# Assessment of Fisheries Plans: Planning Model inputs

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## Summary

The PSC Planning Model (Sub-report A3a) is a simulation tool used by the Fraser River Panel to assess the sensitivity of fisheries plans and achievement of management targets to alternative biological (e.g. run size, diversion rate) and/or management scenarios. This report describes the key biological, management and fisheries inputs used to parameterise the PSC Planning Model and run simulations. Further details regarding model parameterisation and underlying assumptions can be found in Sub-reports A3c and A3d.

## Introduction

Pre-season, the Fraser River Panel (FRP) and Fraser River Technical Committee (FRTC) use the PSC Planning Model to develop preliminary fishing plans, to identify potential limitations to achievement of management objectives, and to explore the effect of uncertain biological and management inputs on proposed fisheries. This simulation model requires a wide range of different inputs: biological inputs to model the behaviour of the different stocks, fisheries inputs to assess the impact of various fisheries on the stocks and management inputs to ensure management objectives are met. Early in the year, these inputs are based on historical data and preliminary schedules and plans, while just prior to the start of the season, the model inputs are replaced with improved forecasts and federally approved escapement plans. Model seeding, or parameterisation, occurs twice per year: once in February/April and a second time in June. The responsibility for providing different model inputs falls primarily onto Canada and the PSC, with the U.S. providing additional domestic-level information regarding their own fisheries as well as domestic targets and constraints. Typically, the Panel will approve the parameterisation of a “base case” model before the conclusion of their final pre-season meeting in June based on the best-available information.

## Data

### Biological INPUTS

The PSC Planning Model simulates the daily migration of 12 different Fraser River sockeye salmon stock groups, in addition to a single group for all Fraser River pink salmon. Table 1 provides a list of the different sockeye salmon stock groupings used in the Planning Model. Table 1 provides a guide for aggregating stock-specific information from historical reconstruction and pre-season forecast files into appropriate groupings currently utilised pre-season. These groups are structured to aggregate groups of fish with identical management constraints and migratory parameters (Sub-report A3a). Table 2 provides a description of the key biological inputs in the PSC Planning Model. Pre-season estimates of run size, timing, spread and diversion are used to parameterise normal distributions of daily abundance entering Johnstone Strait and Juan de Fuca Strait while delay information is used to model the upstream migration timing of various stocks which hold in the Strait of Georgia prior to moving up-river.

**Table 1**. Stock definitions and aggregations within the PSC Planning Model. At the finest resolution, stocks are defined as groups of fish with identical migratory and management parameters.



**Table 2.** A description of the key biological inputs in the PSC Planning Model, including timelines for updating inputs, the data source, the relevant Sub-report containing additional information on how the data are used to derive model inputs and the party responsible for providing the update.



#### Run size

Run size forecasts are a critical aspect of the modelling process, and directly affect the value of management inputs, patterns of daily abundances, and strongly influence the pattern of proposed fisheries which optimise trade-offs between conservation and fishing targets. Fisheries and Oceans Canada (DFO) provides pre-season forecasts of sockeye salmon run size using a suite of stock recruitment and naïve models (Grant et al. 2010; Sub-report A1a). These forecasts are provided at a finer stock resolution than used by the PSC Planning Model, and so must be aggregated to the model group level (Table 1). The uncertainty around the run size forecast is expressed in terms of a probability distribution. As stated in the PST (Chapter 4), the median forecast (p50) is used as the default input for the base case planning scenario, but the Panel may also chose to adopt a more precautionary or optimistic forecast until the in-season run size estimates are available. A key sensitivity analysis performed by the parties during pre-season fisheries planning is to vary the assumed run size from the default median (p50) estimate to either a lower (e.g. p25), or higher (e.g. p75) estimate of abundance. Preseason run size estimates are typically available in February and do not get updated until during the season.

#### Marine timing

In the PSC Planning Model, marine timing is termed as the Area 20 50% date, or the date by which 50% of a run has passed the mid-point of statistical Area 20 assuming all sockeye salmon migrate through the southern approach around Vancouver Island (Sub-report A1b). Both the absolute timing as well as the offsets between the timings of the various management groups (Early Stuart, Early Summer, Summer and Late-run) influence pre-season fishing plans. During the spring, timings for the different stock groups in the PSC Planning Model are calculated based on historical timing data derived from post-season reconstructed daily marine abundance estimates (Sub-report B8d). Statistical and retrospective analyses are used to determine the best available estimates for each stock in a given year. Typically, all-year medians, cycle-line medians or all-year medians excluding 2016 cycle line data are used.

