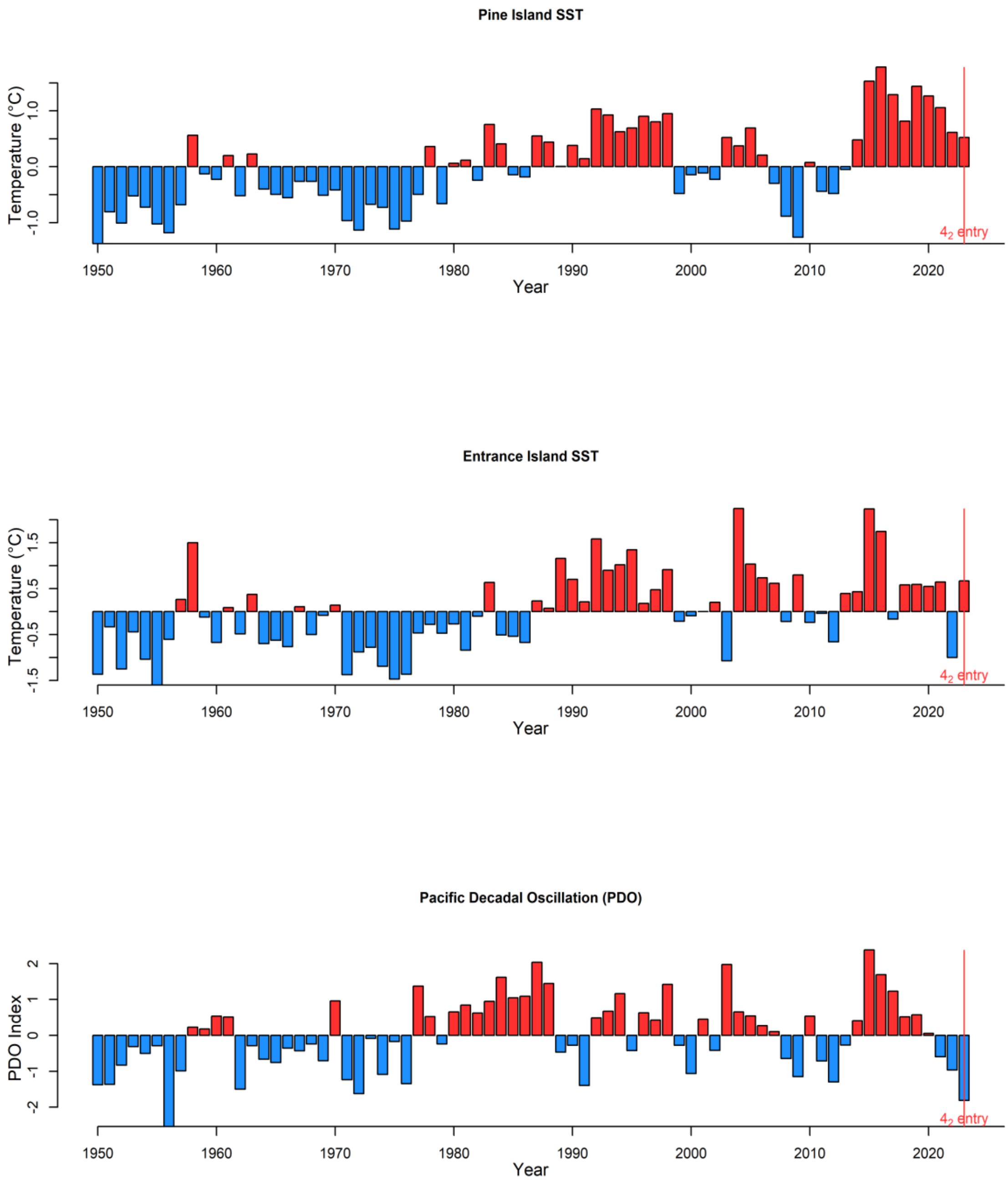
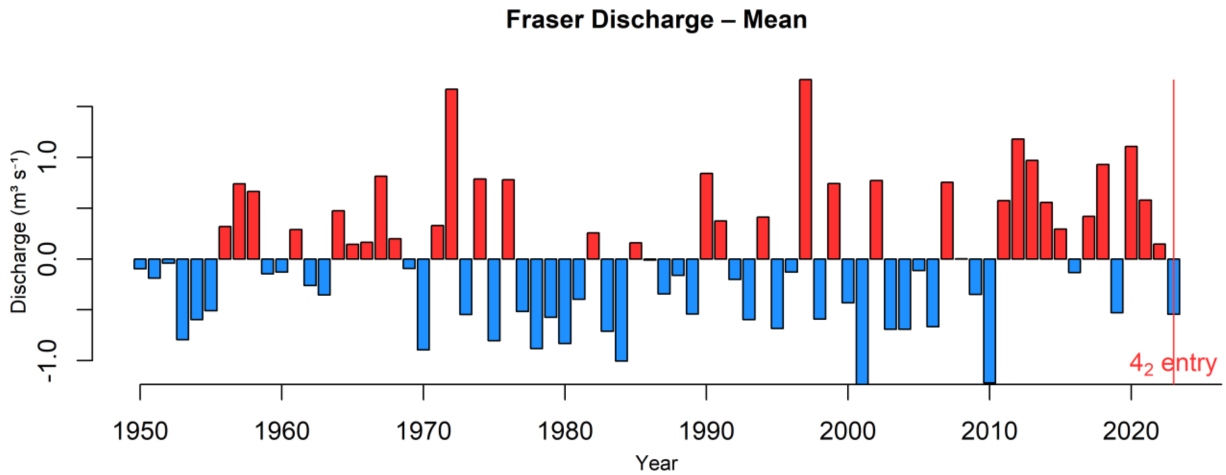


Figure 3. Sea surface temperatures (SST) measured at Entrance Island (Strait of Georgia) (April-June average), Pine Island (Queen Charlotte Strait) (April-July average), and standardized winter PDO index (Nov-March). Temperatures are presented as raw deviations from time-series averages (1950-2023). The 2023 ocean entry year, highlighted with a red vertical line, marks the temperature anomalies that most Fraser Sockeye from the 2021 brood year experienced as smolts (i.e. a 4_2 life cycle). Red bars (positive values) indicate warm temperature anomalies (above average) and blue bars (negative values) indicate cool temperature anomalies (below average).



