Fisheries and Oceans Canada | Pêches et Océans Canada
Ecosystems and Oceans Science | Sciences des écosystèmes et des océans

Pacific Region

Canadian Science Advisory Secretariat
Science Response 2025/001

# STOCK ASSESSMENT OF FRASER RIVER PINK SALMON (*ONCORHYNCHUS GORBUSCHA*) IN 2023

## CONTEXT

The Fisheries Management sector of Fisheries and Oceans (DFO) has requested that reference points consistent with the DFO Precautionary Approach (DFO 2009) be developed for Fraser Pink Salmon (*Oncorhynchus gorbuscha*, 2023-24 Southern BC IFMP) and that the stock status of Fraser Pink Salmon and the performance of the current harvest control rule be assessed relative to those reference points.

This Science Response Report results from the April 29-May 3, 2024, regional peer review on the Fraser Pink Salmon (*Oncorhynchus gorbusha*) Stock Assessment in 2023. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

## SCIENCE ADVICE

### Status

- The Fraser Pink Salmon stock management unit (SMU) is in the Healthy zone because there is a very high probability (>99%) that current (2023) spawner (escapement) abundance is above the median upper stock reference (USR) and both short and longer term escapement trends are increasing.
- The Wild Salmon Policy rapid biological status assessment tool shows an interim green status with high confidence, which means the Fraser Pink SMU is not below the LRP.

### Trends

- Fraser Pink escapement was low but stable in the early part of the escapement time series, followed by a period of increase from mid-1970s to early 1990s. Since the early 1990s, Fraser Pink escapement has been highly variable, with a peak escapement of over 20M in 2003. Escapement has been increasing since the late 2010s.
- The total return of Fraser Pink Salmon (catch plus escapement) has been variable but without a consistent trend, with the recent 10 year (5 generation) average run size of 7.4M fish (2015-2023).
- The average body mass at return has decreased about 1 kilogram to approximately 1.7 kg since the mid-1970s, which has the potential to impact reproductive output via reduced number of eggs per female spawner.
- The recent 10 year (5 generation) intrinsic productivity of 1.2 recruits per spawner is less than half of the long term recruits per spawner of 2.9 (1959-2021 brood years).

## Ecosystem and Climate Change Considerations

- Relative to the long term average, stock productivity is currently depressed, and this is likely due to a combination of declines in reproductive output and poor environmental conditions. However, there are no further anticipated acute negative ecosystem or climate change considerations that would be relevant for short term (until the next assessment in 2 years) fishery, hatchery or habitat management decisions.
- Longer term areas of potential concern that are recommended for continued tracking include:
    - Migration success through known challenging areas – e.g., Hells Gate, Big Bar, Bridge River Rapids.
    - Mismatch of early marine entry and prey availability (indicators include sea-surface temperature, spring bloom timing, and North Pacific Current) – potential to become increasingly unfavorable under climate change, may be affecting survival and/or body mass at return.
    - Further decrease in average body mass at return and hence reproductive output.

## Stock Advice

### Harvest Advice

- Simulations show the existing harvest control rule (HCR) for Fraser Pinks is very unlikely (<5%) to result in the spawner abundance falling below its limit reference point (LRP), and likely (87.5%) to remain above the upper stock reference (USR) over the next 10 years (5 generations).
- This assessment assumes that all available harvest will be caught. However, there are only 2 years (1987 and 1997) when the total allowable catch (TAC) specified by the HCR has been reached or exceeded since it was implemented in 1987. Not harvesting the full TAC has been due to external factors such as management measures to limit impacts on non-target species and fluctuations in the market value of Pink Salmon that moderates demand.
- While the maximum removal reference (RR) on the current HCR (70%) is greater than the candidate RR (56%), the actual average estimated exploitation rate (ER) over the last 5 generations has been 6%, well below the candidate RR.

### Hatchery Advice

- At current estimates of marine survival (fry to adult) near 2%, the 2023 brood year Production Plan to release 6.7M fry would result in an adult return of approximately 135,000 adults to the Fraser River in 2025.

