2016

Report of the Fraser River Panel to the Pacific Salmon Commission on the 2016 Fraser River Sockeye Salmon Fishing Season

Prepared by the

Pacific Salmon Commission

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REPORT OF THE
FRASER RIVER PANEL
TO THE PACIFIC SALMON COMMISSION
ON THE 2016 FRASER RIVER SOCKEYE AND PINK SALMON FISHING SEASON

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I. EXECUTIVE SUMMARY

Pre-season Planning

1. Pre-season expectations were for a median run size (p50 level, Appendix B) of 2,271,000 Fraser River sockeye salmon and a one in two chance that the run size would be between 1,296,000 and 4,227,000.
2. Pre-season expectations of migration parameters included a 75% diversion rate for Fraser River sockeye through Johnstone Strait. Expected Area 20 50% migration dates were July 3 for Early Stuart, July 21 for Early Summer, August 6 for Summer, and August 14 for Late-run sockeye.
3. Pre-season spawning escapement goals were 36,000 Early Stuart, 178,800 Early Summer, 722,000 Summer and 111,000 Late-run sockeye for a total of 1,047,800 sockeye spawners (Table 1). The goals for each sockeye management group were established by applying Canada's Spawning Escapement Plan (Appendix B) to the forecasted run size. For pre-season planning purposes, Early Stuart and Late-run sockeye were respectively constrained by a 10% and a 20% Low Abundance Exploitation Rate (LAER).
4. Management Adjustments (MAs) of 105,500 Early Summer and 79,400 Summer-run sockeye were added to the spawning escapement targets to increase the likelihood of achieving the targets. The spawning escapement targets for Early Stuart and Late-run sockeye were their entire run sizes at median forecast abundance levels. These targets coupled with the application of LAERs and the likelihood of some differences between estimates (DBEs) meant that spawning escapement targets were unlikely to be reached and therefore obviated the need for management adjustments for these two groups.
5. The pre-season MAs were derived from proportional difference between estimates (pDBE) for the Early Summer and Summer-run aggregates. These in turn were estimated as the weighted average of each component's median pDBE using historic data and their median pre-season forecast abundances. For Early Summer-run, the three components consisted of Chilliwack, Pitt and the remaining Early Summer-run stocks while the Summer-run aggregate was divided into Harrison and non-Harrison components. The median pDBE for Chilliwack was calculated using dominant/subdominant years, while the median for all other component groups was based on all years.
6. The projected Total Allowable Catch (TAC) of Fraser River sockeye salmon based on the median forecasted abundances and agreed deductions was 647,700 sockeye (Table 1), of which 16.5% (106,000 sockeye) were allocated to the United States (U.S.).
7. Pre-season model runs indicated it was unlikely the Summer-run TAC could be fully harvested due to fisheries constraints required to achieve spawning escapement targets for co-migrating Early Summer and Late-run stocks.
8. The Panel adopted the Management Plan Principles and Constraints, the 2016 Regulations, and the 2016 Pre-season Agreement on Test Fishing Deductions. (Appendices C, D and E).

In-season Management Considerations

9. Marine migration timing (Figure 3) was earlier than pre-season expectations for all management groups (except Early Stuart fish where the observed timing matched the expected timing): one day for Early Summer run, and 6 days for Summer run and Late run. No delay was detected in the migration behaviour for the Late run.
10. The overall Johnstone Strait diversion rate (Figure 4) for Fraser sockeye was 50% compared to the pre-season forecast of 75%.
11. Returns for all management groups were substantially below median pre-season forecasts (Early Stuart run: 50% below median forecast, Early Summer run: 46% below median forecast, Summer run: 68% below median forecast and Late run: 36% below median forecast). In context to the pre-season forecast range, the Early Stuart return was between the

p10 and p25 forecast, the Early Summer run slightly above the p25 forecast, Summer run below the p10 forecast, and Late run slightly above the p25 forecast.

12. Fraser River discharge was below average for the duration of the season while river temperatures were above average (Figure 5). Despite the high temperatures, the in-season model estimate of differences between potential spawning escapement and the actual number of spawners on the spawning grounds (DBE) was similar to the pre-season forecast for the Early Summer run. While early in the return the in-season DBE for the Summer run was higher than pre-season values, no in-season updates to DBEs were adopted in 2016 and eventually reductions to run size resulted in managing the Summer run under a low abundance exploitation rate (LAER) and the DBE was no longer relevant. As the pre-season forecast was similar to the in-season estimate for the Early Summer run, and the in-season run size for Early Stuart and Late run resulted in the groups being managed under a LAER scenario, DBEs were not relevant factors in determining management actions.

Run Size, Catch, Escapement and Migration patterns

13. Returns of adult Fraser sockeye totalled 858,000 fish (Tables 7 and 8), less than half the brood year abundance of 2,057,700 fish in 2012. This return was the smallest over the last 50 years (Figure 6). Divided into management groups, adult returns totalled 18,000 Early Stuart, 240,500 Early Summer-run, 529,200 Summer-run and 70,600 Late-run sockeye.
14. Catches of Fraser River sockeye salmon in all fisheries totalled 160,000 fish, including 149,000 fish caught by Canada, 1,700 fish caught by the U.S. and 8,800 fish caught by test fisheries (Table 7). Almost all the Canadian catch occurred in First Nations FSC fisheries (Food, Social and Ceremonial, 148,400 fish). In Washington, catches were in non-commercial and Treaty Indian commercial fisheries (850 fish each). Fisheries in Alaska harvested 34,000 Fraser sockeye (preliminary number). The overall harvest rate was 19% of the run, which is the smallest in recent years, excluding 2009, 2013 and 2015 (Figure 7).
15. DFO's near-final estimates of spawning escapements to streams in the Fraser River watershed totalled 485,000 adult sockeye (Tables 7 and 8). This was about half the brood year escapement of 925,000 adults and the lowest escapement on this cycle since 1964 (Figure 6). By management group and for this cycle line, spawning escapements in 2016 were one fourth of the average Early Stuart escapement, slightly higher than the average Early Summer-run escapement, less than 56% below the average Summer-run escapement and the lowest Late-run escapement on record (Figure 9). There were 229,300 effective female spawners in the Fraser watershed, representing an overall spawning success of 90.3%.

Achievement of Objectives

16. In order of descending priority, the goals of the Panel are to achieve the targets for spawning escapement, international sharing of the TAC, and domestic catch allocation.
17. In-season management decisions are based on targets for spawning escapement, which are represented in-season by potential spawning escapement targets (i.e., spawning escapement targets plus MAs). Early Stuart, Summer-run and Late-run sockeye were managed under a LAER, thus their potential spawning escapement targets were equal to the total returns for each group. In-season estimates of potential escapement (i.e., Mission escapement minus all catch above Mission) were 10-25% under the target for all management groups: Early Stuart sockeye (11% under), Early Summer-run (11% under), Summer-run (24% under) and Late-run sockeye (9% under) (Table 10).
18. Spawning ground estimates of Fraser sockeye abundance totalled 484,500 adults (Table 7, Table 8), which is 37% below the post-season target. Spawner abundance was severely below target for Early Stuart sockeye (52% under), on target for Early Summer-run, below target for Summer-run (48% under) and below target for Late-run sockeye (38% under) (Table 11). The Early Stuart (9%) and Late-run (9%) exploitation rate were both below their respective LAERs (10% and 20%). For Early Stuart, Summer-run and Late-run sockeye, the spawning escapement target equalled the run size, so the escapement target could only be obtained in the absence of catches *and* any difference between estimates. The Summer-run exploitation

rate (24%) was higher than the 10% LAER for this management group (Table 8). Even in the absence of catches, due to the observed difference between estimates, the Summer-run run size was insufficient to attain the escapement target, but reduced catches could have increased the spawning escapement to be closer to the target.

19. There was no International TAC (Total Allowable Catch) of Fraser sockeye (Table 12), based on the calculation method set out in Annex IV, Chapter 4 of the Pacific Salmon Treaty. The Washington catch of 1,700 Fraser sockeye was more than their 16.5% share. The total Canadian catch of 149,200 Fraser sockeye, which excludes the ESSR catch of Weaver sockeye (which was 0 in 2016) and includes a catch of 800 fish in the Albion test fishery was 800 fish more than the Canadian share of TAC + AFE. In these calculations, the TAC is fixed on the date that Panel control of the last U.S. Panel Area was relinquished (October 1 in 2016), while catches are post-season estimates.
20. In terms of domestic U.S. allocation objectives for Fraser sockeye, Treaty Indian fishers were 1,700 fish above their shares of the U.S. TAC (Table 13).
21. By-catches of non-Fraser sockeye salmon in commercial net fisheries regulated by the Fraser River Panel totalled 80 sockeye salmon (Table 14). Catches of other Fraser and non-Fraser salmon species included 190 chinook, 200 coho, and 30 chum.

Allocation Status

22. By Panel agreement there is a U.S. payback of 900 Fraser River sockeye to be carried forward from 2015. These were sockeye salmon that were landed in Panel regulated fisheries directed at Fraser River pink salmon in 2015. (Table 15). There is no payback owed for pink salmon.

II. FRASER RIVER PANEL

In 2016, the Panel operated under the terms of Annex IV, Chapter 4 of the Pacific Salmon Treaty between Canada and the United States (U.S.)[1]. The Fraser River Panel was responsible for in-season management of fisheries that target Fraser River sockeye and pink salmon within the Panel Area (Figure 1), including net fisheries in both countries and the Canadian troll fishery in the Strait of Georgia. Coordination of directed harvest of other salmon species and stocks intercepted in south coast areas is the responsibility of the Southern Panel and the Pacific Salmon Commission (PSC). Regulation of Southern Panel related fisheries is the responsibility of the appropriate agencies in each country.

Prior to the fishing season, the Fraser River Panel recommends a fishery regime for Panel Area fisheries to the Pacific Salmon Commission (PSC). The recommendation is based on: (1) abundance, timing and migration route forecasts and escapement targets for Fraser River sockeye and pink salmon provided by Canada's Department of Fisheries and Oceans (DFO); (2) international catch allocation goals set by the Treaty; (3) domestic catch allocation goals established by each country; (4) management concerns for other stocks and species also identified by each country; and (5) historical patterns in migration and fisheries dynamics. In descending priority, the objectives that guide the Panel's decision-making are to: (1) achieve the spawning escapement targets, (2) meet international catch allocation goals, and (3) meet domestic catch allocation objectives. Conservation concerns for other species and stocks that may occur as by-catch in fisheries directed at Fraser sockeye and pink salmon are generally addressed domestically with some international coordination. While not under Panel control, management of Canadian non-Panel area fisheries directed at Fraser River sockeye and pink salmon is based on the same in-season information and hierarchy of objectives.

The Panel's regulatory authority is implemented based on the principle that all Panel-regulated fisheries are to remain closed (Appendix D) unless opened by specific order (Appendix F). The pre-season plan identifies the approximate pattern of fishery openings required to achieve

[1] Pacific Salmon Treaty as modified through May 2014.

the Panel objectives given pre-season expectations. However, the Panel typically determines the actual pattern of fishery openings based on in-season assessments by PSC staff (Staff, Appendix J) of sockeye and pink salmon run size, migration timing and route, in-river migration abundance (i.e., Mission escapement) and Management Adjustments. Thus, the Panel responds to deviations from pre-season expectations in their weekly fishery planning meetings and most substantive fishery decisions are based on in-season rather than pre-season assessments. The Fraser River Panel Technical Committee (Appendix I) works in conjunction with Staff to facilitate Panel activities by providing their respective National sections of the Panel with technical advice and ensuring timely exchange of data between Staff and the Parties.

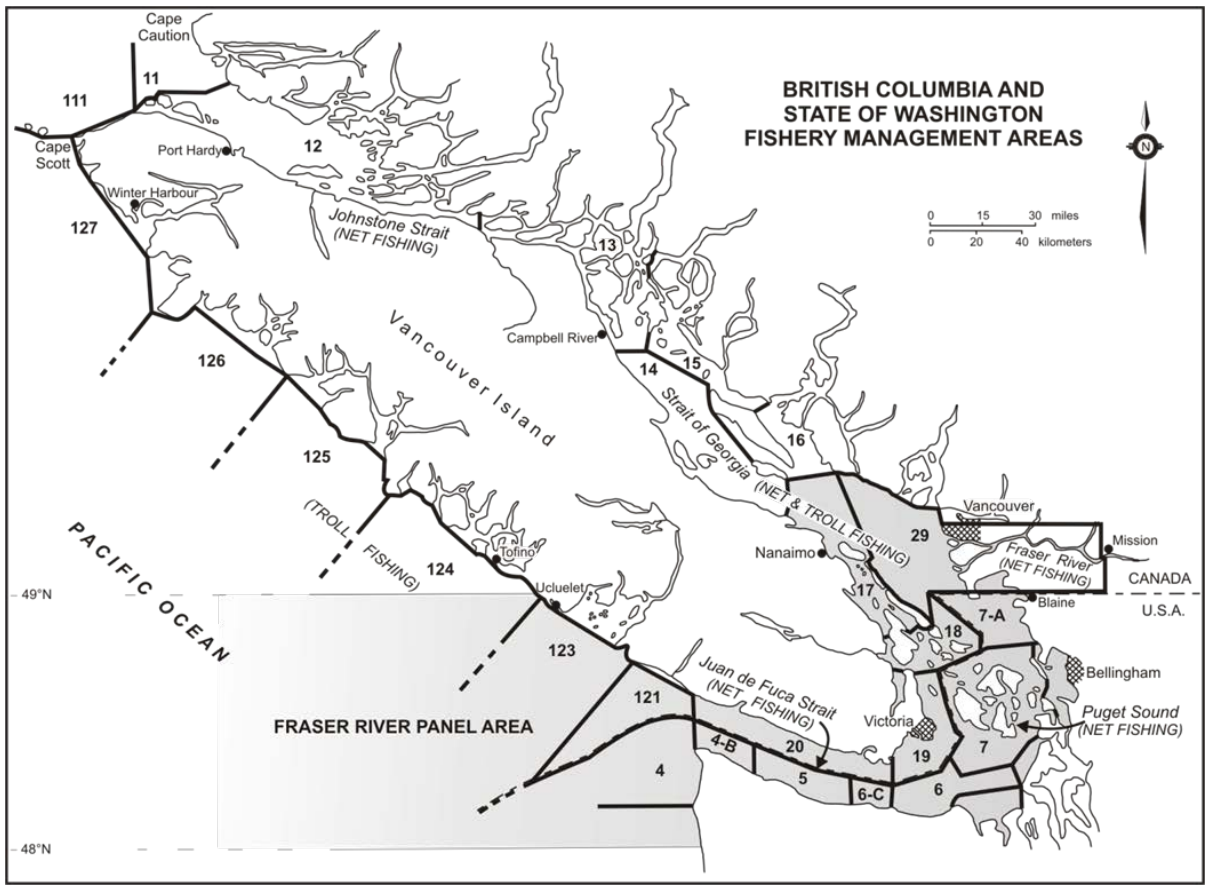

Figure 1. Fishery management areas in the Fraser River Panel Area and south coast waters.