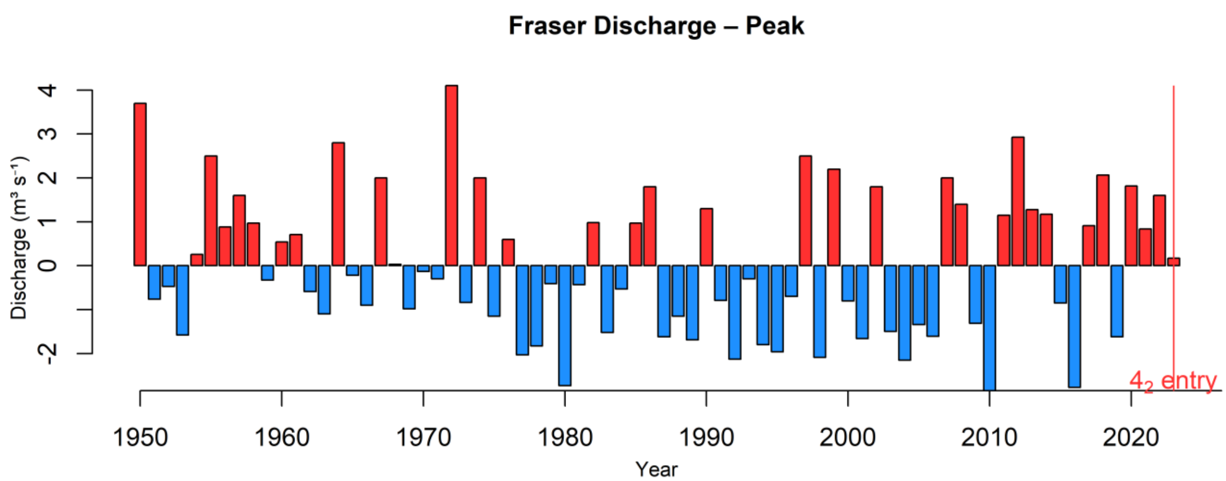
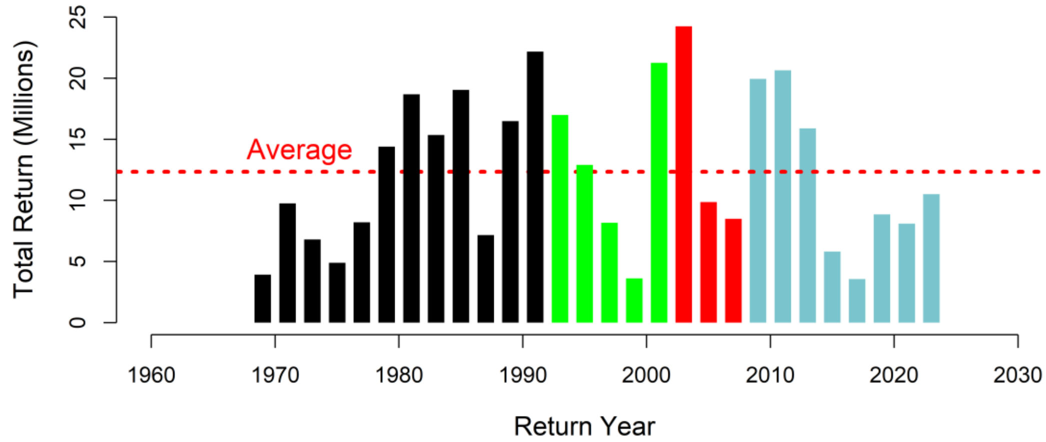


Figure 4. Fraser River discharge shown as mean conditions over April-June and peak discharge. Values are presented as raw deviations from time-series averages (1950-2023). The 2023 ocean entry year, highlighted with a red vertical line, marks the temperature anomalies that most Fraser Sockeye from the 2021 brood year experienced as smolts (i.e. a 4_2 life cycle). Red bars (positive values) indicate increased discharge anomalies (above average) and blue bars (negative values) indicate decreased discharge anomalies (below average).