## Other Management Questions

- Recommend using the methods described in Glaser et al. 2025 to simulation test any new HCRs under consideration, changes to the current HCR and/or any new or revised quantitative fisheries objectives.
- Recommended re-assessment schedule:
    - Re-assessment of status: after every Fraser Pink return (i.e., biannually).
    - Re-assessment of reference points: every two generations (i.e., the next re-assessment of Fraser Pink reference points would be after the 2027 return).

- See the “Exceptional Circumstances/Assessment Triggers” section for proposed exceptions to this schedule.

# BASIS FOR ASSESSMENT

## Assessment Details

### Year Assessment Approach was Approved

This is the first assessment using a state-space spawner-recruit model and simulation evaluation of the current HCR.

### Assessment Type

Full Assessment

### Most Recent Assessment Date

1. Last Assessment:
   a. 2021 run size forecast – DFO (2021)
   b. annual review of the 2021 Fraser Pink return and fishing season – (Pacific Salmon Commission [PSC] 2023)
2. Last Interim Year Update: N/A

### Assessment Approach

1. Broad category: Multiple Approaches: single stock assessment model, closed-loop simulation model, Wild Salmon Policy integrated assessment (through rapid status evaluation algorithm).
2. Specific category: State-Space, Stock-Recruitment Relationship, Closed-loop simulation model.

## Stock Structure Assumption

Stock overview information: from Glaser et al. 2025

- The Fraser Pink SMU consists of 1 conservation unit (CU), the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) is currently reviewing stock structure.
- Return migration occurs on odd years, with adults being virtually absent in the Fraser River in even years.
  - Pinks return as 2 year olds.
  - Marine migration (Area 20 – Southern Vancouver Island) peaks in early September.
- Since the Hells Gate slide (1914), Fraser Pinks spawn predominantly in the lower Fraser watershed, but components of the run return farther upstream to the North Thompson River, Seton-Anderson complex, and Quesnel system.
  - The part of the stock that spawns upstream of Big Bar was affected by the landslide (2019 migration to current).
- Pink Salmon fry migrate to the ocean in the spring following egg deposition and spend approximately 18 months at sea before their return migration.
- There is a small hatchery component within this SMU, including contributions from Chehalis and Chilliwack hatcheries.

## Reference Points

*Table 1. The following candidate precautionary approach (PA) reference points were identified in conjunction with Fisheries Management and peer reviewed in 2024 (Glaser et al. 2025).*

| Reference Point Name | Reference Point Value and Description |
|---|---|
| Limit Reference Point (LRP) | $S_{gen}$ = 1.7M spawners (80% CI: 1.1M – 2.7M). Compare to:<br>• full posterior distribution of spawners in last year of escapement |
| Upper Stock Reference (USR) | 80% $S_{MSY}$ = 4.6M spawners (80% CI: 3.6 - 6.1M). Compare to:<br>• full posterior distribution of spawners in last year of escapement |
| Maximum Removal Reference (RR) | $U_{MSY}$ = 56% (80% CI: 47% - 63%). Compare to:<br>• annual estimates of exploitation rate |
| Target Reference Point (TRP) | not requested |

## Harvest Decision Rule

The current harvest control rule has been in place since 1987:

*Table 2. The harvest control rule for Fraser Pink Salmon fisheries.*

| Run Size (in millions of fish) | Management Action |
|---|---|
| below 7.059M | ER increases linearly from 0% (at run size of 0) to 15% (at 7.059M) |
| between 7.059M–20M | fixed escapement goal of 6M |
| above 20M | fixed ER of 70% |

Additional fisheries management actions are often taken during Pink directed fisheries to reduce impacts on co-migrating stocks of concern. These actions can include:

- Time and area closures;
- Brailing requirements for purse seines; and
- Use of beach seines or shallow seines instead of drift gillnets.

## Enhancement Plan

Production plans can be found in the (odd year) Southern BC Integrated Fisheries Management Plan. The 2023 Production Plan for Fraser Pink Salmon include releases planned to support stewardship, rebuilding, and harvest activities.