III. PANEL MANAGEMENT ACTIVITIES

Information used for Panel management can be divided into three general categories: (1) pre-season forecasts and expectations, on which pre-season planning activities and the management plan are based; (2) in-season estimates that change over the course of the season, on which in-season fishery decisions are based; and (3) post-season estimates derived from information that was unavailable during the season, such as spawning ground estimates of escapement, more complete catch estimates, and adjustments to estimates that with hindsight appear to have been biased or incorrect. Key information in these categories is discussed in the following sections.

A. Pre-season Planning

Pre-season fisheries management plans for Panel Area fisheries were developed by the Panel using the Fishery Planning Model[2], which helps to evaluate the impacts of alternative fishery options on the achievement of management objectives. Model inputs include forecasts of run size, migration timing, diversion rate, Gulf delay, and MAs, as well as test fishery deductions and objectives for spawning escapement and catch allocation. Inputs to the "base case" planning model are summarized under the "Pre-season" rows in Table 1.

Both countries evaluated fishing plans that included directed sockeye fisheries. The fisheries targeted mainly Summer-run fish, as well as a smaller number of Early Summer run fish. The ability of either country to achieve their sockeye TAC was constrained by a 10% low abundance exploitation rate (LAER) applied to Early Stuart sockeye early in the season and a 20% LAER for Late run fish later in the season. The LAER is applied to accommodate by-catch for management groups with little or no TAC, as detailed in Canada's escapement plan (Appendix B) and consistent with the concept of "small but acceptable rate of incidental harvest" outlined in paragraph 3(e) of Chapter 4 of the Treaty. Alternative model runs explored the sensitivity of fishing plans to sockeye salmon run size, and fishing plans were developed based on the p50 run size as well as the p75 run size. At the p50 run size Canada did not include commercial fisheries in the model, but did include First Nations' fisheries. At the p75 level Canada included limited commercial fisheries in the model, while the US included commercial fisheries at both the p50 and p75 level for both the 'All Citizen' and 'Tribal Indian' fisheries. An alternative escapement plan was also modeled, one which included higher escapement targets and therefore lower total allowable catch (TAC); this is referred to as Escapement Option 2.

The preliminary run-size forecast for Fraser River sockeye salmon was produced by Canada using a variety of stock-recruit models similar to those evaluated in previous years and with data up until the 2009 brood year (2010 brood year for Harrison)[3]. Canada presented the Panel with a sockeye run-size forecast corresponding to five probability levels (10%, 25%, 50%, 75% and 90%) that the return would be below, or at, the specified abundance (Appendix B, Table 1). In 2016, the Panel used the median (i.e., 50% probability level) forecast of 2.3 million Fraser River sockeye salmon as the "base case" scenario for planning purposes. The Panel also explored several alternative model scenarios with varying abundances of sockeye salmon ranging from the 50% to 75% probability levels.

Canada used the "Fraser River Sockeye Spawning Initiative" (FRSSI) model[4] to establish escapement goals for the 2016 management season. The spawning escapement plan released by Canada to the Panel (Appendix B, Table 2) was based on FRSSI guidelines with input from a domestic consultation process. Pre-season escapement targets for sockeye at the 50% run size levels by management group were: Early Stuart – 36,000; Early Summer – 178,800; Summer – 722,000; and Lates – 111,000[5]. At this abundance level, the Early Stuart run was managed to a 10% LAER and the Late run was managed to a 20% LAER instead of the associated escapement targets.

Pre-season fisheries management planning was based on assumptions about the proportions of Fraser sockeye salmon that would migrate through Juan de Fuca Strait versus Johnstone Strait (i.e.

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[2] Cave, J.D. and W.J. Gazey. 1994. A pre-season simulation model for fisheries on Fraser River sockeye salmon (*Oncorhynchus nerka*). Can. J. Fish. Aquat. Sci. 51(7): 1535-1549.
[3] DFO. 2016. Pre-season run size forecasts for Fraser River Sockeye (*Oncorhynchus nerka*) salmon in 2016. DFO Can. Sci. Advis. Sec. Sci. Resp. 2016/021.
[4] DFO. 2010. Guidelines for applying updated methods for assessing harvest rules for Fraser River sockeye salmon (Onchorhynchus nerka). Can. Sci. Advis. Sec. Sci. Advis. Rep. 2010/070.
[5] 2016/2017 Salmon Integrated Fisheries Management Plan Southern BC. Fisheries and Oceans Canada.

Johnstone Strait diversion rate, Figure 2) as well as marine timing (i.e. Juan de Fuca or Area 20 50% migration dates). Area 20 dates are indices of marine migration timing and represent the date when 50% of the total run would have entered Juan de Fuca Strait (Canadian Area 20) if the entire run had migrated via that route. For planning purposes, the Panel adopted the median Area 20 run timing forecast of July 2 for Early Stuart, as generated by DFOs oceanographic models[6], which is two days earlier than the historical median of July 4, and August 4 for Chilko fish, which is identical to the historic median on the 2016 cycle, but 5 days earlier than the historical median timing of August 9 for all cycles combined. Area 20 timing for the Early Miscellaneous, Scotch/Seymour, Late Stuart/Stellako, Chilko/Quesnel, Raft/North Thompson, Harrison, Adams/Weaver and Birkenhead groups were calculated as a function of Early Stuart and Chilko timing using historical regression models to forecast the timing of component stocks. The timing of individual stocks was then weighted by the 50% pre-season forecast run sizes (or the 2012 brood year abundance in the case of Horsefly and Mitchell) to calculate a pre-season timing forecast for each aggregate in the Planning Model. For planning purposes, the Panel used weighted average Area 20 dates of July 19 for the Early Summer run, August 3 for Summer run and August 12 for Late run based on the timing and abundance of component groups. Before the planning model for 2016 was finalized, there was an update to the forecast timing. The new forecast was a Chilko timing of August 7. By that point, the Early Stuart run was nearing completion and the in-season timing for that group was July 3. The timing regression models were re-run with these updated timing estimates and the timing for each of the management groups was updated in the planning model accordingly. The final pre-season planning model estimate for the management groups' Area 20 timing was July 3 for Early Stuart, July 21 for Early Summers, August 6 for Summers, and August 14 for Lates.

The Panel chose to adopt a 75% diversion rate of Fraser sockeye through Johnstone Strait forecast from Kains Island May sea surface temperatures and January northward currents by DFOs oceanographic models. The diversion rate for the Harrison component was set to 46% (61% of the diversion forecast for the total sockeye run) based on historical correlations showing a traditionally lower rate of northern diversion. Figure 3 illustrates the distribution of daily abundances for each sockeye management group given these pre-season assumptions of Area 20 timing and total run size.

The Panel adopted a 0-day upstream "delay" for modelling non-Birkenhead Late-run migratory behaviour, corresponding to the median observed delay for the 2016 cycle line, and resulting in an August 22 Mission 50% date (i.e. the date 50% of the run has passed Mission) for the overall Late run. The model also assumed a 0-day delay for Harrison sockeye (median of 2016 cycle line; Harrison sockeye are part of the Summer-run management group), resulting in an August 12th Mission 50% Date.

DFO's Environmental Watch Program provided the Panel with long-range (3-month) projections of Fraser River temperature and discharge conditions. Forecasts projected below-average discharge and above-average water temperatures for all sockeye management groups. Staff used the environmental forecasts in Management Adjustment (MA) models developed jointly by DFO and the PSC to predict how many additional Early Stuart, Early Summer and Summer-run sockeye should be allowed to escape to increase the probability of achieving spawning escapement objectives (see C. Management Adjustments and DBEs). The Panel chose not to adopt any of the proportional management adjustments (pMAs) forecast from the environmental MA models. Instead, the Panel adopted all-years historical median pMAs for Early Stuart, Early Summer, and Summer runs: Early Stuart pMA = 0.69 (24,800 fish), Early Summer

[6] Folkes, Michael J P and Thomson, Richard E and Hourston, Roy A S. 2016 (in press). Evaluating Models To Forecast Fraser Sockeye Return Timing And Diversion Rate. DFO Can. Sci. Advis. Sec. Res. Doc. 2016

pMA = 0.59 (105,500 fish), Summer pMA = 0.11 (79,400 fish), and the 2016 cycle line median for the Late run (pMA = 0.47; 52,200 fish).

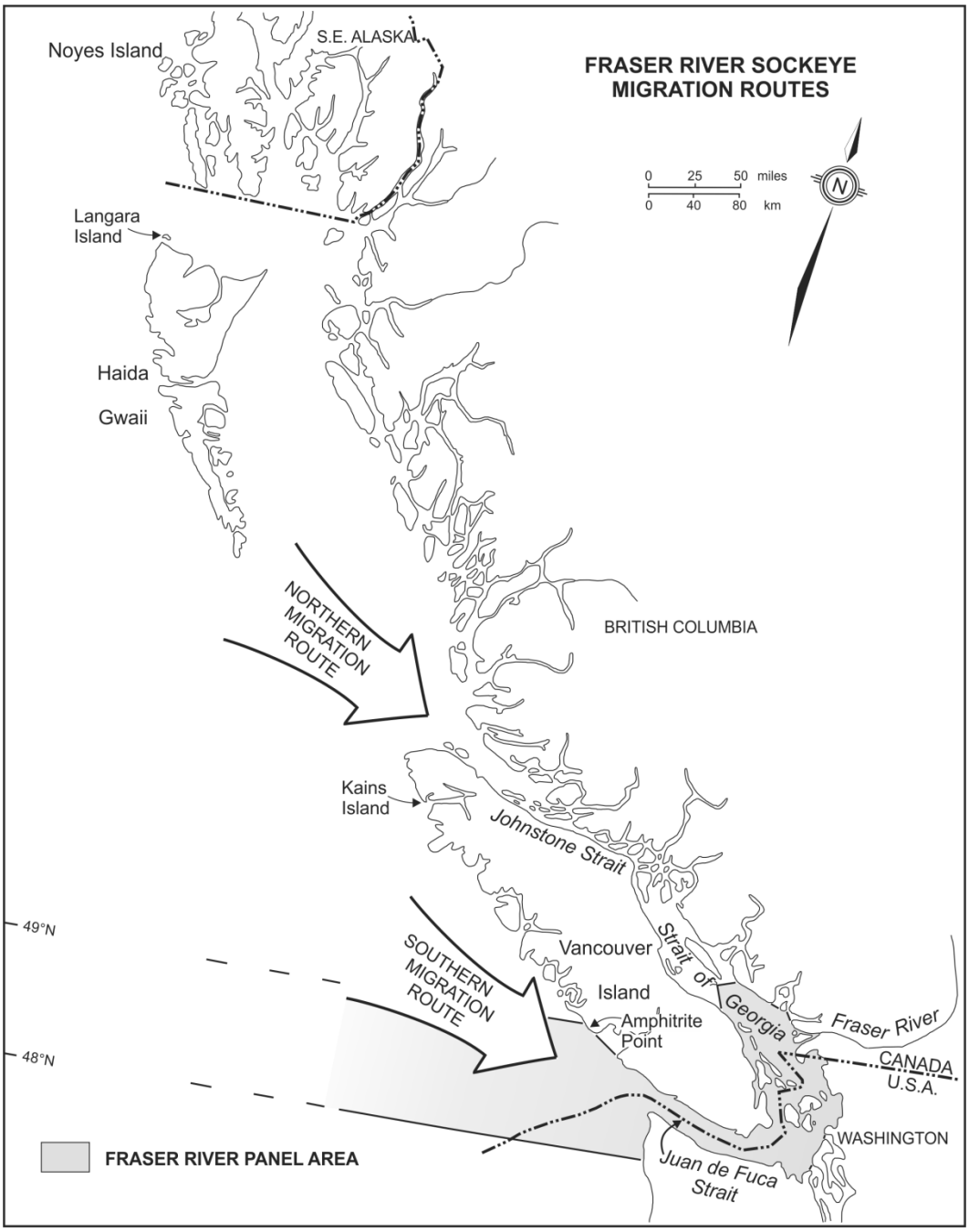

Figure 2. The northern (Johnstone Strait) and southern (Juan de Fuca Strait) routes for sockeye and pink salmon migration to the Fraser River.

At the time of the June meeting, a reduced test fishing program was planned for 2016 due to financial constraints, with the test fishing schedule having later start dates and earlier end dates than in previous years on the same cycle line, as well as fewer test fisheries overall. The test fisheries that would usually run but that were not planned for 2016 included the Naka Creek gillnet test fishery in Area 12, the purse seine test fishery in Area 13, and the gillnet test fishery in

U.S. Area 4B/5. Initial model runs at the June meeting assumed landed catches of 34,000 sockeye, and retention of payfish was delayed by 4 days in Area 12 in the initial planning model runs due to conservation concerns for Sakinaw sockeye salmon. After discussion at the June meeting and subsequent meetings in June and July, it was decided to reduce the Test Fishing deduction to just those fish modelled to be caught in gillnets and those needed for sampling (termed 'non-discretionary catch'), which, based on the planning model, equalled 15,500 sockeye. Retention dates and test fishing deductions by management group for the purposes of calculating the TAC were determined by running the planning model without any competing fisheries. There were some differences in the distribution and abundances of landed test fishing catches once additional fisheries were included in the model.