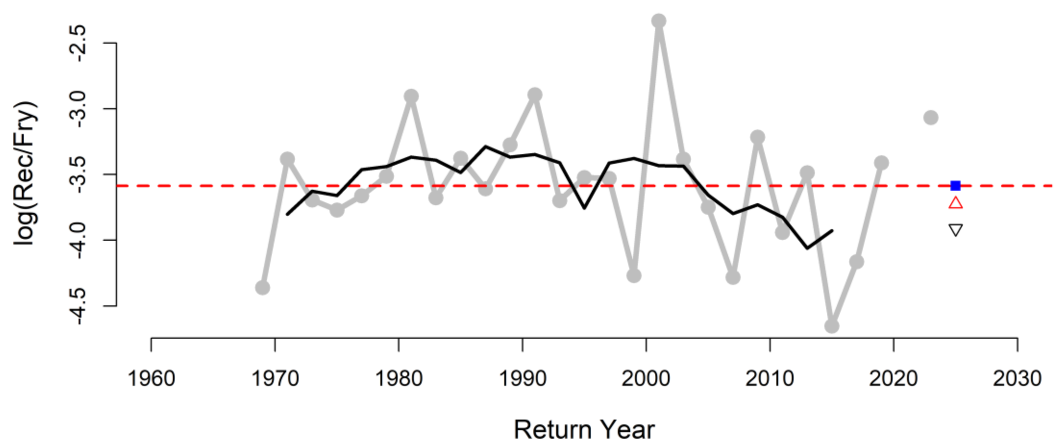


Figure 5. Upper Panel: Fraser River Pink Salmon returns (black or colored bars) estimates. Escapement estimates were generated from system-specific programs from 1957 to 1991 (black bars), system-wide single mark recaptures from 1993 to 2001 (green bars), indirect system-wide marine test fisheries estimates from 2003 to 2007 (red bars), and system-wide hydroacoustic estimate from 2009 to 2021 (blue bars). Given the lack of calibration work between methods, escapement estimates between years are not entirely comparable. The red dashed line is the average pink return (12.3 M); Bottom Panel: Fraser Pink marine survival (recruits-per-fry) from the 1967 to 2019 brood years; these estimates are uncertain and not entirely comparable inter-annually due to differences in return (catch and escapement) estimation methods over time. The red dashed line is the average survival (3.6%). The blue square, red triangle, and black triangle are the 2025 marine survival estimate using the MJR, Power(Fry)SSS and Power(Fry) models, respectively.

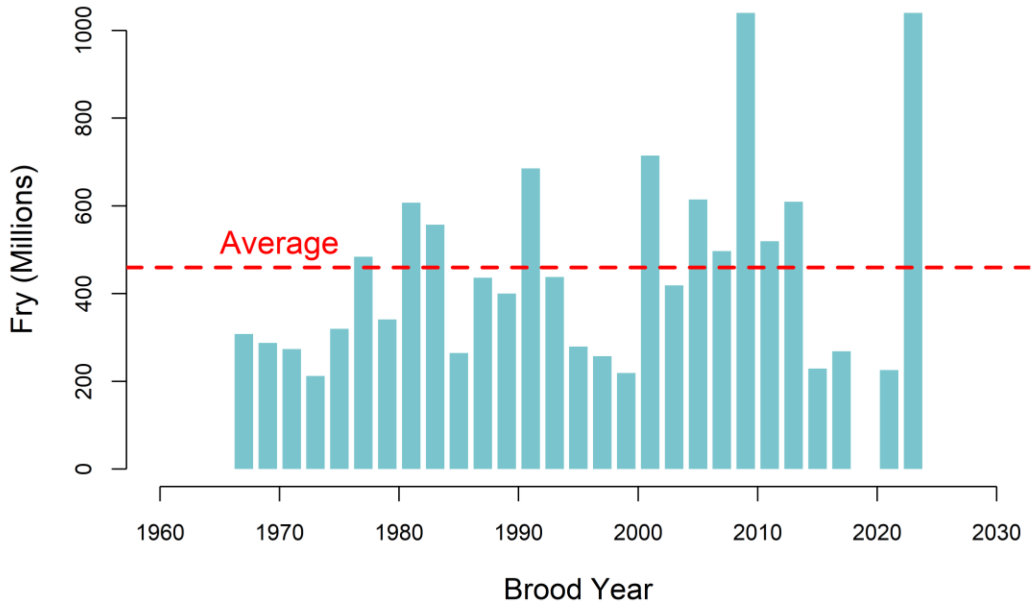


Figure 6. Fraser River Pink Salmon fry abundance. The average fry abundance over the time series is 460 million (dashed red line).