## Data

Main data inputs:

- Escapement – estimation methods have changed over time, see Table 3.
- Catch – estimates of total Pink Salmon catch are provided to the Pacific Salmon Commission (PSC) by Canada and the US.
    - Prior to 1987, Fraser Pink Salmon were identified using run reconstruction methods.
    - Since 1987, PSC staff have applied genetic stock identification (GSI) methods to samples taken from test and commercial fisheries to distinguish Fraser and non-Fraser bound Pink Salmon, using interpolation and projection as appropriate, to the total catch of Pink Salmon.
    - Original GSI methods (1987–2005) used protein genetic markers (allozymes).
    - Current GSI methods (2007–present) use DNA markers (microsatellites).
- Total return (run size) is assumed to be the sum of catch and escapement.

*Table 3. Summary of changes in methods used to assess spawning escapement over time and assumed coefficients of variation (CVs) for each period which were used to define magnitude of observation error in state-space spawner-recruitment model.*

| Years | Method | CV |
|---|---|---|
| 1957–1991 | mark-recapture (system specific)<br>IPSFC 1957–1985 & DFO 1987–1991 | 35% |
| 1993–2001 | mark-recapture (mainstem) - DFO | 20% |
| 2003–2007 | Test fishery - PSC | 50% |
| 2009–present | Mission hydroacoustics - PSC | 10% |

## ASSESSMENT

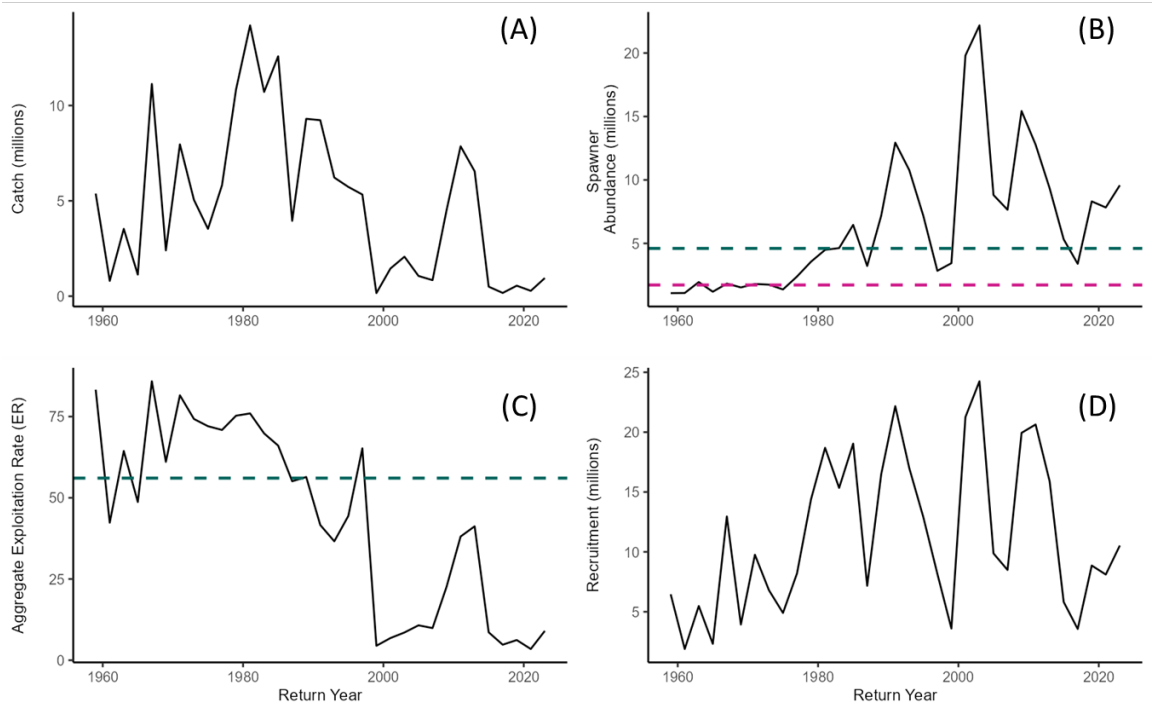


*Figure 1. (A) Catch of Fraser Pink Salmon (millions), (B) escapement relative to candidate Limit Reference Point (lower red dashed line – 1.7M) and candidate Upper Stock Reference (upper green dashed line – 4.6M), (C) exploitation rate relative to the Removal Reference (green dashed line – 56%), and (D) run size (millions).*

