Stock identification of Fraser sockeye smolt samples provides marine fisheries managers with more timely and accurate estimates of adult run size

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Introduction

The Fraser River sockeye fishery is one of the most intensely managed international fisheries in the world, with frequent in-season meetings in which catch, escapement, and run size estimates are reviewed multiple times per week. International allowable catch is sensitive to data collection, including Catch per Unit Effort (CPUE) in marine test fisheries, and escapement to the Fraser River (hydroacoustically estimated). The latter provides relatively precise timing and abundance information and also feeds back into interpretation of the CPUE data by providing estimates of catchability.

There are 4 management groups defined by different arrival timing to the marine fishing areas, and each group has its own harvest targets and constraints. The Late run management group exhibits a delay behaviour (not entering the river a consistent number of days after reaching the marine fishing areas) that prohibits updates to marine catchabilities based on hydroacoustics in the river. The resulting uncertainty in abundance estimates hinders fishery management. For example, in 2010 the Late run return was more than twice the pre-season expectation, but abundance could not be updated until a large number of the sockeye entered the river, making the sockeye unavailable to marine fisheries in both countries, resulting that year costly foregone catch.

Locations

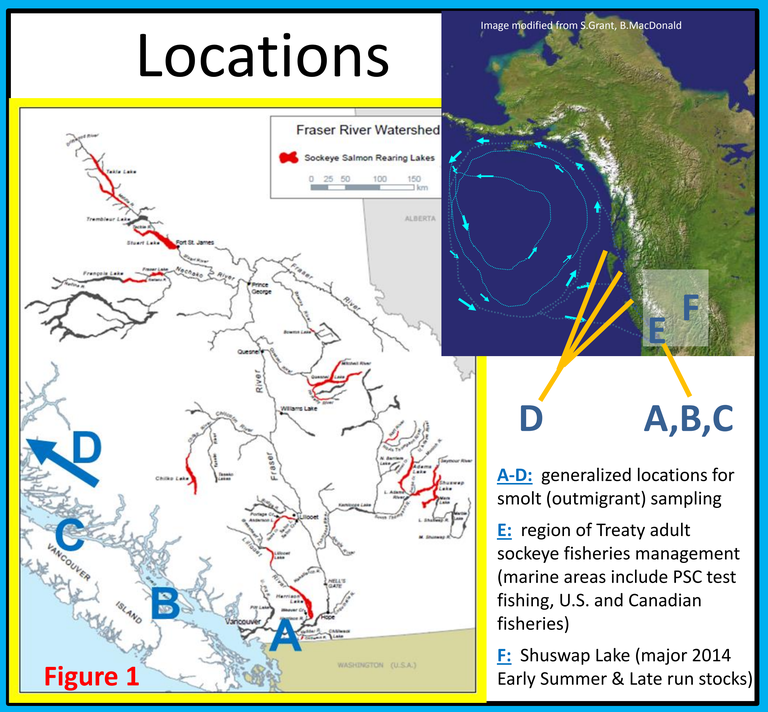


Figure 1

A-D: generalized locations for smolt (outmigrant) sampling

E: region of Treaty adult sockeye fisheries management (marine areas include PSC test fishing, U.S. and Canadian fisheries)

F: Shuswap Lake (major 2014 Early Summer & Late run stocks)

Ratios among smolts

Sample Area	2012 catch dates	$n_{all\ smolts}$	$n_{Shuswap}$	*Ratio
A	April 16 – July 30	2,293	1,276	5.7
B	May 19 – July 2	3,509	2,505	5.0
C	July 12-15	336	290	5.7
D	June 24 – July 12	505	169	5.0

*Ratio shown is late/early stocks of Shuswap Lake origin

H_o: Relative abundance of Early and Late Shuswap is the same in each sampling location; $p = 0.56$.