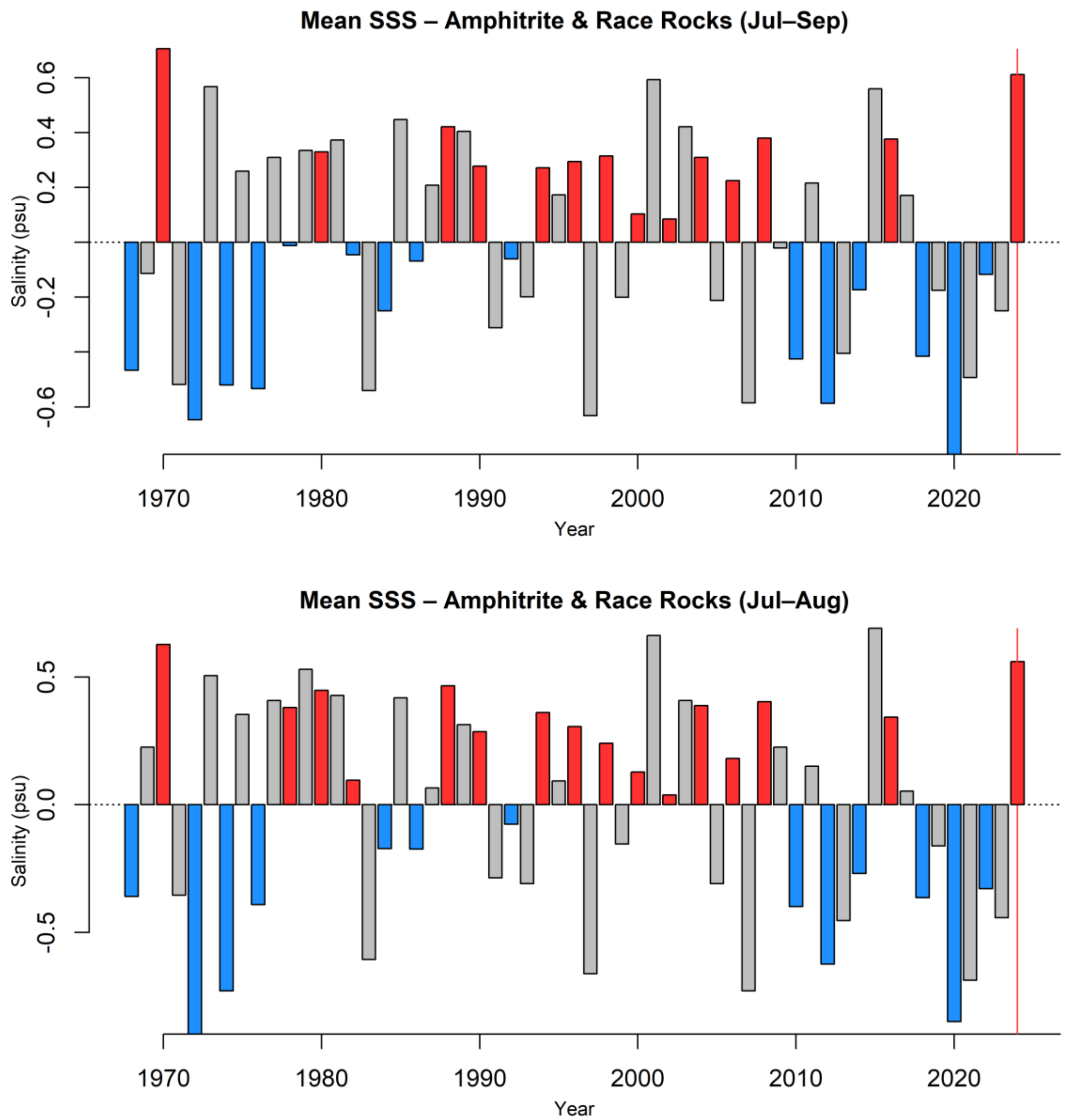


Figure 7. Averaged monthly (July-September (top panel), July-August (bottom panel) sea surface salinity (SSS) at Race Rock and Amphitrite Point. Values are presented as raw deviations from time-series averages (1968-2024). The 2024 ocean entry year, highlighted with a red vertical line, marks the SSS anomalies that most Fraser Pink from the 2023 brood year entered into upon outmigration as smolts. Red bars (positive values) indicate increased SS anomalies (above average) and blue bars (negative values) indicate decreased SSS anomalies (below average).Grey bars indicate SSS values that do not coincide with Fraser River Pink salmon returns.

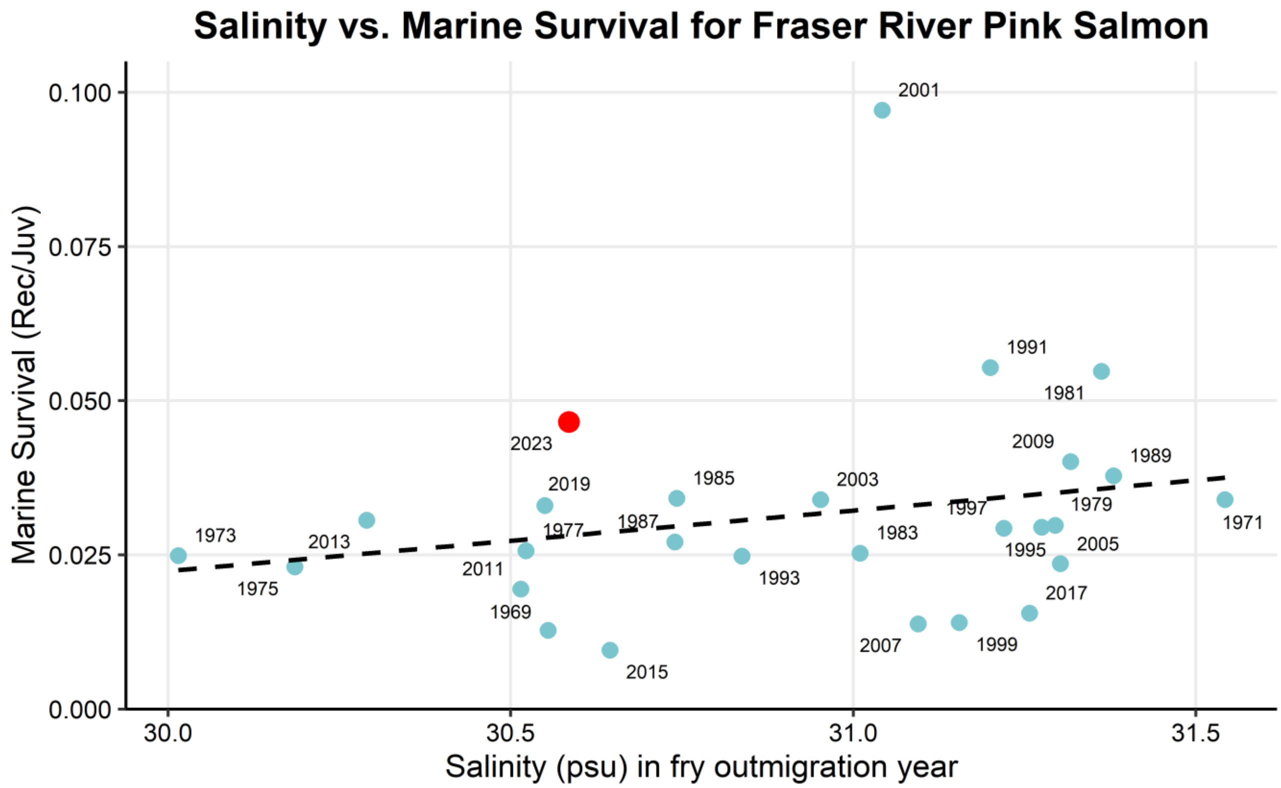


Figure 8. Marine survival of Pink salmon (recruits/juveniles) versus Averaged monthly (July-August) sea surface salinity (SSS) at Race Rock and Amphitrite Point during the Pink juvenile ocean entry year (brood year + 1). Each point represents the adult return year, with the 2023 return year highlighted in red. The dashed line indicates the relationship between salinity and marine survival.