- Fraser Pink Salmon are in the Healthy zone for the following reasons:
    - The entire estimate of the 2023 spawner posterior distribution (point estimate of 9.6M) is above the median estimate of the candidate USR (4.6M) and LRP (1.7M).
    - CU is below $U_{MSY}$ and above $S_{MSY}$ - see Kobe plot (Figure 2).
    - The minimum escapement in the last 10 generations of 3.4M generated a total return of 8.9M for an implied return of 2.6 recruits per spawner.
    - The geographic distribution of spawners covers a large portion of the Fraser watershed
    - The Wild Salmon Policy rapid biological status assessment tool shows an interim green status with high confidence.

## Historical and Recent Stock Trajectory and Trends (1959–2023)

**Total spawners (Figure 1 – Panel B)**

- The estimated spawning escapement in 2023 was 9.6M.
- The 2023 escapement is the highest since 2011.
- The recent 5 generation (10 year) average escapement is 6.9M and compares to an average escapement since 1987 (the first year the current HCR was implemented) of 9.4M.
- The pre-1987 average escapement estimate was 2.5M.

**Total run size (recruitment) (Figure 1 – Panel D)**

- The estimated run size in 2023 was 10.5M.
- The 2023 run size is the highest since 2013.
- The recent 5 generation (10 year) average run size estimate is 7.4M and compares to an average run size since 1987 (the first year the current HCR was implemented) of 12.9M.
- The pre-1987 average run size estimate was 9.3M.

**Exploitation rate (ER) (Figure 1 – Panel C)**

- The estimated ER in 2023 was 9%.
- The 2023 ER is the highest since 2013.
- The recent 5 generation (10 year) average ER is 6% and compares to an average ER since 1987 (the first year the current HCR was implemented) of 25%.
- The pre-1987 average ER was estimated as 69%.

The Fraser Pink stock is not over fished, and is not experiencing over fishing relative to the $S_{gen}$ LRP and Removal Reference, but attaining the full harvest described by the HCR often does not occur.