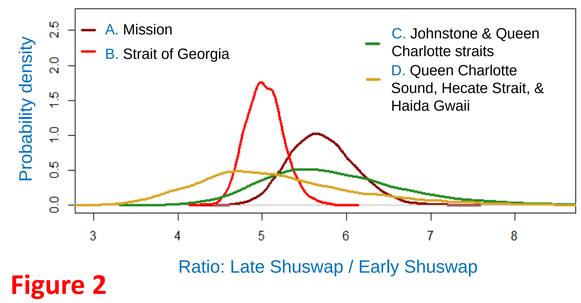


Figure 2

Return abundance

In-season probability distributions for run size were generated as usual for the Early Summer run, updating the forecast return (prior) with in-season daily marine test fishing CPUE and Fraser River hydroacoustic estimates. The late/early ratio in juveniles was tested for heterogeneity among the 4 sampled regions and, when no difference was detected (**Figure 2**), a single combined estimate of the ratio was generated using a Bayesian framework. The probability distribution of the late/early ratio was multiplied against the probability distribution of the in-season Early Shuswap abundance estimate to generate abundance estimates for Late Shuswap. These estimates were expanded to account for other Late run stocks, and results were compared to Late run estimates produced by usual in-season methods (**Figure 3**).

Objectives

- Compile estimates of the ratio of late-returning stocks to early-returning stocks in outmigrating sockeye smolts.
- Compare the estimates and obtain an overall ratio estimate including overall uncertainty.
- Combine the in-season abundance estimate of early-returning stocks with the estimated late/early ratio to obtain a timely Late run estimate.
- Evaluate improvement of the smolt-based estimate (including uncertainty) over the usual in-season abundance methods for Late run sockeye.

Smolt sample collection & GSI

In 2012, outmigrating Fraser River sockeye were targeted for sampling by several DFO programs (Canada) at multiple locations, from the lower Fraser River to Haida Gwaii (**Figure 1**). Capture techniques varied with location: rotary screw trap and inclined plane trap in the lower Fraser; purse seine and trawl in the Strait of Georgia; and trawl in seaward sampling locations.

The relative prevalence of Early and Late Shuswap sockeye, which originate in the same system of lakes and accounted for 92% and 93% of the 2014 forecast for Early Summer and Late runs, respectively, was estimated using GSI. Genotyping and mixture analyses were performed by DFO's Molecular Genetics Laboratory, examining 14 microsatellite and 5 SNP loci with CBAYES software. This is the same laboratory and process that provides GSI results for assessment of returning adults.

2014 Early Summer and Late run assessments

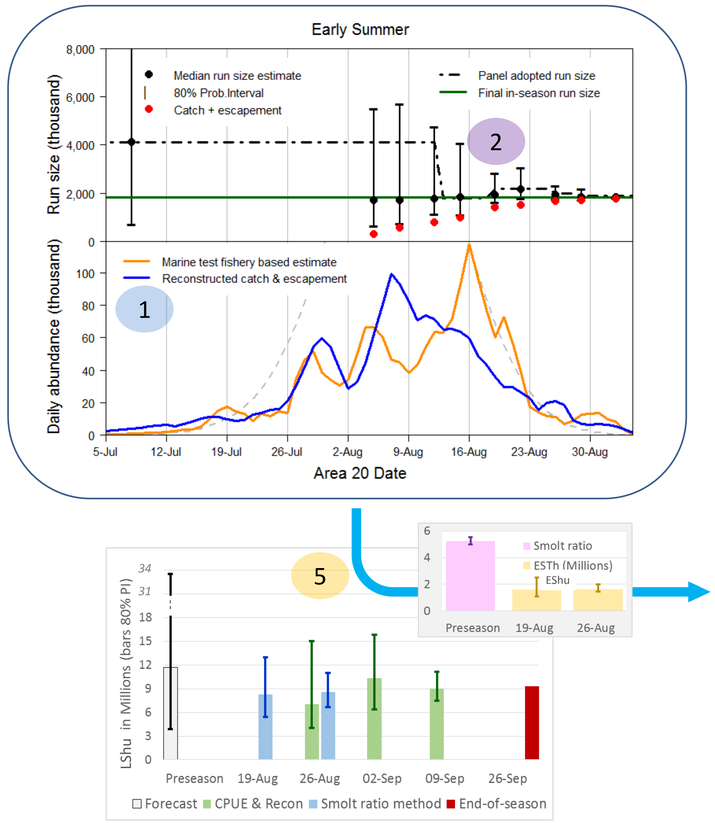
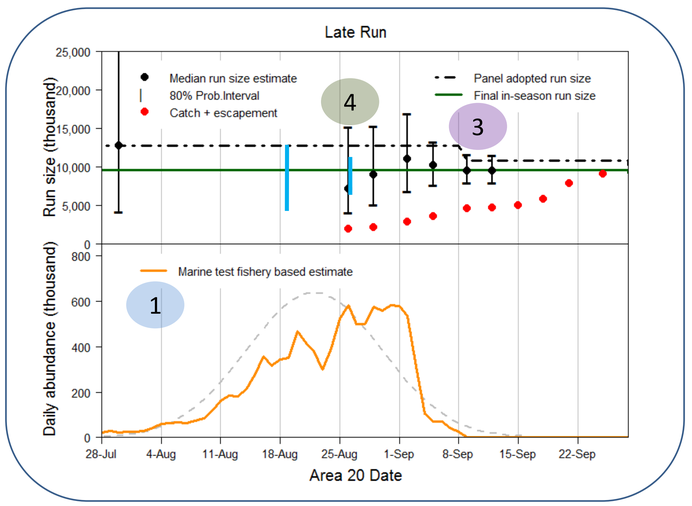