The Panel considered four alternative planning scenarios at the June meeting that included variations in the assumed sockeye salmon run sizes, two different escapement options, and different levels of fishing intensity. At the time of the meeting, Canada's escapement plan had not yet been approved by Canada's Minister of Fisheries and Ocean, and so the fishing plan was not finalized. The fishing plan was finalized in mid-July, at which point the model was run again with the final escapement plan, and assuming a p50 run size. The final planning model run included a test fishing deduction of 15,500 sockeye, and also included timing and diversion rate expectations, as previously mentioned. Canada and the U.S. updated their fishing plans based on the finalized input, and adopted the finalized planning model as the "base case" scenario.

Canada and the U.S. adopted a management plan under the "base case" conditions described above, including the "2016 Fraser River Panel Management Plan Principles and Constraints" and "2016 Pre-season Agreement on Test Fishing Deductions and use of the Test Fishing Revolving Fund", (Appendices C and E). Due to conservation concerns, a 3-week moving window for closure of fisheries on Early Stuart sockeye and 1-week closure for early timed components of the Early Summer run as well as restrictions in place to protect Sakinaw sockeye constrained fishery openings for earlier dates in the pre-season plan[7]. In the pre-season plan, the first potential salmon fisheries directed at Fraser sockeye commenced on July 23 in U.S. Panel-Area waters. Other than marine FSC fisheries, Canada did not model any sockeye directed fisheries in Panel-Area waters as part of their pre-season plan. If in-season assessments indicated that return abundances of sockeye were lower or higher than forecast, that the migration timing of sockeye salmon were substantially different than forecast, or that in-season forecasts of MAs deviated from the pre-season forecasts, then the start dates and duration of planned fisheries could deviate from the proposed plan.

Calculations of TACs and international harvest shares for Fraser sockeye were based on Annex IV, Chapter 4 of the Pacific Salmon Treaty. The pre-season TAC for international sharing was 647,700 sockeye (Table 1), of which the 16.5% U.S. (Washington) share was 106,900 fish. The U.S. payback carried over from the previous year was 900 sockeye, leaving 106,000 as the U.S. share. Treaty Indian fishers were allocated 67.9% of the U.S. TAC and All Citizen fishers the remaining 32.2%. The remaining balance to Canada including the 400,000 Aboriginal Fishery Exemption (AFE) was 941,700 sockeye. Pre-season catch targets for non-commercial fisheries in Canada included 697,400 fish for in-river First Nations and 244,300 fish for marine First Nations. There were no Canadian commercial fisheries planned pre-season based on the p50 run size.

During the pre-season planning process, both countries identified salmon stocks for which they had conservation concerns and that would influence management decisions for fisheries directed at Fraser sockeye salmon. Canada identified Sakinaw sockeye salmon, southern Georgia Strait Coho and Chinook stocks, Interior Fraser coho and some Steelhead populations, particularly in the Thompson River, as well as non-salmon species including southern resident killer whales and lingcod. The U.S. highlighted concerns for Puget Sound Chinook salmon, Hood Canal

[7] Pacific Salmon Commission. 2016/17 32nd Pacific Salmon Commission Annual Report. http://www.psc.org/publications/annual-reports/commission/.

summer-run chum salmon, and the southern resident killer whale. Three individual populations of Puget Sound Chinook salmon are of particular concern because of listings under the Federal Endangered Species Act: Dungeness, South Fork Stillaguamish, and South Fork Nooksack. The U.S. also highlighted that U.S. coastal Coho salmon stocks are at critical thresholds throughout Puget Sound and along the Washington coast.

B. In-season Management

In 2016, all sockeye salmon management groups returned at run sizes that were well below the median pre-season forecasts, and with marine timing earlier than forecasted except for the Early Stuart run which returned with marine timing as forecast (Figure 3).

The Fraser River Panel convened 14 times between July 08, 2016 and August 26, 2016 to discuss run status and enact in-season orders (Appendix F) to regulate fisheries directed at Fraser River sockeye salmon harvests in Panel Areas. Table 1 summarizes pre-season and in-season data by management group and by meeting date, including estimates of run size and the various deductions that result in the calculated TAC (i.e., spawning escapement target, MA, projected test fishery catch and Aboriginal Fishery Exemption). Also shown are estimates of available harvest (run size minus spawning escapement target and MA), catch to date, Mission escapement to date and 50% migration dates. The last date shown in Table 1 (October 1) is the "TAC date", which is when the Panel relinquished regulatory control of the last U.S. Panel Area and is therefore when the U.S. share of the TAC was established. The main events that transpired each week of the season are summarized below with a focus on Staff assessments and Panel decisions.

Jul 02 – Jul 08, 2016:

The first in-season Panel meeting took place on Friday, July 08. Only a small number of sockeye had been caught in the in-river test fisheries at the time of the meeting. While the limited data did not allow an assessment of run size and timing for Early Stuart and Chilliwack, daily abundance estimates seemed to correspond with pre-season expectations. The Fraser River water temperature at Hope was 16.4ºC and the discharge was 5,336 $m^3 \cdot s^{-1}$.

Jul 09 – Jul 15, 2016:

Due to favorable deployment conditions, the Mission hydroacoustics program was operational on July 08, three days earlier than expected. Flow levels continued to decrease while temperature stayed fairly constant for the week, around 17.7°C. An updated forecast was received from DFO which had a 1% lower northern diversion rate of 75% and a Chilko timing of August 7, three days later than the June forecast. The Early Stuart sockeye run appeared to be tracking near the p25 pre-season forecast of 22,000. Preliminary assessments of the Chilliwack component of the Early Summer-run group indicated that their run size was below the median forecast of 138,000 fish.

Jul 16 – Jul 22, 2016:

Marine test fisheries indicated a moderate migration of Fraser River sockeye through marine assessment areas. On July 19, the Panel decreased the Early Stuart run size to 22,000 with a 50% marine timing through Area 20 of July 3. The Chilliwack component of the Early Summer-run group indicated a run size of 81,000, which is below the median forecast of 138,000 fish. Daily abundance estimates for the remainder of the Early Summer run seemed to be tracking the p25 forecast. The diversion rate continued to be low at 23%. On July 22, the Panel approved a drift gillnet Treaty Indian Fishery in Areas 4B, 5 and 6C, with an expected catch of about 100 sockeye/boat/day. The Fraser River water temperature at Qualark was 18.6ºC and the discharge was 3,952 $m^3 \cdot s^{-1}$.

Table 1. Pre-season and in-season updates of run size, spawning escapement targets and other TAC-related values for Fraser River sockeye salmon in 2016. The available harvest (run size minus spawning escapement target and management adjustment), catch to date, Mission escapement to date and migration timing are also shown.

Date		Management Group	Total Abundance	TAC* Spawning Escapement Target***	pMA	Manage-ment Adjust.	Test Fishing ***	Aboriginal Fishery Exemption ***	Total Allowable Catch	Available Harvest **	Catch to date	Mission Passage to date	50% Migration Date Area 20
	Pre-season	Early Stuart	36,000	36,000	NA	NA	100	3,400	0	0			3-Jul
		Early Summer	447,000	178,800	0.59	105,500	3,800	79,400	79,500	162,700			21-Jul
		Summer	1,677,000	722,000	0.11	79,400	11,200	296,200	568,200	875,600			6-Aug
		Late	111,000	111,000	NA	NA	400	21,000	0	0			14-Aug
		Sockeye	**2,271,000**	**1,047,800**		**184,900**	**15,500**	**400,000**	**647,700**	**1,038,300**			
July 8	In-season	Early Stuart	36,000		NA	NA					0	NA	
		Early Summer	447,000		0.59						0	NA	
		Summer	1,677,000		0.11						0	NA	
		Late	111,000		NA	NA					0	NA	
		Sockeye	**2,271,000**								**0**	**NA**	
July 12	In-season	Early Stuart	36,000		NA	NA					0	7,600	
		Early Summer	447,000		0.59						100	27,900	
		Summer	1,677,000		0.11						0	0	
		Late	111,000		NA	NA					0	0	
		Sockeye	**2,271,000**								**100**	**35,500**	
July 15	In-season	Early Stuart	36,000	36,000	NA	NA	100	3,400	0	0	100	10,200	3-Jul
		Early Summer	447,000	178,800	0.59	105,500	3,800	79,400	79,500	162,700	300	36,900	21-Jul
		Summer	1,677,000	722,000	0.11	79,400	11,200	296,200	568,200	875,600	100	800	6-Aug
		Late	111,000	111,000	NA	NA	400	21,000	0	0	0	0	14-Aug
		Sockeye	**2,271,000**	**1,047,800**		**184,900**	**15,500**	**400,000**	**647,700**	**1,038,300**	**500**	**47,900**	
July 19	In-season	Early Stuart	22,000	22,000	NA	NA	100	3,400	0	0	200	11,100	3-Jul
		Early Summer	447,000	178,800	0.59	105,500	3,800	79,400	79,500	162,700	600	53,200	21-Jul
		Summer	1,677,000	722,000	0.11	79,400	11,200	296,200	568,200	875,600	300	2,200	6-Aug
		Late	111,000	111,000	NA	NA	400	21,000	0	0	0	0	14-Aug
		Sockeye	**2,257,000**	**1,033,800**		**184,900**	**15,500**	**400,000**	**647,700**	**1,038,300**	**1,100**	**66,500**	
July 22	In-season	Early Stuart	22,000	22,000	NA	NA	200	2,100	0	0	300	15,200	3-Jul
		Early Summer	447,000	178,800	0.59	105,500	3,800	79,700	79,200	162,700	1,600	75,600	21-Jul
		Summer	1,677,000	722,000	0.11	79,400	11,200	297,100	567,300	875,600	900	9,200	6-Aug
		Late	111,000	111,000	NA	NA	300	21,100	0	0	0	100	14-Aug
		Sockeye	**2,257,000**	**1,033,800**		**184,900**	**15,500**	**400,000**	**646,500**	**1,038,300**	**2,800**	**100,100**	
July 26	In-season	Early Stuart	22,000	22,000	NA	NA	200	2,100	0	0	400	16,900	3-Jul
		Early Summer	447,000	178,800	0.59	105,500	3,800	79,700	79,200	162,700	2,500	108,800	21-Jul
		Summer	1,677,000	722,000	0.11	79,400	11,200	297,100	567,300	875,600	3,100	29,000	6-Aug
		Late	111,000	111,000	NA	NA	300	21,100	0	0	0	100	14-Aug
		Sockeye	**2,257,000**	**1,033,800**		**184,900**	**15,500**	**400,000**	**646,500**	**1,038,300**	**6,000**	**154,800**	
July 29	In-season	Early Stuart	22,000	22,000	NA	NA	200	2,100	0	0	500	16,700	3-Jul
		Early Summer	447,000	178,800	0.59	105,500	3,800	79,700	79,200	162,700	4,400	146,300	21-Jul
		Summer	1,677,000	722,000	0.11	79,400	11,200	297,100	567,300	875,600	5,100	75,400	6-Aug
		Late	111,000	111,000	NA	NA	300	21,100	0	0	200	700	14-Aug
		Sockeye	**2,257,000**	**1,033,800**		**184,900**	**15,500**	**400,000**	**646,500**	**1,038,300**	**10,200**	**239,100**	
August 2	In-season	Early Stuart	22,000	22,000	NA	NA	200	2,000	0	0	500	17,900	3-Jul
		Early Summer	300,000	156,000	0.59	92,000	3,800	48,200	0	48,200	4,900	181,400	22-Jul
		Summer	1,677,000	722,000	0.11	79,400	11,200	327,900	536,500	864,400	6,200	144,600	6-Aug
		Late	111,000	111,000	NA	NA	300	21,900	0	0	400	2,300	14-Aug
		Sockeye	**2,110,000**	**1,011,000**		**171,400**	**15,500**	**400,000**	**536,500**	**912,600**	**12,000**	**346,200**	
August 5	In-season	Early Stuart	18,000	18,000	NA	NA	200	1,100	0	0	800	17,900	3-Jul
		Early Summer	300,000	156,000	0.59	92,000	3,800	48,200	0	48,200	14,900	195,800	22-Jul
		Summer	992,000	722,000	0.11	79,400	11,200	179,400	0	179,400	31,300	187,600	6-Aug
		Late	111,000	111,000	NA	NA	300	21,900	0	0	1,700	6,000	14-Aug
		Sockeye	**1,421,000**	**1,007,000**		**171,400**	**15,500**	**250,600**	**0**	**227,600**	**48,700**	**407,300**	

Table 1, continued on next page

Table 1, continued.