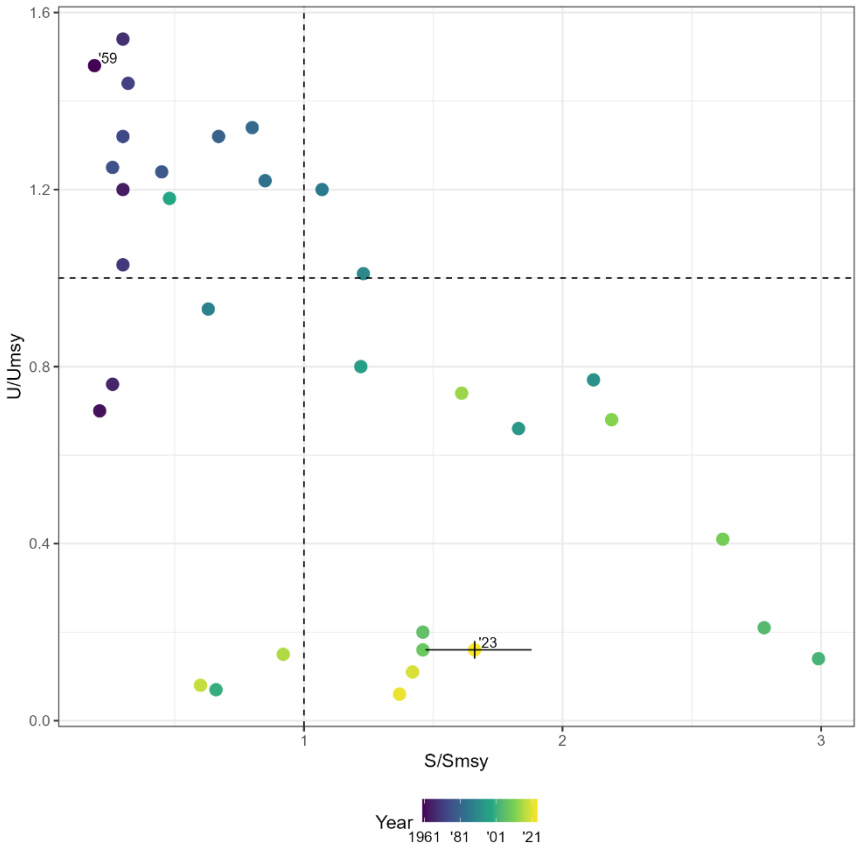


*Figure 2. Kobe plot of Fraser Pink status over time. Years are colour coded and the first and last years of data are labelled. 80% credible intervals are included for the last year of assessment. Values above the horizontal dashed line indicate the stock is experiencing overfishing and values to the left of the vertical dashed line indicate the stock is overfished.*

## History of Fisheries Management

In most years after the current HCR was implemented in 1987, the actual ER is well below the ER described by the HCR (Figure 3). The two exceptions were 1987 and 1997. Harvest of Fraser Pink Salmon occurs during the adult return migration in the late summer and early fall on odd calendar years. Opportunities to harvest Fraser Pink are limited by management constraints designed to limit impacts on co-migrating stocks and species of concern (e.g., Cultus Sockeye, Interior Fraser Coho, Fraser Steelhead) and by demand that is moderated by fluctuations in the market value of Pink Salmon.

**Catch (Figure 1 – Panel A)**

- The estimated catch in 2023 was 0.9M
- The 2023 catch is the highest since 2013
- The recent 5 generation (10 year) average catch is estimated to be 0.5M and compares to an average catch since 1987 (the first year the current HCR was implemented) of 3.5M
- The pre-1987 average catch was estimated to be 6.8M

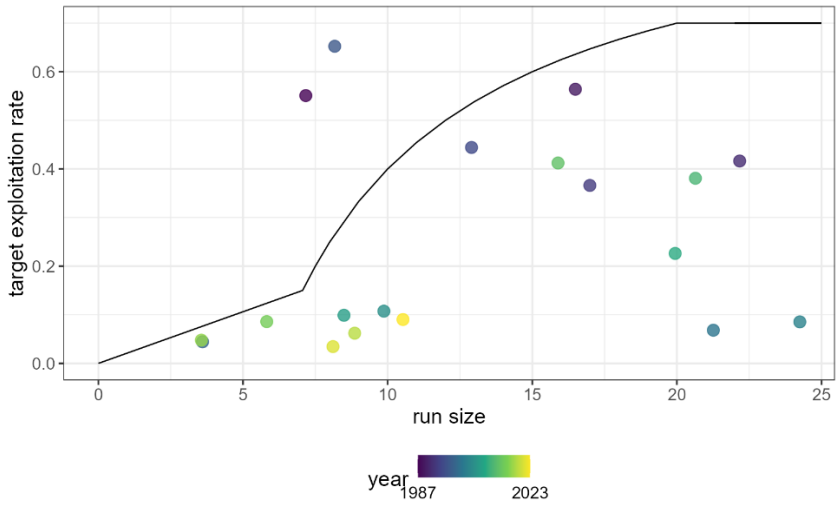


*Figure 3. The 1987-2023 estimated annual ERs at each run size (dots) compared to the current HCR (line). The years where ER exceeded the HCR are 1987 &1997.*

## Simulations

Performance of the current harvest control rule was tested in a closed loop simulation model that takes into account recent estimates of productivity (Glaser et al. 2025). The results show that:

- Assuming all available TAC is caught, the existing Fraser Pink HCR results in fewer than 5% of simulations falling below the LRP and 88% of simulations being above the USR over the next 5 generations (10 years). The average yearly TAC during this timeframe is estimated to be 10.3M fish (Figure 4).
- Under a no fishing scenario, fewer than 4% of the simulations fall below the LRP and 93% of the simulations stay above the USR over the next 5 generations (10 years).
- This model was built to test the robustness of harvest control rules over the longer term and is not meant to be used for annual fishery planning.
- Forecasts used for annual fishery planning (run size, timing, etc.) are not included in this document. Fraser Pink Salmon run size forecasts are developed and reviewed bi-annually.