In June, DFO provides additional timing forecasts for Early Stuart and Chilko based on oceanographic models (Folkes et al. 2018; Sub-report A1b). These estimates are applied directly to update the Early Stuart and Chilko timing estimates. For all other stock groups, the historical timing is updated either earlier or later depending on the difference between the Chilko timing forecast to the Chilko historically-based timing estimate. This approach assumes the underlying oceanographic conditions affecting Chilko salmon will have the same effect on other co-migrating stocks. It is at the Fraser River Panel’s discretion to utilise these updated timing forecasts, to use the historical timing estimates, or to adopt some alternative value.

#### Spread

Another parameter used to define the anticipated daily abundances of fish is the spread of the run. Assuming the run follows a normal distribution, the spread indicates the number of days for 95% of the run to migrate past a reference location (i.e. the standard deviation of the normal distribution). Annual spreads are calculated from reconstructed historical marine timing profiles (Sub-report B8d) and are quantified using the same subset of years selected for the historical timing estimates. Spread estimates for aggregated stocks are calculated by first summing daily reconstructed abundances and then re-calculating the spread of the group. The spread model inputs are only updated once a year, during the initial model seeding process.

#### Northern diversion rate

The diversion rate is defined as the proportion of the run that migrates through Johnstone Strait, i.e. the northern approach. The models to predict the diversion rate have varied over time and will likely continue to evolve. In 2018, a new process of predicting the diversion rate in March was applied whereby the daily diversion rates over the last three years on the cycle line were averaged. In June, DFO provides an additional annual forecast of the total Fraser River sockeye salmon diversion rate using a suite of oceanographic models (Folkes et al. 2018; Sub-report A1b). The pattern of daily diversion based on the historical data is then multiplied by a scaler to ensure the total diversion was equivalent to the DFO forecast. The daily diversion rate estimates are multiplied by the daily abundances of the various stock groups to calculate the abundances migrating through Johnstone Strait versus Juan de Fuca Strait. Unlike other Fraser River sockeye salmon stocks, Harrison sockeye migrate predominantly through the south. Given the limited amount of historical data, a Harrison-specific diversion rate is derived by adjusting the diversion rate based on the historical relationship between total Fraser and Harrison-only diversion rates.

#### Delay in upstream migration

A percentage of Harrison (Summer run) and Late-run stocks (excluding Birkenhead and Big Silver) typically delay their migration in the Strait of Georgia for a variable number of days prior to continuing their upriver migration (Cooke et al. 2004). Historically, the number of days delay and the upstream timing has differed across cycle lines and except for odd cycle line years, cycle line medians are used as model input. The proportion of the run that delay their upstream migration, the Mission 50% migration date of both the delaying and non-delaying components, and the spread of the delay component are all inputs into the PSC Planning Model. Using expert judgement, these inputs are adjusted to produce results consistent with the historical median estimates of delay and the median 50% migration date at Mission.

### Management INPUTS

Most of the bi-lateral management parameters are provided by Canada, pursuant to guidance in the Pacific Salmon Treaty (Article IV, Chapter 4). In addition, PSC staff provide test fishing deductions (Sub-report A1e) and management adjustments (Sub-report A1c); both of which also influence the calculation of Total Allowable Catch (TAC). Preliminary escapement plans from Canada are generally aligned with rules corresponding to either the previous year, or previous year on the cycle line. Updated values are normally available by June, but Ministerial approval may be delayed until early in the fishing season.

#### TAMs, SETs, AFEs, and LAERs

Under the Pacific Salmon Treaty (Chapter 4, Article IV), Canada is responsible for providing harvest control rules for the management of Fraser River sockeye stocks. Prior to each fishing season, the Minister of Fisheries, Oceans and the Canadian Coast Guard must formally approve an annual Integrated Fisheries Management Plan (IFMP) following a series of consultations with key stakeholder groups. This plan includes harvest control rules that define the Spawning Escapement Targets (SET), Total Allowable Mortality (TAM), and Low Abundance Exploitation rates (LAERs) for each sockeye salmon management group (DFO 2018). Fraser River sockeye salmon follow abundance-based harvest rules and so the SET and TAM values vary as a function of the assumed run size. The Aboriginal Fisheries Exemption, or AFE, is also described in the IFMP provided by Canada. This is a fixed 400,000 sockeye deduction from the bi-lateral Total Allowable Catch (TAC) to meet Canadian First Nations fishing requirements. More detail about all these management parameters can be found in Sub-report A1d.

#### Management Adjustments

Management Adjustments (MAs) represent the expected number of additional fish required to pass the Mission hydroacoustic facility to achieve the desired SET. Initial pre-season MAs are based on historical discrepancies, or differences between escapements at Mission and those on the spawning grounds (DBEs), after accounting for known catch removals from historical data sets. Historical discrepancies (Sub-reports A1c, B10) may exist because of errors in stock assessment, catch accounting, or natural en route losses. In June, long range environmental forecasts (Sub-report A1c) produced by the DFO Environmental Watch Program are used to predict MAs for Early Stuart, Early Summer and Summer-run using multiple regression models fit to time series of lower river discharge and temperature data (Macdonald et al. 2010; Cummings et al. 2011). The Late-run MA is either left as the historical median or updated to a predicted MA estimate based on estimated upstream timing (Macdonald et al. 2010; Cummings et al. 2011). However, the Panel may choose alternative MAs for any of the management groups.