2023 OCEAN CONDITION INDICATORS TREND

good fair poor

	ECOSYSTEM INDICATORS	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
CLIMATE & ATMOSPHERIC	PDO (Sum Dec-March)	23	9	5	17	10	25	16	21	18	13	7	2	20	6	4	11	14	26	24	22	15	19	12	8	3	1
	PDO (Sum May-Sept)	14	5	11	8	13	23	18	21	17	19	7	16	9	4	3	10	24	26	25	20	15	22	12	6	2	1
	ONI (Average Jan-June)	25	1	1	9	17	19	18	21	10	15	3	13	22	6	8	10	12	23	26	16	7	24	20	5	4	14
LOCAL PHYSICAL	SST NDBC buoys (°C; May-Sept)	21	7	9	5	6	13	26	14	2	17	1	12	3	8	10	19	24	23	22	15	18	25	11	4	20	16
	Upper 20 m T (°C; Nov-Mar)	25	14	11	13	8	19	20	16	17	7	1	12	22	6	4	9	3	26	24	23	18	21	2	10	15	5
	Upper 20 m T (°C; May-Sept)	18	12	14	5	1	3	26	21	10	11	2	7	19	9	8	20	24	15	16	13	17	25	23	4	22	6
	Deep Temp (°C; May-Sept)	25	7	10	5	1	12	15	17	13	6	2	9	8	11	4	16	24	21	14	19	20	18	26	3	23	22
	Deep Salinity (May-Sept)	25	4	12	5	7	21	22	13	8	2	3	18	17	15	16	14	26	20	10	9	6	11	24	1	23	19
LOCAL BIOLOGICAL	Copepod richness (May-Sept anom)	24	3	1	11	10	19	18	23	20	14	12	13	22	6	9	4	15	25	26	21	17	16	7	5	2	8
	N copepod biomass (May-Sept anom)	24	19	14	15	6	21	18	25	20	16	9	13	11	3	5	7	8	22	26	23	10	4	2	1	17	12
	S copepod biomass (May-Sept anom)	26	2	7	4	3	18	20	25	17	14	1	9	21	13	10	8	15	23	24	22	16	19	12	5	6	11
	Biological transition	24	13	9	8	11	19	15	23	18	5	1	2	21	3	12	6	6	24	24	22	17	19	14	10	4	16
	Nearshore Ichthyoplankton (Jan-Mar)	21	4	14	8	1	25	26	20	11	22	3	17	2	10	5	13	23	18	19	16	12	24	9	6	15	7
	Near & offshore Ichthyoplankton (community index Jan-Mar)	11	6	4	8	10	13	20	24	1	16	3	12	18	5	2	7	9	22	25	26	21	23	19	15	14	17
	Chinook salmon juvenile catch	23	2	7	20	6	10	18	25	14	12	1	8	5	16	3	4	9	17	22	26	21	15	24	13	11	19
	Coho salmon juvenile catch	24	13	21	5	7	6	23	25	19	2	4	10	11	20	15	1	12	18	17	26	3	16	22	14	9	8
MEANS & RANKS	Mean of ranks	22.1	7.6	9.4	9.1	7.3	16.6	19.9	20.9	13.4	11.9	3.8	10.8	14.4	8.8	7.4	9.9	15.5	21.8	21.5	19.9	14.6	18.8	14.9	6.9	11.9	11.4
	Rank of the mean rank	26	5	8	7	3	19	21	23	14	13	1	10	15	6	4	9	18	25	24	21	16	20	17	2	12	11
NOT INCLUDED IN THE MEAN OF RANKS OR STATISTICAL ANALYSES	Physical Spring Trans (UI based)	4	8	24	21	5	15	18	25	15	1	7	3	10	13	22	11	23	12	6	20	13	15	9	2	26	19
	Physical Spring Trans. Hydrographic	25	4	14	9	6	13	17	26	7	10	1	10	21	4	12	2	19	8	20	24	17	16	22	2	22	15
	Upwelling Anomaly (sum April-May)	12	4	21	8	11	18	16	25	12	6	9	10	19	21	19	14	23	1	3	24	7	5	16	2	26	15
	Length of Upwelling Season (UI based)	6	2	22	14	1	16	12	26	5	3	9	3	18	21	18	17	24	13	8	15	7	10	20	10	24	23
	Copepod Community Index (May-Sept)	25	5	7	10	4	20	18	24	21	13	1	9	17	12	8	6	15	23	26	22	16	19	14	3	2	11

Figure 9. Stoplight chart of ocean indicators favourable for the production of juvenile salmon in the California Current in 2023. Source: NOAA 2023 (https://www.fisheries.noaa.gov/west-coast/science-data/ocean-conditions-indicators-trends

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Appendix A. Stock group data summaries

Early stuart (Takla-Trembleur-Early Stuart CU)