Date		Management Group	Total Abundance	TAC* Spawning Escapement Target	pMA	Manage-ment Adjust.	Test Fishing	Aboriginal Fishery Exemption***	Total Allowable Catch	Available Harvest **	Catch to date	Mission Passage to date	50% Migration Date Area 20
August 9	In-season	Early Stuart	18,000	18,000	NA	NA	175	1,100	0	0	800	17,900	3-Jul
		Early Summer	250,000	156,000	0.59	92,000	3,000	48,200	0	0	16,900	211,800	21-Jul
		Summer	700,000	700,000	0.11	77,000	6,000	179,400	0	0	53,700	262,500	3-Aug
		Late	111,000	111,000	NA	NA	500	21,900	0	0	4,400	15,600	14-Aug
		Sockeye	**1,079,000**	**985,000**		**169,000**	**9,675**	**250,600**	**0**	**0**	**75,800**	**507,800**	
August 12	In-season	Early Stuart	18,000	18,000	NA	NA	175	1,100	0	0	1,300	17,900	3-Jul
		Early Summer	250,000	156,000	0.59	92,000	3,000	22,000	0	0	24,700	216,000	21-Jul
		Summer	600,000	600,000	0.11	66,000	6,000	64,000	0	0	90,000	295,900	31-Jul
		Late	111,000	111,000	NA	NA	500	21,700	0	0	5,900	20,600	14-Aug
		Sockeye	**979,000**	**885,000**		**158,000**	**9,675**	**108,800**	**0**	**0**	**121,900**	**550,400**	
August 16	In-season	Early Stuart	18,000	18,000	NA	NA	175	1,100	0	0	130	17,900	3-Jul
		Early Summer	250,000	156,000	0.59	92,000	3,000	22,000	0	0	24,700	221,200	21-Jul
		Summer	600,000	600,000	0.11	66,000	6,000	64,000	0	0	90,400	350,200	31-Jul
		Late	111,000	111,000	NA	NA	1,000	21,700	0	0	5,900	31,200	14-Aug
		Sockeye	**979,000**	**885,000**		**158,000**	**10,175**	**108,800**	**0**	**0**	**121,130**	**620,500**	
August 19	In-season	Early Stuart	18,000	18,000	NA	NA	175	1,100	0	0	1,500	17,900	3-Jul
		Early Summer	240,000	156,000	0.59	92,000	3,000	22,000	0	0	25,100	221,900	20-Jul
		Summer	520,000	520,000	0.11	57,200	6,000	64,000	0	0	98,000	382,400	30-Jul
		Late	75,000	75,000	NA	NA	1,000	21,700	0	0	6,000	36,600	8-Aug
		Sockeye	**853,000**	**769,000**		**149,200**	**10,175**	**108,800**	**0**	**0**	**130,600**	**658,800**	
August 26	In-season	Early Stuart	18,000	18,000	NA	NA	175	1,300	0	0	1,500	17,900	3-Jul
		Early Summer	240,000	156,000	0.59	92,000	3,000	22,700	0	0	25,900	226,700	20-Jul
		Summer	520,000	520,000	0.11	57,200	6,000	101,000	0	0	107,900	427,300	30-Jul
		Late	75,000	75,000	NA	NA	1,000	5,400	0	0	6,200	49,600	8-Aug
		Sockeye	**853,000**	**769,000**		**149,200**	**10,175**	**130,400**	**0**	**0**	**141,500**	**721,500**	
October 1	TAC Date	Early Stuart	18,000	18,000	NA	NA	175	1,381	0	0	1,600	17,900	3-Jul
		Early Summer	240,000	156,000	0.59	92,000	3,000	23,096	0	0	26,300	228,800	20-Jul
		Summer	528,000	528,000	0.11	58,100	6,000	106,046	0	0	113,200	476,000	31-Jul
		Late	70,000	70,000	NA	NA	1,000	5,439	0	0	6,200	64,700	8-Aug
		Sockeye	**856,000**	**772,000**		**150,100**	**10,175**	**135,962**	**0**	**0**	**147,300**	**787,400**	

* The TAC is determined by the run sizes and TAC deductions (spawning escapement targets, management adjustments, projected test fishing catches and AF Exemptions) that were in effect when Panel control of the last U.S. fishery area was relinquished.

** Available Harvest = Total abundance minus spawning escapement target and Management Adjustment.

*** Spawning escapment target, test fishing deductionsand aboriginal fishery exemptions not in place until July 15 Panel meeting.

Jul 23 – Jul 29, 2016:

The Early Stuart run was very close to completion with an estimated catch plus escapement of 17,200. The Early Summer run continued to return in fairly low abundances especially for Chilliwack sockeye. Pitt sockeye on the other hand, appeared to be returning at levels similar to the pre-season forecast of 90,000. The accounted run to date of Early Summer-run sockeye was 150,700. The age composition of marine samples for the returning sockeye was cause for concern as the proportion of 4 year olds was lower than expected preseason. As of July 28, the Fraser River water discharge at Hope was 3,868 $m^3 \cdot s^{-1}$ and the water temperature at Qualark was 19.3ºC. Total Fraser sockeye catches in Areas 4B, 5 and 6C thus far totaled 1,600 sockeye (approximately equally split between commercial and ceremonial and subsistence harvests). On July 29, the Panel approved an extension to the Treaty Indian gillnet commercial fishery in Areas 4B, 5 and 6C through Wednesday August 3rd.

Jul 30 – Aug 5, 2016:

On August 2, the Panel decreased the Early Summer-run run size to 300,000 with a 50% marine timing through Area 20 of July 22. The Panel also approved the extension of the Area 4B, 5 and 6C gillnet commercial fishery until Saturday, August 6.

As of August 4 the estimated catch plus escapement of Early Stuart, Early Summer-, Summer- and Late-run sockeye was 18,700, 210,700, 218,900 and 7,700 fish, respectively. The Fraser River water discharge at Hope was 3,270 $m^3 \cdot s^{-1}$ and the water temperature at Qualark was 19.0ºC. On August 5, the Panel decreased the Early Stuart run size to 18,000 while the 50% marine timing through Area 20 remained July 3. The Summer-run group was the dominant management group in the marine area samples; however, the daily abundance levels were much less than expected. Given the high fractions of age 5 sockeye (32% for Chilko compared to 3% expected pre-season), this indicated a poorer return of age 4 sockeye. As a result, on August 5 the Panel decreased the Summer-run run size to the p25 forecast of 992,000 sockeye, while the 50% marine timing through Area 20 remained at August 6. The decreases to the Early Summer- and Summer-run run sizes resulted in no available international total allowable catch (TAC).

Aug 6 – Aug 12, 2016:

Given the lack of available International TAC and low effort, the gillnet fishery in Areas 4B, 5, and 6C closed as scheduled (August 6) with an estimated total Fraser sockeye catch of only 1,700 fish. On August 9, the Panel decreased the Early Summer-run to 250,000 with a 50% marine timing through Area 20 of July 21. The fraction of age 5 sockeye remained high for the Summer-run component. On August 9, the Panel decreased the Summer-run to 700,000 with a 50% marine timing through Area 20 of August 3, and on August 12 the Panel adopted a further reduction to 600,000, with a 50% marine timing through Area 20 of July 31. The low run size estimate for both the Early Summer as well as the Summer-run management group triggered the implementation of a low abundance exploitation rate (LAER) limit of 10% for both groups as of August 9. Catch as well as escapements past Mission remained low through August 11, totaling 672,300 sockeye. As of August 11, the Fraser River water discharge at Hope was 3,002 $m^3 \cdot s^{-1}$ and the water temperature at Qualark was 20.2ºC. The Panel did not change the management adjustment factor for the Early Summer-run since there was no management implications due to the LAER.

Aug 13 – Aug 19, 2016:

Catch as well as escapements remained low, totaling 789,400 sockeye on August 18. On August 19, the Panel adopted decreases to the Early Summer-, Summer- and Late-run run sizes of 240,000, 520,000 and 75,000 sockeye, respectively. This resulted in an in-season run size estimate for total Fraser River sockeye of 853,000 fish, which was the lowest run-size estimate since 1893, the earliest year for which run size estimates are available. The associated estimates of median marine timing dates for these management groups were July 20, July 30 and August 8, respectively, while the 50% marine timing for the total Fraser sockeye run was July 27. As of August 18, the Fraser River water discharge at Hope was 2,706 $m^3 \cdot s^{-1}$ and the water temperature at Qualark was 20.6ºC. Since run sizes for all management groups were at levels leading to implementation low abundance exploitation rates (LAERs), no management adjustments to account for adverse river conditions were required.

Aug 20 – Aug 26, 2016:

Catch as well as escapements remained low, totaling 789,400 sockeye on August 25. Based on the total in-season run size estimates of 853,000 sockeye, about 7% (63,600 fish) of the run was still expected to be seaward of Mission, most of which was in the Summer-run aggregate.

On October 1, Panel control of the last U.S. Panel Area was relinquished, in accordance with the pre-season regulations. The inputs used to calculate the TAC and international shares were frozen on this date (except for post-season updates to the test fishery catch deduction), according to the revised Annex IV, Chapter 4 of the Pacific Salmon Treaty. The achievement of these in-season catch objectives will be assessed by comparison with post-season catch estimates in the Achievement of Objectives section of this report.

Overviews of commercial fisheries openings in U.S. Panel Areas are contained in Table 2. There were no commercial fisheries in Canadian Panel Areas.

Table 2. Number of days when major U.S. net fisheries in the Fraser River Panel Area were open for directed harvest of Fraser River sockeye salmon in 2016. Regulatory control of U.S. Panel Areas was relinquished by the Panel on September 3 for Areas 4B, 5, 6C, 6, 6A, 7 and portions of 7A. The remaining portions of 7A were relinquished on October 1 in accordance with pre-season regulations (Appendix F).

	Treaty Indian		All Citizen		
	Areas	Areas	Areas 7 and 7A		
Date	4B, 5, 6C	6, 7, 7A	Purse Seine	Gillnet	Reefnet
May.1-Jun.18					
Jun.19-Jun.25					
Jun.26-Jul.2					
Jul.3-Jul.9					
Jul.10-Jul.16					
Jul.17-Jul.23	1				
Jul.24-Jul.30	7				
Jul.31-Aug.6	7				
Aug.7-Aug.13					
Aug.14-Aug.20					
Total	15	0	0	0	0

Table 3. Panel-approved stock monitoring operations (test fishery, hydroacoustic and observer) conducted during the 2016 fishing season.

Area	Location	Gear	Dates	Operated by
Canadian Panel Areas				
20	Juan de Fuca Str.	Gillnet	July 11 - August 3	PSC
20	Juan de Fuca Str.	Purse Seine	July 22 - August 12	PSC
29-14	Fraser R. (Cottonwood)	Gillnet	July 7 - August 23	PSC
29-16	Fraser R. (Whonnock)	Gillnet	June 30 - September 11	PSC
29-16	Fraser R. (Mission)	Hydroacoustic	July 8 - August 29	PSC
	Fraser R. (Qualark)	Gillnet	July 1 - September 2	PSC
	Fraser R. (Qualark)	Hydroacoustic	July 1 - September 3	DFO
	Fraser R. (Hells Gate)	Observer	July 2 - August 26	PSC
Canadian non-Panel Areas				
12	Queen Charlotte Str. (Round Is.)	Gillnet	July 11 - August 9	DFO
12	Johnstone Str. (Blinkhorn)	Purse Seine	July 21 - August 12	DFO
United States Panel Areas				
7	San Juan Islands	Reefnet	July 21 - July 29	PSC

IV. MANAGEMENT INFORMATION

To facilitate decision making, the Panel requires information about the abundance, timing, migration route and catch levels of Fraser River sockeye (by management group). Pre-season, these quantities are provided by DFO in the form of forecasts that are augmented by PSC Staff through analysis of historical data. Staff update these estimates in-season through various

assessment programs (Appendix G). Stock monitoring programs collect information about abundance at various points along the migration route using test fisheries, a hydroacoustic facility (Mission) and observers (Hells Gate). The locations and schedule for these Staff and DFO programs are listed in Table 3. These data are augmented with catch information from commercial, First Nations, recreational and other fisheries that are provided by the two countries. Stock identification programs collect and analyze biological samples (e.g., DNA, scales) from various fisheries, which are used to apportion the total abundance of sockeye into component stock groups. Table 4 shows the sockeye stock resolution that was reported in 2016.

Stock assessment activities conducted by Staff use the data described above to provide estimates of daily catch, daily abundance, Mission escapement, migration timing and diversion rate, which are the basis for estimating total abundances, escapement targets and catch allocations for the different sockeye management groups. Staff also provide estimates of Management Adjustments (MAs), which are a measure of how many additional fish should be allowed to escape past Mission to increase the likelihood of achieving spawning escapement targets, given historical discrepancies, current year migration timing and observed and forecasted river conditions from DFO's Environmental Watch program. These data are compiled and analysed by Staff and the results provided to the Panel. The section "In-season Management" above summarized how these estimates changed each week as data from the programs accumulated. The following sections provide a summary of the end-of-season results.

Table 4. Major component stocks included in Fraser River sockeye stock groups used in 2016. Most stock groups also include a miscellaneous component.

Stock Group	Component Stocks
Early Stuart	
Early Stuart	Early Stuart stocks
Early Summer	
Chilliwack	Chilliwack Lake, Chilliwack River, upper
Early Miscellaneous	Nadina, Bowron, Gates, Nahatlatch
Early South Thompson	Scotch, Seymour, early Eagle, Cayenne, Upper Adams
North Barriere River/Taseko	Upper Barriere, Taseko, Harper Creek
Pitt	Pitt
Summer	
Raft/N.Thompson	Raft, North Thompson main stem
Chilko	Chilko River, south end Chilko Lake
Horsefly/McKinley	Horsefly, McKinley
Mitchell/Lake Tributaries	Mitchell, Roaring, Wasko, Blue Lead, Deception Point
Late Stuart/Stellako	Stellako, Tachie, Middle, Pinchi, Kuzkwa
Harrison	Harrison, Widgeon
Late	
Birkenhead	Birkenhead, Big Silver
Late Shuswap/Portage	Lower Adams, Portage, Lower Shuswap, Middle Shuswap, Shuswap Lake, late Eagle
Weaver/Cultus	Weaver, Cultus

A. Abundance

Final in-season estimates of run-size adopted by the Panel totalled 856,000 Fraser sockeye (Table 1): this much lower-than-forecasted abundance constrained fishing opportunities in both countries. The post-season abundance estimate (858,000 fish, Tables 7 and 8) based on accounted

catches, spawning ground enumerations and run-size adjustments is similar to the end-of-season estimate, and 62% lower than the pre-season median forecast (2,271,000 fish).