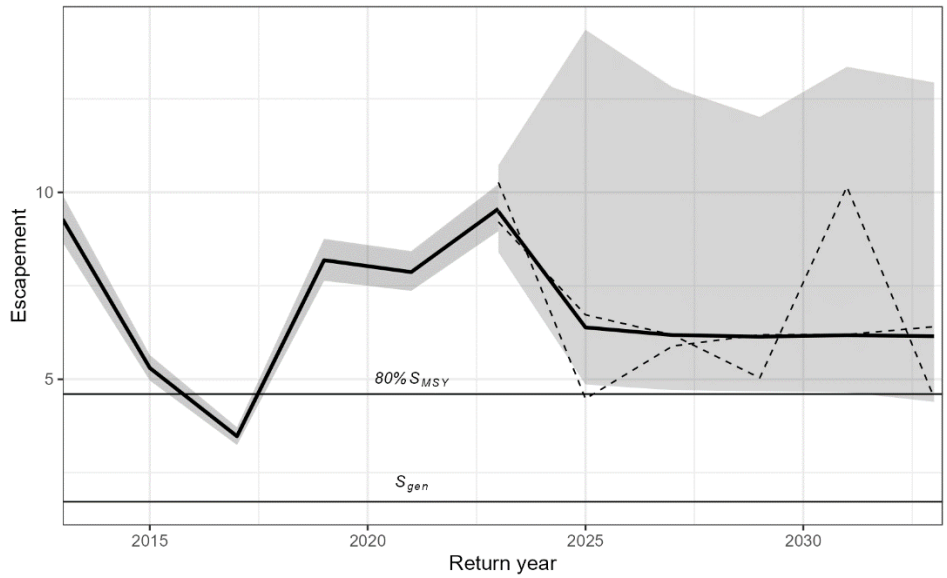


*Figure 4. Projected Fraser Pink escapement (in millions of fish) over next 10 years when the current HCR is-applied. Historical escapement is included for reference. Shaded polygons are 80% credible intervals. Dashed lines are examples of individual model trajectories.*

## Ecosystem and Climate Change Considerations

As a result of their extensive migrations spanning both freshwater and marine environments, Fraser Pink Salmon interact with a broad range of ecosystem and climate conditions over the course of their life cycle.

- Freshwater limiting factors:
    - Single age class, but broad spawning distribution and typically return in sufficiently large numbers to limit the impact to the SMU from a single catastrophic event.
    - Most Fraser Pink Salmon production occurs in the Lower Fraser from the Fraser Canyon downstream and habitats in this region are relatively highly impacted by anthropogenic activities (e.g., gravel removal, road development and overall high degree of land cover alteration).
    - Due to their relatively small body size Pink Salmon are especially vulnerable to flow-related impacts during return freshwater migrations.
    - Extreme flows (e.g., from fall rain events) can cause high mortality in the egg to alevin stage as a result of scouring.
    - Landslides – recent (Big Bar) and historic (Hells Gate) have occurred along the migration route. The Hells Gate slide had a large and lasting impact on the freshwater distribution of Pink Salmon in the Fraser watershed.
- Marine limiting factors:
    - Marine survival is negatively associated with above average sea-surface temperatures during early marine life, earlier spring bloom timing, and a weak North Pacific Current – these factors likely affect prey production, transport, and availability during early marine life.
    - Potential inter- and intra-specific competition for prey with other salmon in the North Pacific, leading to decreased adult size which is likely to impact reproductive output.

- The physical and biological oceanographic conditions that affect prey production and Pink Salmon survival are likely to continue to vary as the North Pacific warms as a result of climate change.