Run Timing Group	Escapement				2019 Stock Contributions
Early Stuart	Avg.	Cyc. Avg	BY(2021)	BY Trend[a]	Early Stuart
All stocks[b]	37,7800	91,200	25,900	UP	100%

a. Trend refers to change from previous brood year (2015)

b. Escapement and cycle year average 1952-2019

Early summer

Run Timing Group	Escapement				2019 Stock Contributions										
Early Summer	Avg.	Cyc. Avg.	BY(2021)	BY Trend[a]	Bowron	Seymour	Fennell	Scotch	Gates	Nadina	Pitt	South Thom	Taseko	Chilli-wack	Naha-tlatch
Primary stocks[b]	61,700	36,000	46,500	UP	4%	10%	1%	16%	35%	15%	19%	NA	NA	NA	NA
Total (including misc.)[c]	135,600	59,200	53,700	UP	3%	9%	1%	15%	32%	13%	17%	2%	0%	5%	3%

a. Trend refers to change from previous brood year (2017)

b. Escapement and cycle year average 1952-2021

c. Escapement and cycle year average 2003-2021

Summer

Run Timing Group	Escapement				2019 Stock Contributions								
Summer	Avg.	Cyc. Avg.	BY (2019)	BY Trend[a]	Late Stuart	Stellako	Raft	Quesnel	Chilko	Harrison	North Thom. Trib	North Thom. Riv	Widgeon
Primary stocks[b]	560,200	892,300	889,600	UP	21%	7%	0%	6%	61%	5%	NA	NA	NA
Total (including misc.)[c]	645,500	790,600	890,400	UP	21%	7%	0%	6%	60%	5%	0%	0%	0%

a. Trend refers to change from previous brood year (2017)
b. Escapement and cycle year average 1952-2021
c. Escapement and cycle year average 2003-2021

Late

Run Timing Group	Escapement				2019 Stock Contributions					
Late	Avg.	Cyc. Avg.	BY (2019)	BY Trend[a]	Late Shuswap	Birkenhead	Portage	Weaver	NonShu Harrison	Cultus[d]
Primary stocks[b]	396,400	56,200	81,600	UP	24%	29%	2%	45%	NA	--
Total (including misc.)[c]	405,800	85,400	83,700	UP	23%	28%	2%	43%	5%	--

a. Trend refers to change from previous brood year (2017)
b. Escapement and cycle year average 1952-2021
c. Escapement and cycle year average 2003-2021
d. Cultus Is not included because only juvenile data are used for this stock

Miscellaneous Stocks – All Management Units

Forecast Unit	Populations*
Early Summer	
EShu	Adams Channel, Adams River (upper and lower), Anstey River, Blueberry Creek, Burton Creek, Cayenne Creek, Celista Creek, Craigellachie Creek, Crazy Creek, Eagle River, Four Mile Creek, Hiuhill Creek, Hunakwa Creek, Loftus Creek, Momoch River(upper and lower), Nikwikwaia Creek, Onyx Creek, Perry River, Ross Creek, Salmon River, Sinmax Creek, Yard Creek
Taseko	Taseko Lake, Taseko River(upper), Yoheta (upper and lower), Lastman Creek
Chilliwack	Chilliwack Lake, Chilliwack River, Chilliwack River(upper)
Nahatlatch	Nahatlatch River, Nahatlatch Lake
Summer	
North Thompson Tributaries	Barriere River, Clearwater River, Dunn Creek, Finn Creek, Grouse Creek, Hemp Creek, Lemieux Creek, Lion Creek, Mann Creek
North Thompson River	North Thompson River
Widgeon	Widgeon Creek, Widgeon Slough
Late	
Non-Shuswap	Big Silver Creek, Cogburn Creek, Crazy Creek, Douglas Creek, Green River, Joffre Creek, Miller Creek, North Creek, Pemberton Creek, Railroad Creek, Sampson Creek, Sloquet Creek, Tipella Creek, Ure Creek

Forecast total return of miscellaneous stocks and the proxy used for long term productivity

	Effective Females		Proxy for long-term Prod.	Forecast total Return				
	2020	2021		10%	25%	50%	75%	90%
Early Summer								
Misc(EShu)	97	2,596	Scotch/Seymour	1,207	1,547	9,871	17,921	21,848
Misc(Taseko)	30	664	Chilko	313	386	1,482	2,902	3,429
Misc(Chilliwack)	19,310	883	All ES Stocks	2,391	4,176	15,409	41,074	76,345
Misc(Nahatlatch)	1,386	3,053	All ES Stocks	1,093	1,910	7,046	18,780	34,907
Summer								
Misc(N. Thomp. Tribs)	137	542	Raft/Fennell	195	297	755	2,071	4,082
Misc (N. Thomp. River)	119	249	Raft/Fennell	96	146	373	1,022	2,014
Misc (Widgeon)	94	62	Birkenhead	17	51	67	1,395	2,746
Late								
Misc (Non-Shuswap)	331	2,093	Birkenhead	313	964	1,264	26,349	51,848

Appendix B. Model Selection Criteria and Rationale

The Fraser River Sockeye forecast model selection process is an expert-driven process, which took place over a two day meeting in December 2023. Previously, forecast model selection was based on methods and results (model ranking from retrospective analysis) summarized in MacDonald and Grant (2012) in conjunction with the recent productivity trend. Recognition of relatively inaccurate forecast results from recent years (2015-2020) led to the update and revision of the retrospective analysis used for the model selection process and the addition of a new tool: Taylor Diagrams. Additionally, a set of new environmental covariates were incorporated into the existing biological models for assessment. Generally the model selection process follows the steps outlined below but deviations at the stock level can occur.