B. Migration Timing and Diversion Rate

Figure 3 shows the forecasted and observed daily migrations, and Area 20 50% migration dates for each sockeye management group and for total Fraser sockeye salmon. The end-of-season estimates of marine migration timing in 2016 were the same for Early Stuart run but earlier than expected for Early Summer run (1 day earlier), Summer and Late-run (each 6 days earlier). The timing of the sockeye stocks was earlier than the historical average and either similar to or earlier than the cycle line average for all groups except the Late-run whose timing was 3 days later than the cycle line average.

Diversion rate in 2016 was lower than forecast. The observed annual diversion through Johnstone Strait was 50% of the Fraser sockeye return, compared to the forecast of 75% used for pre-season planning (Figure 4).

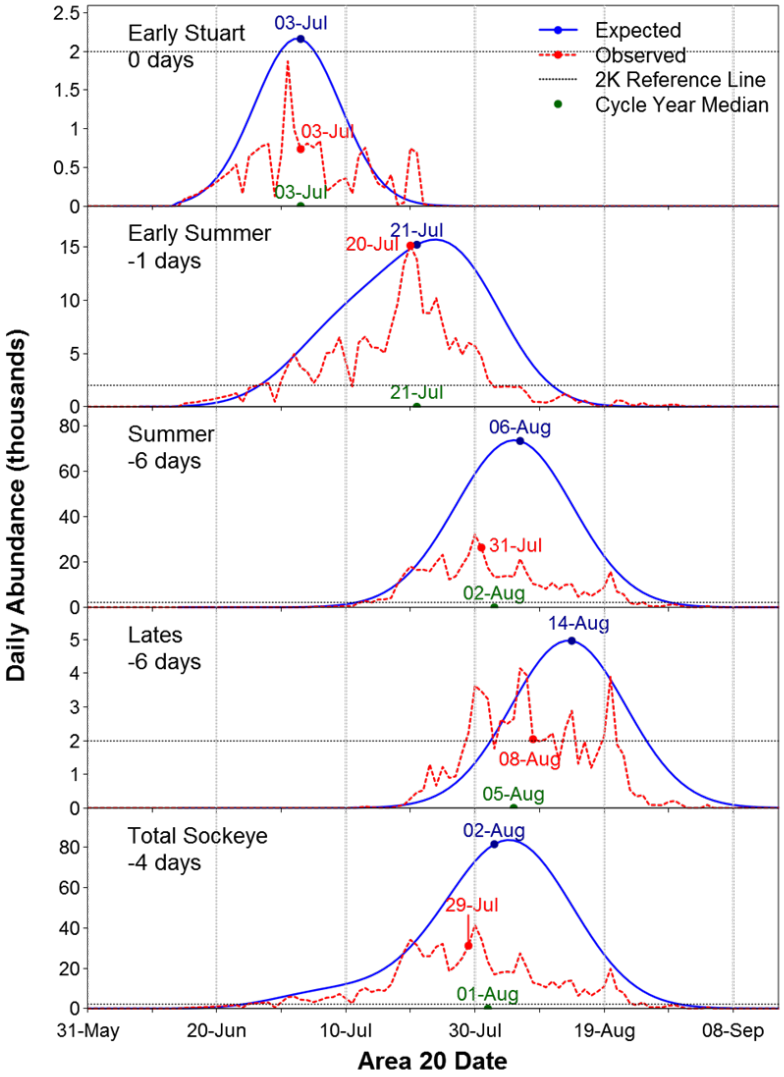

Figure 3. Pre-season projections and post-season reconstructions of daily Fraser River sockeye salmon abundance in 2016 (Area 20 date), including the 50% dates. Cycle-year median dates are also shown.

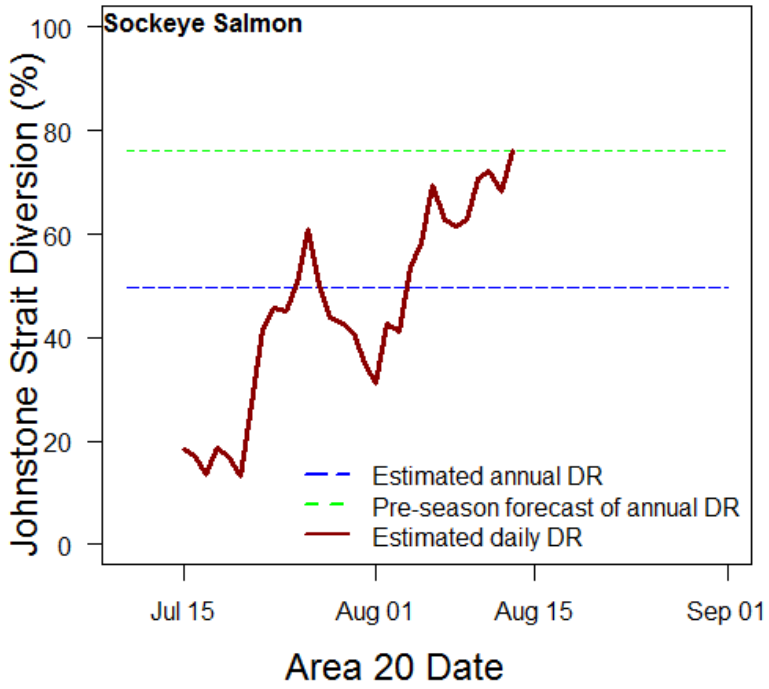

Figure 4. Pre-season forecasts of annual Johnstone Strait diversion rate (DR) for Fraser sockeye salmon, compared to in-season estimates of short-term and annual rates.

C. Management Adjustments and DBEs

Management Adjustments (MAs) are based on statistical models [8,9,10,11] that consider the historical differences between in-season projections of spawning escapement (i.e., Mission escapement minus catch above Mission, or "potential spawning escapement") and post-season estimates (i.e., spawning ground estimates). For Early Stuart, Early Summer-run and Summer-run stocks, the models relate historical escapement differences (difference between estimates, or DBEs) to river conditions measured near Hope, BC in the Fraser River. When discharge levels or temperatures are above average, DBEs also tend to be high. In addition, for Early Stuart and Early Summer runs, in-season estimates are consistently higher than spawning ground estimates even when migration conditions are within normal ranges, and this tendency is also captured by the MA models. For Late-run sockeye, historical DBEs are related to the date when half the run has

[8] Hague, M.J., and Patterson, D.A. 2007. Quantifying the sensitivity of Fraser River sockeye salmon (*Oncorhynchus nerka*) Management Adjustment models to uncertainties in run timing, run shape and run profile. Can. Tech. Rep. Fish. Aquat. Sci. 2776 : vii + 55p.

[9] Macdonald, J.S., Patterson, D.A., Guthrie, I., Lapointe, M. 2008. Improvements to environmental Management Adjustment models: SEF final report.

[10] Macdonald, J.S., Patterson, D.A., Hague, M.J., Guthrie, I.C. 2010. Modeling the Influence of Environmental Factors on Spawning Migration Mortality for Sockeye Salmon Fisheries Management in the Fraser River, British Columbia. Transactions of the American Fisheries Society 139:768-782.

[11] Cummings, J.W., Hague, M.J., Patterson, D.A., and Peterman, R.M. 2011. The impact of different performance measures on model selection for Fraser River sockeye salmon. N. Am. J. Fish. Aquat. Sci. 31: 323-334.

migrated past Mission (i.e., Mission 50% date), which captures the impact of the early migration behaviour observed since the mid-1990s on the migration success of these stocks.

Pre-season MA models and DBEs are based on median values from historical datasets for each management group, or are based on models using long-range forecasts of river conditions and in-river migration timing. In-season values are generated using updated migration timing estimates and observed and/or short-range forecasts of lower river discharge and temperature in combination with other considerations such as watershed-wide environmental conditions, and evidence of migratory distress (i.e. carcasses, fish holding, fish straying). In contrast, post-season values are calculated independently of any environmental data using post-season estimates of potential spawning and spawning ground escapements.

Spring snowpack values were near average in the upper Fraser, but with early freshet and above normal air temperatures conditions, discharge was below average and water temperatures remained above average through the end of August. Observed temperatures rose beyond the upper range of the optimum temperature for aerobic swimming for Early Summer-run, Summer-run and Late-run sockeye during most of their 31-day migration period centered on the 50% Hells Gate date[12] (Figure 5). Cooler air temperatures and some rain events at the end of August allowed for cooling in the Fraser (Figure 5); however, observed temperatures at Qualark did not drop below the plus one standard deviation line until early September.

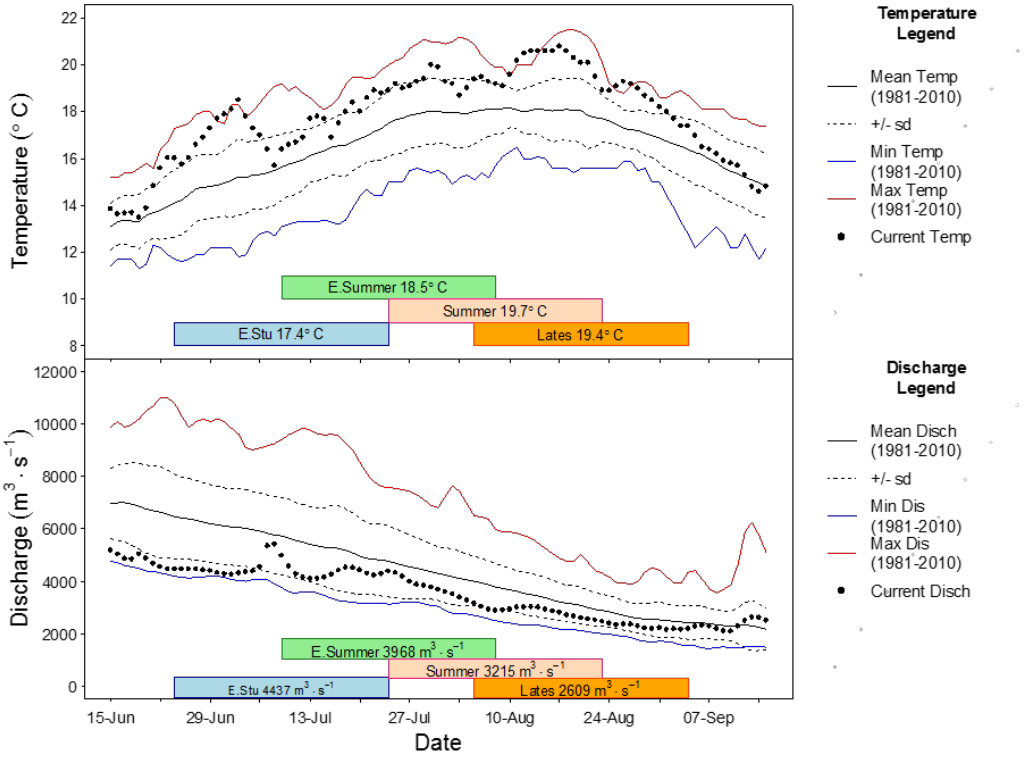

Figure 5. Fraser River temperature and discharge measured near Hope in 2016. Also shown are the run timing bars that represent a 31-day spread of the run centred around the Hells Gate date and the mean temperature and discharge for the 31-day spread.

[12] Eliason, E.J., Clark, T.D., Hague, M.J., Hanson, L.M., Gallagher, Z.S., Jeffries, K.M., Gale, M.K., Patterson, D.A., Hinch, S.G., and Farrell, A.P. 2011. Differences in Thermal Tolerance Among Sockeye Salmon Populations. Science 332:109-112.

A summary of the pre-season and in-season MA models adopted during 2016 are provided in the "Management Adjustment and DBE" section in Appendix G. Comparisons of % DBE (pMA) estimates for the pre-season, in-season and post-season periods are shown in Table 5. Given the 2016 pre-season forecast of abundances, fisheries decisions that could impact Early Stuart sockeye were based on a Low Abundance Exploitation Rate (LAER) limit of 10%. An MA was not estimated in-season for Early Stuart sockeye because it would have no management implications. The observed %DBE of -47% for Early Stuart was more negative than the %DBE adopted pre-season -41%. The small Early Stuart return and the sizeable DBE resulted in a much lower spawning escapement (8,600 sockeye; Table 7) than the final in-season target of 18,000 sockeye (Table 1). In-season model predictions for the Early Summer-run were very similar to the pre-season adopted % DBE values, consequently the Panel did not update the pre-season adopted value. For Early Summer-run sockeye, the low run-size and predicted %DBE resulted in a LAER approach. The observed %DBE of -27% was more positive than the %DBE of -37% adopted by the Panel. The spawning escapement target for Early Summer run (156,000 sockeye; Table 1) was achieved (Table 7). For Summer-run sockeye, the low run-size resulted in a LAER approach. The observed %DBE of -31% was more negative than the %DBE of -10% adopted pre-season. The small return of Summer-run sockeye and the sizeable DBE resulted in a much lower spawning escapement (276,000 sockeye) than the target of 527,000 sockeye. Given the 2016 pre-season forecasts of abundances, fisheries decisions that could impact Late-run sockeye were based on a LAER limit of 20%. An MA was not estimated in-season for Late-run sockeye because it would have no management implications. The observed %DBE of -31% was similar to the upstream timing model %DBE prediction of -33%. The small return and sizeable DBE resulted in a much lower spawning escapement (44,100 sockeye; Table 7) than the final target of 70,000 sockeye (Table 1).