**Table 3.** A description of the key management inputs in the PSC Fisheries Planning model.

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#### Test fishery deductions

Pursuant to the PST (Article 4, Chapter 4), the TAC is reduced by the amount of catch in Panel authorised test fisheries. A detailed description of how test fishery deductions are predicted for pre-season planning is provided in Sub-report A2b. Pre-season, the Panel agrees to a draft test fishing plan put forth by PSC staff. Test fishing catches from the proposed plan are generated using a smaller pre-season simulation model for test fisheries planning (Sub-report A1e). Estimated catches by fishery are calculated from historical catchability estimates applied to simulated daily fish abundances. Gill net test fisheries are assumed to retain all fish, whereas purse seine fisheries are modelled as either non-retention (fish are only landed to meet scientific sampling requirements) vs. retention (all fish are landed and fish in excess of the sampling requirements are used to offset the cost of the test fishing program).

The distribution of test fishing catches across management groups is calculated using a combination of two approaches. First, the non-discretionary catch (i.e. all gill net test fishery catch plus scientific samples in the purse seine test fishery) is proportionally assigned to each group based on the historical distribution of non-discretionary catches average over the last 3 cycle lines and adjusted for the current proposed test fishery dates. Second, the discretionary catch (i.e. fish landed above and beyond those required for scientific samples), is proportionally distributed as a function of the available harvestable surplus for each management group (i.e. run size minus spawning escapement target and management adjustment). These approaches are sometimes revised to meet the expected stock composition and/or test fishery schedule assumed for a given year.

#### International and domestic allocations

The PST (Article 4, Chapter 4) assigns 16.5% of the TAC available for international sharing to the U.S. with the balance assigned to Canada. In addition, each country allocates their respective share across different stake-holder groups following pre-season consultations. These percentages are then used as objectives to help guide the fishing plans in the PSC Planning Model. Canada assigns allocations to different commercial fishing sectors: Area B seine, Area D gill net, Area E gill net, Area H troll, and Area G troll. Allocation targets are also specified for marine, lower river, and interior First Nations fisheries as well as marine and in-river recreational fisheries. In the US, allocation percentages are used to divide the TAC between Tribal and All Citizen fisheries.

### FISHERIES INPUTS

Fisheries inputs relate to the number of vessels expected to participate to a fishery, i.e. the fishing effort, or expected catches and the schedule when fishing is expected to occur. Table 4 provides a description of the key fisheries inputs in the PSC Planning Model.

**Table 4.** A description of the key fisheries inputs in the PSC Fisheries Planning model.



#### Fishing effort

Effort-based harvest rate equations are used in the PSC Planning Model to generate estimates of catch for derby-style fisheries. The model is seeded with historical estimates of fishing effort (total number of vessels) for the following fisheries: marine gillnet (Area 11, Area 12), marine purse seine (Area 12, Area 13 and Area 20), troll (Area 29), Treaty Indian (Area 4B56C, Area 7, Area 7A), and All Citizen (Area 7, Area 7A).

#### Fixed catch (for fisheries not modelled dynamically)

Some fisheries are not dynamically modelled within the PSC Planning Model, either because of unparameterized harvest equations, or because they are outside of the current geographic scope. Instead, experts provide estimates of catch by management group, including estimates of fishing induced sockeye mortalities (FIMs) in pink salmon directed fisheries. The Canadian FRTC chair provides catch estimates for the following fisheries: marine recreational catch, in-river beach seine FIMs, and gulf seine FIMs. PSC staff will provide catches estimates for the purse seine test fishing samples. These catches are relatively small and are estimated based on daily sample sizes and distributed across management groups based on historical stock composition information.

#### Fishing plans

Once the model has been fully parameterised under a given set of assumptions, the FRTC works with PSC Staff to develop a fishing plan for each country. The goal of these plans is to optimise trade-offs between conservation and fishing objectives by developing fishing scenarios that meet Spawning Escapement Targets, come as close as possible to meeting the international TAC allocations as well as domestic allocation requirements. Model input requirements vary by fishery depending on the underlying equations. At a minimum, derby-style fisheries must include a start and end date, while ITQ-style fisheries (Individual Transferable Quota) must also indicate an anticipated target catch. Users can choose to specify the hours of fishing operations, the fishing effort and if sockeye catches would be retained or not. Initial fishing plan developed in March/April are updated and finalised following an update of the model inputs in June.

## References

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