1. Taylor diagram	2. Ranking table	3. Historical performance	4. Forecast and implied productivity
•Age4 model •Age5 model •Total model	•Overall ranking •Age4 ranking •Age5 ranking •Age4-cyclic •Age5-cyclic •Age4-other •Age5-other •Old ranking	•Used model •Overall performance •Age-specific performance	•Forecast Numbers •Implied productivity and trend •Brood year effective female spawners •Mean Run size

1. **Step 1: Taylor diagram**: For each stock, models are compared graphically on the Taylor diagram as it comparatively demonstrates the differences between model and observation and among models in regard to three statistics: the Pearson correlation coefficient, the root-mean-square error (RMSE), and the standard deviation (SD). All the candidate models for the forecast are presented on a Taylor diagram among age 4, age 5 and total population (age 4 and 5 combined). Generally, a model is desired and considered for further selection process when it shows a relatively high correlation coefficient, low RMSE, and a SD similar to the observation.

2. **Step 2: Ranking table**: Models are then ranked according to their relative performance on each of four performance measures: mean raw error (RME), mean absolute error (MAE), mean percent error (MPE) and RMSE (see Cass et al. 2006 for details). Ranks across the four performance measures are then averaged to generate an overall score and rank for each model evaluated. The previous retrospective analysis was based on returns from 1997-2004 (see Table 5 in MacDonald and Grant 2012). To update the model performance, the current analysis was conducted to produce new model ranking tables based on the returns from the past three generations (2009-2020). The ranking tables are divided into all-year, cyclical year and other (non-cyclical year) categories in an age-specific manner. For cyclical stocks, rankings based on the cycle-line years are preferred.

3. **Step 3: Historical performance:** Performance of previously used forecast models in 2009-2020 is presented for each stock by comparing the estimates with actual returns in number

and percentage for both age classes (age 4 & 5) and total population. The yearly deviation and overall correlation between the past forecast number and observation are reviewed. Performance of the historically top-ranked models is considered in addition to the tendency to over or under estimate returns in recent years which may result in the selection of alternate models.

4. **Step 4: Forecast and implied productivity**: The total and age-specific forecasts resulted from top-ranked models and their corresponding implied productivities are presented; they are compared with historical time-series of observed productivity (both raw and log scale). Since many stocks have shown lower-than-average productivities in recent generations, efforts are made to choose models that might capture the dynamics of these recent declines in productivity (i.e. using environmental covariates). In addition, models with new covariates are proposed but they are mainly used as reference for comparison.

Model choice rationales for individual stock

Early Stuart: Ricker(Ei)

Sockeye returns to Early Stuart in 2024 were very low which led to the selection of a forecast model for total return instead of using a the highly ranked sibling model and generating an age specific forecast in 2025. Ricker(Ei) ranks the highest for biological models with the Ricker(PDO) ranking second. The Ricker(Ei) has been regularly selected for forecasting Early Stuart sockeye and results in forecasts with smaller differences between observed and forecast.

Bowron: R1C4Sibling5

The sibling model ranks highest in age-5 Taylor diagram and had the lowest forecasted abundance of age-5 sockeye (which coincides with a very low return from the 2020 BY of 172 EFS). The top ranked approved model for the age-4 forecast is the naive R1C followed by RickerCyc and Ricker(Pi). The Ricker models suggested forecasts that were quite optimistic given recent productivity observations and as such, the R1C model was selected to forecast age-4 sockeye and the sibling model to forecast age-5 Bowron sockeye.

Upper Barriere/Fennell: LLY

Based on the age-5 Taylor diagram, the sibling model performs well but so does the highly ranked naïve LLY model. The sibling model has an implied productivity >1 which has not been observed for over a decade. The sibling model has been chosen for three of the last four years due to consistency between models, but has a tendency to overpredict. Therefore, a total forecast was selected for Upper Barriere/Fennell using a LLY model.

Gates: R2C

The Age-5 Taylor diagram does not indicate clear top models. For the total forecast, like last year (LLY) is the best performing model followed by PowerJuv models, Larkin models, R2C and TSA. Larkin models have been historically selected for this stock but have had a tendency to overpredict this stock. For the 2025 forecast, the implied productivity suggested by the Larkin model is outside of the range of recent observations which led to the selection of the R2C forecast.

Nadina: RickerCyc4Sibling5

Both the sibling model and LLY rank high in the age 5 Taylor diagram. The sibling model also ranks the highest in the retrospective ranking table. For age-4, RickerCyc is the top ranked model and the productivity implied by the forecast aligns with recent observations of productivity.

Upper Pitt: LarkinBasic4Sibling5

Age-5 Taylor diagram shows strong support for the sibling model, but an implied productivity of 9.9 exceeds historical observations. Although Pitt tends to have higher productivity for age-5 than age-4, 9.9 has not been observed in the past decade. However, the sibling model is ranked the highest on the Taylor Diagram and in the retrospective ranking table and was therefore selected. Larkin basic model implies a productivity of 1.5 which aligns well with the last 3 years of observations and is selected for the age-4 component of the forecast.

Scotch: LarkinBasic4Sibling5

Based on the age-5 Taylor diagram, the sibling model and Ricker(Pi) model are highly ranked. However, the sibling model has the highest correlation, lowest RMSE and has a SD closest to the observation and is therefore selected to forecast the age-5 component of the 2025 Scotch forecast. Larkin models rank highest for this highly cyclic stock and the implied productivity for the Larkin model falls within the range of observations and therefore it was selected to forecast the age-4 component for Scotch.

Seymour: Ricker(Pi)

The sibling model performs well for the age-5 forecast for Seymour sockeye based on the Taylor Diagram and retrospective ranking tables. However, the implied productivity from the sibling model exceeded recent historic observations and was therefore excluded from selection. Both Ricker(Pi) and RickerCyc are reasonable choices based on their implied productivities. The RickerCyc model has been selected several times and has a tendency to over forecast. Ricker(Pi) is the highest ranked based on the retrospective ranking table therefore is chosen.