Table 5. Pre-season, in-season and post-season estimates of DBEs (differences between estimates) and pMAs (proportional management adjustments). Pre-season predictions are based on long-range forecasts of migration timing and of 31-day mean Fraser River temperature and discharge or median values from historical datasets. In-season estimates reflect the final values adopted by the Panel for in-season management. Observed DBEs are calculated from final in-season estimates of potential spawning escapement and post-season estimates of spawning populations based on field enumeration programs conducted by DFO. (See Appendix A: Glossary of terms and abbreviations for DBE definition)

Description	Early Stuart		Early Summer [1] Aggregate		Summer [2] Aggregate		Late [3] Aggregate	
	%DBE	pMA	%DBE	pMA	%DBE	pMA	%DBE	pMA
Pre-season adopted [4]	NA	NA	-37%	0.59	-10%	0.11	NA	NA
In-season adopted [4]	NA	NA	-37%	0.59	-10%	0.11	NA	NA
Observed [5]	-47%	0.90	-27%	0.36	-31%	0.46	-32%	0.46

1 The Early Summer-run aggregate %DBE was estimated from the weighted average of the %DBE for the non-Pitt and non Chilliwack Early Summer component (that is updated in-season based on river conditions) and the %DBE for Pitt of -15% and the %DBE for Chilliwack of -53% (that remain fixed in-season) based on the p50 level of abundances.
2 The Summer-run aggregate %DBE was estimated from the weighted average of the %DBE for the non-Harrison Summer component (that is updated in-season based on river conditions) and the %DBE for Harrison of -29% (that remains fixed in-season) based on the p50 level of abundances.
3 The Late-run aggregate preseason %DBE was estimated from the weighted average of the %DBE for the non-Birkenhead Late component (historic cycle (2016) median) and the %DBE for Birkenhead of 21%, based on the p50 level of abundances.
4 Given the 2016 pre-season forecasts of abundances, fisheries decisions that could impact Early Stuart and Late-run sockeye management groups were based on Low Abundance Exploitation Rate (LAER) limits of 10% and 20%, respectively.
5 Derived from Final escapement estimates

In recent years, pre-season MA estimates for some management groups have been estimated based on the weighted average of component abundances and their respective MAs (see Table G2). In such cases, changes in relative abundances of component stocks may impact the MAs for the aggregate even when river conditions are relatively unchanged.

D. Mission Escapement

The estimated sockeye escapement at Mission was 787,000, consisting of 18,000 Early Stuart, 229,000 Early Summer-run, 476,000 Summer-run and 65,000 Late-run sockeye (Table 6). Approximately 3% of the estimate for Early Stuart and Early Summer-run, and 2% of the Summer- and Late-run passage estimates were derived from Whonnock test fishery CPUEs divided by their respective historical catchability coefficients. The river test fishing based method is applied during periods prior to and after operation of the hydroacoustic program because it is more cost effective. The remainder of the sockeye passage (95% of the total) was calculated from the total salmon passage estimated by the Mission hydroacoustics program. The same standardized sampling method was applied as in recent years, by combining observations from a vessel-based split-beam, a left bank shore-based split-beam and a right bank shore-based DIDSON (Dual Frequency Identification Sonar). Detailed descriptions of the hydroacoustics program sampling methodology for 2016 are provided in Appendix G.

Table 6. Fraser River sockeye salmon escapement at Mission in 2016.

Management Group	Mission Passage	
Stock Group	fish	%
Early Stuart	**17,900**	**2%**
Early Summer	**228,800**	**29%**
Chilliwack	75,100	10%
Early Miscellaneous	84,000	11%
Early South Thompson	4,800	1%
North Barriere/Taseko	6,700	1%
Pitt[1]	58,200	7%
Summer	**476,000**	**60%**
Raft/N.Thompson	43,200	5%
Chilko	271,000	34%
Quesnel	9,200	1%
Late Stuart/Stellako	78,400	10%
Harrison	74,200	9%
Late	**64,700**	**8%**
Birkenhead	53,700	7%
Late Shuswap/Portage	400	0%
Weaver/Cultus	10,600	1%
Total Sockeye	**787,400**	**100%**

1 Pitt does not escape past Mission

V. RUN SIZE, CATCH AND ESCAPEMENT

A. Sockeye Salmon

The total abundance of sockeye salmon in 2016 was 858,000 fish (Tables 7 and 8), which is 62% smaller than the median forecast of 2,271,000 fish and less than half the total adult return in 2012 (2,065,300). The 2016 return was the smallest estimated run size since estimates began in 1893. The causes of the small 2016 Fraser River sockeye return are unknown. The forecast for age 4 Summer run included a large return of four year olds, predominantly Chilko. In-season, the return of age 4 Chilko fish was much lower than forecast which is consistent with the low run size observed in-season. This poor survival coupled with the poor returns relative to forecast of several Fraser sockeye stock groups (see below), suggests that a marine mechanism may have caused the poor productivity observed in 2016. The returns of several other salmon stocks were also extremely low relative to their historic time series[13]. However, returns of other sockeye stocks and other salmon species which shared at least part of their ocean residence with Fraser River sockeye were also not uniformly poor. Thus, while it is tempting to blame the low return on the anomalously warm ocean temperatures in the Gulf of Alaska where age 4 Fraser River sockeye that returned in 2016 reared from late fall of 2014 through the spring of 2016, the lack of consistent response among populations and species suggests a more complicated causal mechanism.

All management groups returned at lower abundances than their median (p50 level) pre-season forecast abundances. The total return of Early Stuart sockeye was 18,000 adults (Tables 7 and 8) half the median forecast level of 36,000 fish. Early Summer-run sockeye returns totalled 240,000 fish, slightly more than half of the median forecast level. The abundances of Early Miscellaneous (89,000 fish), Chilliwack (77,000) and Pitt (62,000) sockeye were the dominant Early Summer-run components. The abundance of Summer-run sockeye was 527,000 adults, only 31% of the median forecast level. Most Summer-run fish were from the Chilko group which had poorer than expected marine survival. The total abundance of the Harrison group (81,000 adults) was less than half of its median pre-season forecast of 176,000 fish. Returns to all Late-run components were very poor relative to their median forecasts resulting in an aggregate Late-run return (71,000) that was only 63% of the group's median pre-season forecast.

For a historical perspective, Figure 6 shows total annual sockeye abundance and spawner abundance since 1893. The total sockeye catch of 160,000 fish was about 19% of the run (Tables 7 and 8). This exploitation rate is one of the lowest in recent years (Figure 7). Of the total sockeye catch, 149,200 fish were caught in Canada, and 1,700 fish in the U.S. and 8,800 fish in test fisheries. All of the Canadian catch was taken in First Nations Food, Social and Ceremonial (FSC) fisheries. There was no recreational or commercial catch in Canada. In Washington State the commercial catch of 850 sockeye (Table 9) was taken in Treaty Indian fisheries and the rest in Ceremonial fisheries. The Alaska catch of Fraser sockeye was estimated to be 34,000 (preliminary number).

DFO annually assesses the spawning ground abundance of sockeye populations in the Fraser watershed (Figure 8). In 2016, the final estimate of adult spawners (primarily age 4 and age 5 fish) totalled 485,000 fish, or 57% of the total run. This escapement was slightly more than half of the brood year (2012) escapement of 920,400 adults.

Spawner abundances for most management groups were much less than those observed in the brood year (2012, Figure 9). By management group and for this cycle line, spawning escapements in 2016 were much lower than average escapement to the Early Stuart system, slightly above average for the Early Summer run, similar to the long-term average for the Summer run, and well

[13] McKinnell, Skip. 2017. Atmospheric and Oceanic Extrema in 2015 and 2016 and their Effect on North American Salmon. Pacific Salmon Commission Technical Report No. 37.

below average for the Late run. The very low escapements relative to those in the brood year are attributed primarily to the combination of low overall returns and the very warm Fraser River temperatures that Fraser sockeye experienced during their upstream migrations in 2016.

Table 7. Catch by major fishing area or group, escapement, difference between estimates and run size for Fraser River sockeye salmon by management group in 2016.

	Fraser Sockeye					
	Early Stuart	Early Summer	Summer	Late	Total	% of Run
CANADIAN CATCH	**1,500**	**24,500**	**117,700**	**5,600**	**149,200**	**17%**
Commercial Catch	**0**	**0**	**0**	**0**	**0**	0%
Panel Area	0	0	0	0	0	0%
Non-Panel Areas	0	0	0	0	0	0%
First Nations Catch	**1,500**	**24,300**	**117,100**	**5,500**	**148,400**	17%
Marine FSC	0	4,100	25,300	2,900	32,300	4%
Fraser River FSC	1,500	20,200	91,800	2,600	116,100	14%
Economic Opportunity	0	0	0	0	0	0%
Non-commercial Catch	**10**	**100**	**600**	**90**	**800**	0%
Marine Recreational	0	0	0	0	0	0%
Fraser Recreational	0	0	0	0	0	0%
Charter (Albion)	10	100	600	90	800	0%
ESSR	0	0	0	0	0	0%
UNITED STATES CATCH	**10**	**600**	**900**	**90**	**1,700**	**0%**
Washington Total	**10**	**600**	**900**	**90**	**1,700**	**0%**
Commercial catch	**10**	**300**	**500**	**50**	**850**	0%
Treaty Indian	10	300	500	50	850	0%
All Citizen	0	0	0	0	0	0%
Non-commercial Catch	**0**	**300**	**500**	**40**	**850**	0%
Ceremonial	0	300	500	40	850	0%
Recreational	0	0	0	0	0	0%
Alaska* **	na	na	na	na	na	
TEST FISHING CATCH	**200**	**2,500**	**5,700**	**600**	**8,800**	**1%**
PSC (Panel Areas)	**200**	**1,800**	**4,000**	**400**	**6,400**	**1%**
Canada	200	1,800	4,000	400	6,400	1%
United States	0	0	0	0	0	0%
Canada (non-Panel Areas)	**10**	**600**	**1,600**	**200**	**2,400**	**0%**
TOTAL RUN	**18,000**	**240,500**	**529,200**	**70,600**	**858,300**	**100%**
Total Catch in All Fisheries	1,700	27,600	124,300	6,200	159,700	19%
Adult Spawning Escapement *	8,600	155,900	276,000	44,100	484,500	56%
Jack Spawning Escapement	0	200	1,800	300	2,300	0%
Difference Between Estimates**	7,700	56,800	127,100	20,000	211,700	25%
Percentage of Total Run	**100%**	**100%**	**100%**	**100%**	**100%**	
Total Catch in All Fisheries	9%	11%	23%	9%	19%	
Spawning Escapement	48%	65%	52%	63%	57%	
Difference Between Estimates	43%	24%	24%	28%	25%	

* Spawning escapement estimate for Cultus and Weaver sockeye include 207 and 59 individuals captured as brood stock, respectively.

** Difference between estimates as at the time of the final spawning ground estimates.

*** Alaska catch of 34,000 is a preliminary number.

Table 8. Catch, escapement, difference between estimates, run size and exploitation rate for Fraser River sockeye salmon by stock group in 2016.

Management Group / Stock Group	Catch[3]	Adult Spawning Escapement	Difference Between Estimates	Abundance			Portion of Run	Adult Exploitation Rate
				Adult	Jack [1]	Total		
Fraser Sockeye Salmon								
Early Stuart	**1,700**	**8,600**	**7,700**	**18,000**	**0**	**18,000**	**2%**	**9%**
Early Summer-run	**27,600**	**155,900**	**56,800**	**240,300**	**200**	**240,500**	**28%**	**11%**
Chilliwack	2,000	57,900	16,500	76,500	0	76,500	9%	3%
Early Miscellaneous	18,300	37,300	33,400	89,000	200	89,200	10%	21%
Early South Thompson	1,500	1,500	2,500	5,600	30	5,600	1%	27%
North Barriere/Taseko	1,600	1,300	4,000	7,000	0	7,000	1%	23%
Pitt	4,100	57,800	400	62,300	0	62,300	7%	7%
Summer-run	**124,300**	**276,000**	**127,100**	**527,400**	**1,800**	**529,200**	**62%**	**24%**
Raft/N.Thompson	9,900	14,600	24,000	48,500	0	48,500	6%	20%
Chilko	82,300	155,000	64,300	301,600	800	302,300	35%	27%
Quesnel	1,400	900	7,500	9,800	200	10,000	1%	14%
Late Stuart/Stellako	23,100	39,500	23,900	86,600	800	87,500	10%	27%
Harrison/Widgeon	7,500	66,000	7,400	80,900	0	80,900	9%	9%
Late-run	**6,200**	**44,100**	**20,000**	**70,300**	**300**	**70,600**	**8%**	**9%**
Birkenhead/BigSilver	5,100	41,100	12,100	58,200	50	58,300	7%	9%
Late Shuswap/Portage	90	50	400	500	0	500	0%	18%
Weaver/Cultus	1,100	2,900 [2]	7,600	11,600	200	11,800	1%	9%
Total	**159,700**	**484,500**	**211,700**	**855,900**	**2,300**	**858,300**	**100%**	**19%**
Portion of Total Run	19%	56%	25%	100%	0%	100%		

1 ESSR catches are included in the total Weaver and pink salmon total.

1 Jack ratios were not estimated for fisheries; estimates include only those jacks that were actually sampled and are therefore underestimates.

2 Spawning escapement estimates of Cultus and Weaver sockeye include 207 and 59 individuals captured as brood stock, respectively.

3 Preliminary Alaska catch of 34,000 not included in total catch.

The overall spawning success of adult female sockeye in the Fraser watershed was 90%. The effective female spawning population in 2016 totalled 229,300 fish, which was lower than the number of effective females in 2012.

The DBE[14] estimate was 212,000 fish, or 25% of the total return. As a percentage of run size for each management group, Early Stuart had the largest DBE (43%) and the remaining management groups ranged from 24% to 28% (Tables 7 and 8).

Further details regarding sockeye salmon abundances, catches and spawning escapements including comparisons with the last four cycle years can be found in Appendix H (Tables H1 and H2).

[14] In estimates of total return, Difference Between Estimates (DBEs) will eventually be replaced by Run-size Adjustments (RSAs) which are revisions to the total run size in cases when there is evidence that more fish returned than were accounted for in catch and escapement, e.g., evidence of en route mortality, evidence of biased or incomplete estimates of catch, Mission escapement or spawning escapement. The focus of RSAs is on providing the best assessments of total returns, i.e., recruitment. Models that relate recruitment and spawning stock are used to develop both pre-season abundance forecasts and escapement policy. The methods used to estimate RSAs are currently under review by PSC and DFO staff and members of the Fraser River Panel Technical Committee.