Figure 3

1. Abundance estimates based on test fishing CPUE verified by hydroacoustics for Early Summer but not Late run sockeye.
2. Early Summer run size known to be less than median forecast after Aug. 16 (CPUE prediction not confirmed).
3. Usual in-season assessment procedures were not reliable enough to downgrade return of Late run sockeye until Sept. 9.
4. New approach could support that decision on Aug. 19.
5. This approach combined the ratio of Shuswap stocks in smolt samples with the observed return of Early Summer run adults.



Results & discussion

The 2014 Early Shuswap in-season return abundance estimate became more certain as the run progressed, but particularly after August 16. The estimate was **1.6** Million (80% Probability Interval: **1.1-2.5**) on August 19 and **1.6** Million (**1.4-2.0**) on August 26.

Combined with the late/early ratio estimate of **5.3** (**5.0-5.5**), available pre-season from the 2012 smolt samples, estimates of Late Shuswap run size on those dates were **8.3** Million (**5.4-13**) and **8.6** Million (**6.7-11**), respectively.

In-season run size estimates of Late Shuswap based on CPUE, catch, and escapement (without smolt ratio information), were unavailable on August 19 owing to the characteristic delay behavior of these sockeye.

Estimates of Late Shuswap could not be made with nearly equivalent confidence, to estimates made with smolt ratio information, until approximately 2 weeks later: **10** Million (**6.4-16**) and **9.0** Million (**7.5-11**) on September 2 and 9, respectively.

Advancing availability of reliable run size information by 2 weeks would facilitate better fisheries planning and assist treaty implementation regarding international allowable catch, but the amount of benefit would be year-specific.

In addition to body size, Early and Late Shuswap sockeye likely have similar health and survival during outmigration. Members of each stock mature almost exclusively at age 4. As adults they have very different timing, with the later stock exhibiting problematic behaviour for usual assessment procedures. Thus the new method may be best applied to these important stocks (especially every fourth year when these stocks are dominant).

Next steps

- Further explore spatial and temporal differences in the outmigration of Early and Late Shuswap sockeye stocks.
- Evaluate additional samples of outmigrants, including addition years and stocks, for consistency in ratios of stocks in smolts and returning adults. (Can this technique be useful in other years, with other dominant stocks?)
- Develop framework integrating smolt-ratios (e.g., as a prior) into usual in-season estimation, if appropriate.
- Explain similarity/dissimilarity in stock ratios among outmigrating smolts and returning adults.