Chilko: RickerCyc4/Sibling5

Historically, we have selected juvenile models, but not in recent years due to their overly optimistic forecasts as freshwater survival has greatly improved while marine survival has been poor but trending toward average. The sibling model ranks the highest on Taylor diagram and the retrospective ranking table for the age 5 component. Additionally, the 2024 forecast returned at a level below expectations relative to the forecasted pre-season abundance and we wanted to account for the likely lower than expected productivity of age-5 Chilko fish from the same brood year. Additionally, the implied productivity from the sibling model aligns well with recent observations and was therefore selected.

For the age-4 component of Chilko, many aspects need to be considered for 2025. There is a large amount of discrepancy in forecasts among top ranked models, all of which demonstrate implied productivities that fall within the range of recent observations. The highest ranked models are RickerCyc and Larkin Basic cycle age which suggest a forecast of 916,000 and 2.3M respectively. The raw stock-recruit relationship for Chilko suggests that at the EFS value for this forecast, both some of the highest and lowest recruitment events have been observed historically. The cycle-specific stock-recruit relationship demonstrates that this is very far on the right side of the stock-recruit curve suggesting that we would expect overcompensation to be possible at these values. The RickerCyc model is preferred for the 2025 forecast as the RickerCyc is more highly ranked than the Larkin and the Larkin has a history of overforecasting when selected in previous forecasts.

Late Stuart: RS14/Sibling5

The sibling model performs well based on the Taylor Diagram and the retrospective ranking table and is therefore selected for the age-5 Late Stuart sockeye forecast. The Taylor Diagram demonstrates that the RS1 model compared to biological models performs much stronger with higher correlation and similar SD and RMSE for the age-4 component of the forecast. The top two models for the total forecast based on the retrospective ranking table are RS1 and R1C. Historically selected Power models suggest similar age-4 forecasts to the RS1 forecast and provide further support for this highly ranked model. The productivity implied by the forecast also aligns with recent observations and is therefore selected.

Quesnel: RickerEi

The sibling model does not rank well based on the age-5 Taylor diagram. The highest ranked model for the total forecast based on the retrospective ranking table is Ricker(Ei). The implied productivity of the Ricker(Ei) forecast aligns well with recent observations and is selected.

Stellako: LarkinBasic4/Sibling5

The sibling model ranks highly in the Taylor diagrams as well as in the retrospective ranking table. The productivity implied by the sibling forecast also aligns well with recent observations so the sibling model is selected for the age-5 component of the forecast. For age-4, Larkin models are highly ranked and the implied productivity of the Larkin model aligns well with recent observations of productivity for Stellako sockeye.

Harrison: LLY3/Sibling4

The extreme variability in this time series has resulted in a stock-recruit dataset that does not fit well with biological models. Additionally, in 2024 we over predicted Harrison sockeye by selecting the TSA model. The years of anomalously high returns for Harrison are included in the dataset and are likely pulling the forecast using the TSA higher than we should expect in the new productivity regime observed in Harrison. Sibling models rank well for the age-4 component of the Harrison forecast, the productivity implied by the forecast aligns well with recent observations and is selected. For age-3, TSA is the top ranked naive model followed by the RAC and LLY model. The LLY model does not incorporate the very high abundance years and has an implied productivity more closely aligned with recent observations of age-3 productivity and is selected.

Raft: LLY4/Sibling5

The sibling model ranks well on the age-5 Taylor diagram and is the top ranked model in the retrospective ranking table. The implied productivity aligns well with recent observations and is selected for the age-5 component. For age-4 returns, the LLY model is the highest ranked followed by the RickerCyc model. Both models have similar forecasts and implied productivities so the highest ranked model was selected to forecast the age-4 component of Raft.

Cultus: PowerJuv(Pi)

The sibling model does not rank well based on the age-5 Taylor diagram and is therefore not favoured to forecast age-5 Cultus Sockeye. PowerJuv models have been historically selected for Cultus and tend to perform relatively well at the very low abundances we are consistently observing for this stock. The PowerJuv models all have a nearly identical forecast and so the PowerJuv(Pi) model that has been consistently selected was selected again.

Late Shuswap: Ricker(Pi)4/Sibling5

The sibling model is highly ranked on the age-5 Taylor diagram with a productivity value that aligns well with recent observations. For age-4 forecasts, both Ricker(Pi) and RickerCyc model rank high but the Ricker(Pi) has productivity values that are more closely aligned with observations and is therefore selected.

Portage: Ricker(Ei)

The sibling model does not rank well based on age-5 Taylor diagram. Ricker(Ei) ranks the highest based on total forecast and has an implied productivity that aligns well with recent observations.

Weaver: RickerCyc4/Sibling5

The sibling model does not appear to rank well on the age-5 Taylor diagram but most models do not rank well and the sibling model is the highest ranked in the retrospective ranking table. The sibling model has an implied productivity that aligns well with recent observations and is considered optimal for the age-5 component of the Weaver sockeye forecast in 2025. The RickerCyc model ranks highest for the age-4 component and juvenile data were unable to be incorporated to consider PowerJuv models. The RickerCyc has an implied productivity of 8 which aligns well with recent observations for Weaver which have been consistently around 10.

Birkenhead: Ricker(Pi)4/Sibling5

The sibling model estimates an implied a productivity of 0.5 which aligns well with recent observations of productivity and is therefore selected. Ricker and Power models perform well for Birkenhead with the Ricker(Pi) model being the top ranked biological model for Birkenhead. The implied productivity of the forecast with Ricker(Pi) aligns well with recent observations of productivity and is selected.