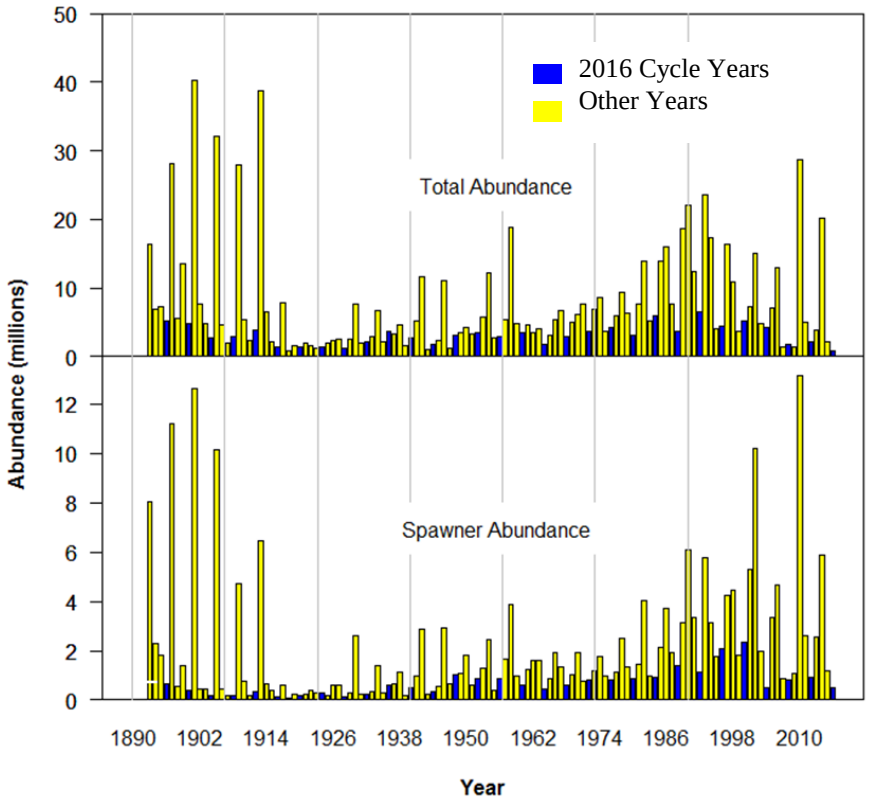

Figure 6. Total run size and spawning escapement of Fraser River sockeye salmon in 1893-2016. Returns on the 2016 cycle are emphasized.

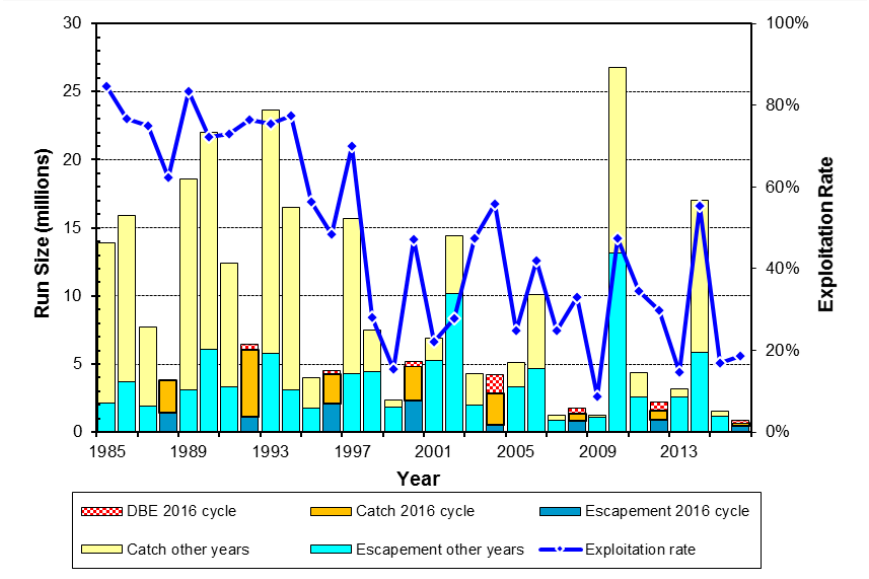

Figure 7. Total catch, escapement, difference between estimates (DBE), run size and exploitation rate for Fraser River sockeye salmon in 1985-2016, with returns on the 2016 cycle emphasized.

Table 9. U.S. commercial catches of Fraser River sockeye salmon by user group, gear type and statistical area in 2016.

Areas	Troll	Purse Seine	Gillnet	Reefnet	Total
Panel Area (Washington)	**0**	**0**	**800**	**0**	**850**
Treaty Indian *	**0**	**0**	**800**	**0**	**850**
4B, 5 and 6C	0	0	800	0	850
6 and 7	0	0	0	0	0
7A	0	0	0	0	0
All Citizen **	**0**	**0**	**0**	**0**	**0**
7	0	0	0	0	0
7A	0	0	0	0	0
Alaska (District 104) Catch***	0	**34,000**	0	0	**34,000**
United States Total					**34,850**

* Estimates for Treaty-Indian fisheries are from the "TOCAS" database.

** Estimates for All Citizen fisheries are from the WDFW "LIFT" database.

*** Preliminary number

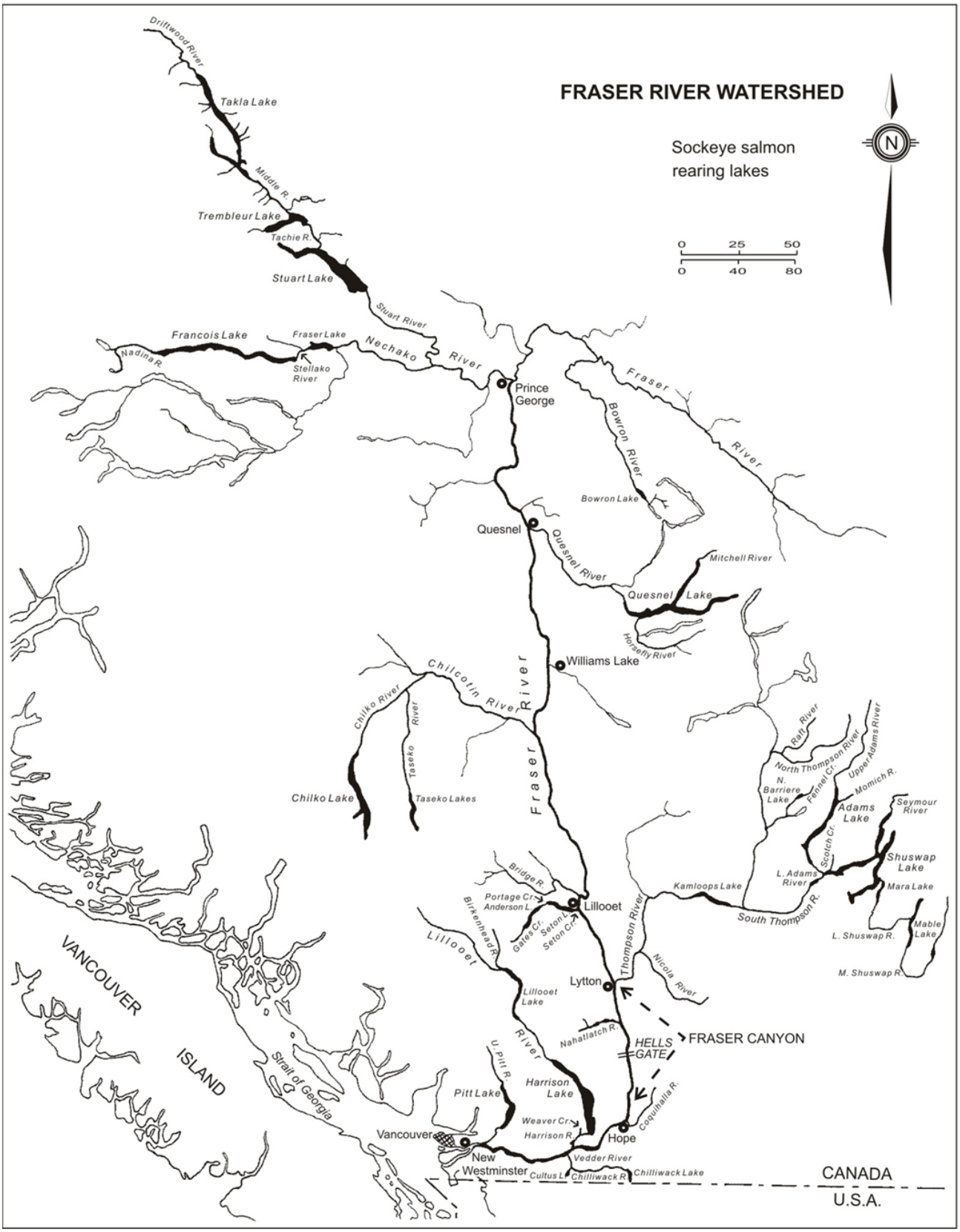

Figure 8. Sockeye salmon spawning areas in the Fraser River watershed.

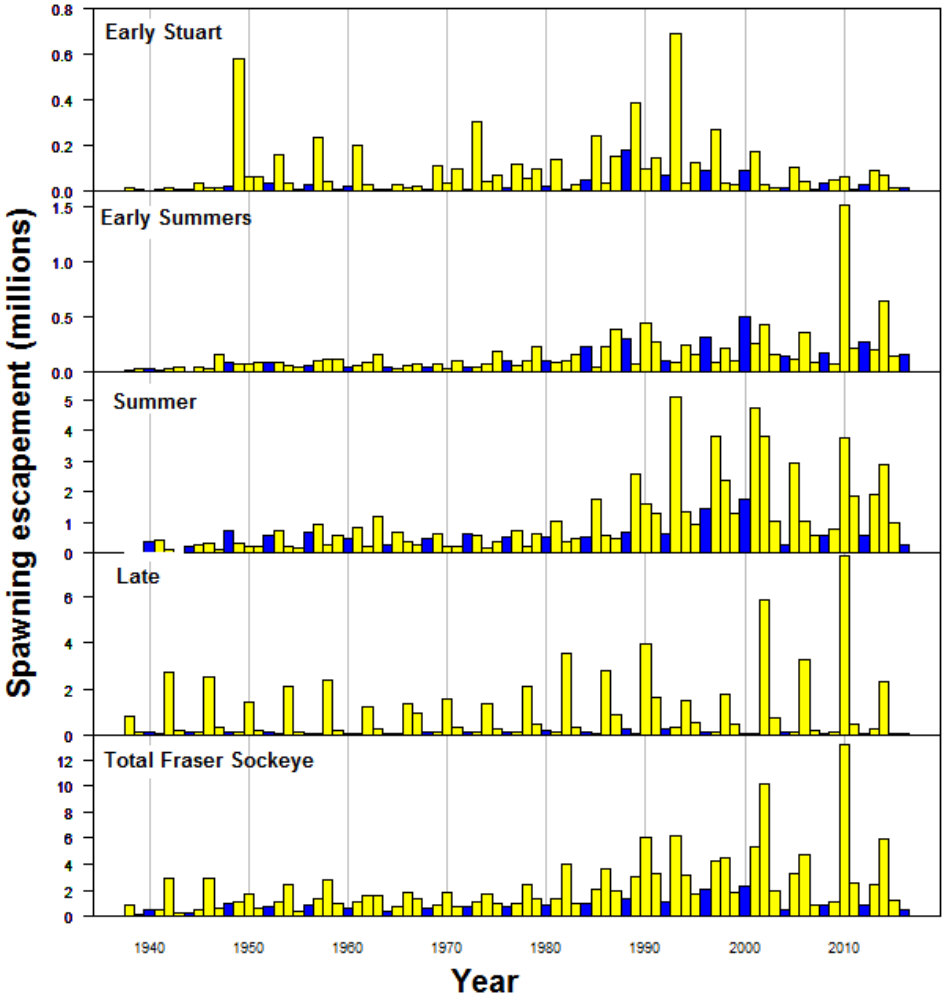

Figure 9. Annual adult spawning escapement of Fraser River sockeye salmon for each management group and for total sockeye in 1938-2016, with escapements on the 2016 cycle emphasized.

VI. ACHIEVEMENT OF OBJECTIVES

The mandate of the Fraser River Panel is to manage commercial fisheries in Panel Area waters to achieve a hierarchy of objectives. In order of importance, the objectives are to: (1) achieve spawning escapement targets for Fraser River sockeye and pink salmon that are set by Canada; (2) achieve targets for international sharing of the TAC as defined in the Treaty; and (3) achieve domestic allocation goals within each country. In addition, the Treaty instructs the Panel to plan and manage its fisheries consistent with the provisions of other chapters of Annex IV to ensure that the conservation needs and management requirements for other species and other sockeye and pink salmon stocks are taken into account. Panel management is evaluated after each season to determine whether the goals were achieved and to identify potential improvements in data collection programs, assessment methods and management techniques. While not formally under Panel control, management of Canadian non-Panel fisheries directed at Fraser River sockeye and pink salmon is based on the same in-season information and hierarchy of objectives,

with priority given first to conservation, and then to First Nations Food, Social and Ceremonial (FSC) harvest within Canada's allocation.

A. Escapement

The Panel's first task is to achieve spawning escapement targets as specified by Canada. Spawning escapement targets were determined by applying Canada's spawning escapement plan to abundance estimates for each management group.

In-season monitoring of the progress toward spawning escapement targets is not directly quantifiable because in most cases spawner abundance cannot be assessed on the spawning grounds until well after the fishing season has ended. In-season management is therefore based on targets for potential spawning escapement (i.e., PSE target = in-season spawning escapement target + MA). Progress towards these targets is monitored by comparison with in-season PSE estimates (i.e., Mission escapement to-date - catch above Mission).