## Evaluation of Exceptional Circumstances/Assessment Triggers

Exceptional circumstances and assessment triggers are intended to proactively identify conditions and/or circumstances that may represent a substantial departure from those under which the advice in this assessment was developed.

### Exceptional Circumstances

We recommend a re-assessment of the stock-recruit and simulation model assumptions along with stock status and reference points be triggered if any of the following occur:

- Stock productivity changes drastically, where the median estimate of time-varying productivity (annual Ricker α) falls outside the 50th percentile (i.e., 1.8–2.93), of the 3 generation median productivity used to condition our forward simulation model;
- New information becomes available that results in changes to the historical time-series of spawner abundance and catches used in this working paper; and
- New information becomes available that results in changes to our understanding of stock structure (e.g., the current Conservation Unit is split into two) and/or major drivers of stock dynamics.

### Assessment Triggers

If Fisheries Management considers changes to the existing HCR and/or revisions to the fishery objectives against which it needs to be evaluated, then we recommend that the assessment model and closed-loop simulation framework we describe be revisited to ensure they adequately capture key attributes needed to support decision making.

# SOURCES OF UNCERTAINTY

- Uncertainties in the estimated reference points in accurately estimating the total run size, harvest, and escapement of Fraser Pink Salmon. The challenges include potential biases originating from: stock ID, uncertainty of harvest, different spawning escapement estimation methods.
- An additional uncertainty is the structural form of the assumed spawner-recruitment relationship.
- Uncertainties that relate to the management relevance of the reference points include the impacts of climate-driven change (e.g., temperature, river discharge, prey-distribution) on productivity and demography.

## Additional Considerations

- The simulation results of the HCR testing presented in this document assume current productivity. A robustness test at 10% of current productivity was conducted. Results are available in Glaser et al. 2025.
- The performance of a HCR that was explicitly based on the LRP and USR was also tested. Results are available Glaser et al. 2025.

- COSEWIC is in the process of reviewing the status of Fraser Pinks, including the potential for Fraser Pinks to be more than one designatable unit.

### Research Recommendations

- *Develop a Fraser Pink Salmon life cycle model* that partitions freshwater and marine survival, and explicitly accounts for changing reproductive potential (due to declines in body size). This approach would enable more explicit consideration of ecosystem and climate drivers of stock dynamics and enable them to be taken into account when estimating benchmarks and assessing stock status.
- *Evaluate evidence for, and consequences of, non-stationarity in stock dynamics.* If there is evidence of time varying spawner recruitment dynamics, then the closed-loop simulation framework we have developed could be used to explore their implications for characterization of stock status and evaluation of HCR performance.
- *Improve understanding of changes in spatial distribution of adult spawners.* The last detailed assessment of changes in the spatial distribution of Fraser Pink Salmon was done with data up to 1987. Since then, there has been anecdotal evidence of continued changes in the spatial distribution of spawning Pink Salmon.
- *Adapt the closed-loop simulation model to better capture contemporary fishery dynamics*. A multi-species Operating Model in our closed-loop simulations that explicitly or implicitly incorporates contemporary Fraser Sockeye dynamics, and revised fishery sub-model that takes at-risk Sockeye considerations into account, could be developed to enable more realistic evaluation of HCR performance.

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## SOURCES OF INFORMATION

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## THIS REPORT IS AVAILABLE FROM THE:

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ISSN 1919-3769
ISBN 978-0-660-74787-3 Cat. No. Fs70-7/2025-001E-PDF


Correct Citation for this Publication:

DFO. 2025. Stock Assessment of Fraser River Pink Salmon (*Oncorhynchus gorbuscha*) in 2023. DFO Can. Sci. Advis. Sec. Sci. Resp. 2025/001.

*Aussi disponible en français :*

*MPO. 2025. Évaluation des stocks de saumon rose du fleuve fraser (*Oncorhynchus gorbuscha*) en 2023. Secr. can. des avis sci. du MPO. Rép. des Sci. 2025/001.*