Final in-season PSE estimates indicate variable achievement of in-season PSE targets among management groups: Early Stuart (11% under), Early Summer (11% under), Summer (24% under) and Late (9% under) (Table 10). As discussed in the pre-season planning section, for pre-season planning purposes, Early Stuart and Late-run sockeye were respectively constrained by a 10% and a 20% Low Abundance Exploitation Rate (LAER). For the Early Summer run deviations were limited to within 11% of the targets as the Panel's response to the low in-season run size estimates triggered the implementation of a LAER. The Summer run was also managed under a LAER (10%); however, the post season estimates of harvest are higher than the guidelines under the LAER (23% exploitation rate). As the season progressed the sockeye TAC and available harvest decreased dramatically (Figure 10), resulting in the Panel constraining sockeye-directed fisheries.

Table 10. Comparison of in-season targets and in-season estimates of potential spawning escapement (PSE) for adult Fraser River sockeye salmon in 2016.

Management Group	Final In-season Abundance Estimate	Potential Spawning Escapement (PSE)					
		Spawning Escapement Target	Management Adjustment *	In-season PSE ** Target	PSE *** Estimate	Difference Fish	Difference %
Adult sockeye	**856,000**	**772,000**	**150,100**	**856,000**	**696,000**	**-160,000**	**-19%**
Early Stuart	18,000	18,000	NA	18,000	16,000	-2,000	-11%
Early Summer	240,000	156,000	92,000	240,000	213,000	-27,000	-11%
Summer	528,000	528,000	58,100	528,000	403,000	-125,000	-24%
Late	70,000	70,000	NA	70,000	64,000	-6,000	-9%

* Adjustment of spawning escapement targets to achieve spawning escapement goals.

** Spawning escapement target + MA. If the spawning escapement target + MA exceeds the total abundance, then the target equals the total abundance.

*** Mission passage minus all catch above Mission.

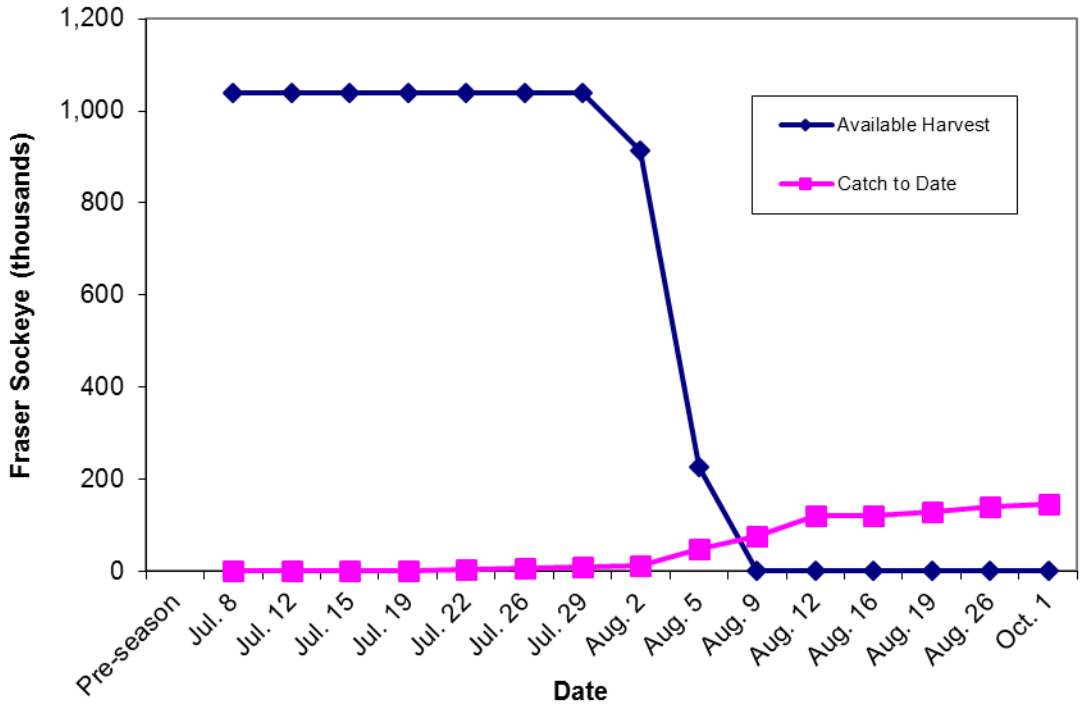

Figure 10. Available harvest of Fraser sockeye compared to catch to date in all fisheries in 2016. The available harvest is calculated as run size minus spawning escapement target and management adjustment, and represents fish that are available for catch in all commercial, recreational, First Nations and test fisheries. Note: Final spawning escapement plan was not approved until after July 12.

In terms of the achievement of post-season objectives, the spawning ground escapement estimates were 37% below the Fraser sockeye aggregate target and each sockeye management group was 38-52% below their target with the exception of the Early Summer-run which was on target (Table 11). The spawning escapement targets for Early Stuart, Summer and Late-run sockeye equalled their run sizes, so the escapement targets were unattainable unless there was no harvest and no difference between estimates. The exploitation rates of Early Stuart (9%) and Late-run sockeye (9%) were low and less than their respective LAERs (10% and 20%). Thus, the negative deviations observed between spawning escapements and targets largely reflect the impact of the negative %DBEs observed for these groups (Table 5). The spawning escapement target for Summer-run also equalled its run-size (Table 11). The exploitation rate of Summer-run sockeye (24%) exceeded its LAER of 10% and the %DBE was also larger (more negative) than the Panel adopted value (Table 5). Thus, both factors contributed to the spawning escapement being less than the target for this group. Initially, the Early Summer-run return was sufficient to generate a TAC, but harvest restrictions on co-migrating Early Stuart and Summer-run groups limited directed fisheries, and after August 2 this management group was also in a LAER. As a result, the Early Summer-run sockeye spawning escapement target was met (Table 11).

Table 11. Comparison of post-season spawning escapement targets and escapement estimates for adult Fraser River sockeye salmon in 2016. Post-season estimates of sockeye escapement are from spawning ground enumeration programs (DFO).

Management Group	Post-season Run-size Estimate	Spawning Escapement			
		Post-season Target	Adult Estimate	Difference	
				Fish	%
Sockeye salmon	**858,300**	**773,800**	**484,500**	**-289,200**	**-37%**
Early Stuart	18,000	18,000	8,600	-9,400	-52%
Early Summer	240,500	156,000	155,900	-100	0%
Summer	529,200	529,200	276,000	-253,200	-48%
Late	70,600	70,600	44,100 *	-26,500	-38%

* Late-run escapement estimate includes 207 Cultus and 59 Weaver fish kept for broodstock.

B. International Allocation

The Panel's second priority is to achieve the goals for international allocation of the TACs for Fraser sockeye and pink salmon. In accordance with Annex IV, Chapter 4 of the Pacific Salmon Treaty, the TAC calculations are based on the run sizes, spawning escapement targets and MAs in effect when the Panel relinquished control of the last U.S. Panel Area (October 1). However, the test fishing catch and Aboriginal Fisheries Exemption deductions are the post-season estimates.

With the total in-season abundance estimate of 856,000 Fraser sockeye, minus deductions for spawning escapement, MA, test fishing catch and AFE, there was no International TAC in 2016 (Table 12). Due to the 900 fish carryover from the 2015 season and the catch of 1,700 fish in Washington, there was a negative deviation for the United States of 2,600 fish. For TAC comparison purposes, Canada's catch excludes ESSR catch. In 2016, the ESSR catch was 0 fish. Canada's catch of 149,200 Fraser sockeye deviated by 800 fish more than the total of their allowable harvest of the International TAC plus the AFE of 148,400 (i.e., the actual catch estimate, because it is less than the agreed 400,000 maximum AFE amount). A detailed version of the TAC calculations by management group is presented in Appendix H, Table H3.

Table 12.Total allowable catch (TAC) and achievement of international catch shares for Fraser River sockeye salmon in 2016. TAC calculations use the in-season estimates of run size, spawning escapement target and management adjustment at the time the Panel relinquished control of the last U.S. Panel Area (October 1), in accordance with Annex IV of the Treaty.

		Sockeye	
TOTAL ALLOWABLE CATCH			
In-season Total Run Size		**856,000**	
Deductions		**1,079,300**	
In-season Spawning Escapement Target		772,000	
In-season Management Adjustment		150,100	
Aboriginal Fishery Exemption (AFE)		148,400	
Post-season Test Fishing Catch		8,800	
Total Allowable Catch	*1, 2*	**0**	
UNITED STATES			
Washington Share		**-900**	
Washington Share of TAC	*1, 3*	0	16.5%
Payback		-900	
Washington Catch		**1,700**	
Deviation		**-2,600**	
In-season Alaska Catch Estimate		0	
CANADA			
Canadian Share of TAC + U.S. Payback + AFE		**148,400**	
Canadian Catch excluding ESSR Catch		**149,200**	
Deviation		**-800**	

1 TAC and Washington sockeye share according to Annex IV, Chapter 4 of the Pacific Salmon Trea

2 TAC may not equal the total run minus total deductions shown due to adjustments required when the run size of individual management groups is less than the nominal deductions. A more detailed TAC calculation showing these intermediate calculations is shown in the Appendix.

3 United States share according to revised Annex IV of the Pacific Salmon Treaty: Sockeye: 16.5% of the TAC - payback (maximum 5% of share).

C. Domestic Allocation

The third priority of the Panel is to achieve domestic allocation goals as specified by the Parties. While the Panel manages all commercial fisheries directed at Fraser River sockeye and pink salmon in Panel Area waters (Figure 1), Canada has sole responsibility for regulating fisheries including commercial net and troll fisheries in non-Panel areas such as Johnstone Strait, and First Nations and recreational fisheries in all fishing areas.

With respect to domestic allocations of Fraser sockeye salmon, Treaty Indian fishers in the U.S. caught more than their share of the TAC; 1,700 fish, (Table 13).

The only fisheries in Canada directed on Fraser sockeye salmon were in First Nations FSC fisheries which caught their allowable harvest of 148,400 fish. An additional 800 Fraser River sockeye were caught in a domestic, in-river Chinook test fishery.

Table 13. Achievement of domestic catch goals in Washington for Fraser River sockeye salmon in 2016.

User Category	Actual Catch Fish	Actual Catch %	Share of TAC Fish	Share of TAC %	Deviation
Washington Total	**1,700**	**100.0%**	**0**	**100.0%**	**1,700**
Treaty Indian *	1,700	100.0%	0	67.7%	1,700
All Citizen **	0	0.0%	0	32.3%	0

* Treaty Indian catch includes commercial and ceremonial catches.

** All Citizen catch includes commercial and recreational catches.

D. Conservation of Other Stocks and Species

Non-target stocks and species are caught in Panel Area fisheries directed at Fraser River sockeye and pink salmon. The conservation needs and management requirements for these stocks and species caught incidentally in fisheries regulated by the Fraser Panel are taken into account through a variety of bilateral and domestic processes associated with the implementation of Chapter 4 (Fraser River sockeye and pink salmon) and other Chapters of Annex IV. A comprehensive summary of all the methods in which by-catch impacts are taken into account is beyond the scope of this report, but we provide a few examples below. In the United States, the Pacific Fishery Management Council considers modelled by-catch of Chinook and Coho salmon in Fraser Panel regulated sockeye and pink directed fisheries to ensure consistency with Chapters 3 (Chinook) and 5 (Coho) of Annex IV. Similarly, Canada through its Integrated Fisheries Management Plan for South Coast salmon fisheries specifies closure windows for sockeye and pink directed fisheries in the Fraser River and these closures are regularly implemented to protect Chinook and Coho. By-catches of non-Fraser sockeye and pink salmon in commercial net fisheries regulated by the Fraser River Panel totalled 80 sockeye and 0 pink salmon in 2016 (Table 14). Catches of other Fraser and non-Fraser salmon species included 190 Chinook, 200 Coho, and 30 chum.

Table 14. Catches of non-Fraser sockeye and pink salmon and catches of other salmon species in commercial fisheries regulated by the Fraser River Panel in 2016.

Area and Gear	Non-Fraser Sockeye	Non-Fraser Pink	Fraser and Non-Fraser Chinook	Coho	Chum	Steelhead
United States *	**80**	**0**	**190**	**200**	**30**	**0**
Areas 4B, 5 and 6C Net	80	0	190	110	30	0
Areas 6, 7 and 7A Net	0	0	0	100	0	0
Canada **	**0**	**0**	**0**	**0**	**0**	**0**
Area 20 Net	0	0	0	0	0	0
Area 29 Net	0	0	0	0	0	0
Total	**80**	**0**	**190**	**200**	**30**	**0**

* Estimates for All Citizen fisheries are from the WDFW "LIFT" database, while estimates for Treaty-Indian fisheries are from the "TOCAS" database.

** Estimates are from DFO in-season hail program.

** There were no commercial fisheries directed at Fraser River sockeye or pink salmon in Canadian Panel waters in 2016.

VII. ALLOCATION STATUS

Annex IV, Chapter 4, (paragraph 8 (c)(iv)) specifies that *the US share will not be adjusted for an overage resulting from TAC reductions after the scheduling of the last Fraser River Panel approved U.S. fishery of the season.* The resulting calculations indicate there was no overage for Fraser River sockeye in 2016 (Table 15). However, the Panel agreed post-season that the 900 sockeye landed in Panel regulated fisheries directed at Fraser River pink salmon in 2015 would be carried over as payback to 2017. Thus, the U.S. owes a payback of 900 Fraser sockeye to Canada in future years (Table 15). These 900 sockeye were not sold, but retained by US tribes for ceremonial and subsistence purposes. There are no paybacks due for Fraser pink salmon from the 2015 season.

Table 15. Allocation status for Fraser River sockeye salmon in 2012-2016. No new paybacks were incurred by the U.S. from the 2016 fishing season.

	2012 (Aug 10)	2013 (Oct 05)	2014 (Oct 04)	2015 (Aug 07)	2016 (Aug 02)
TOTAL ALLOWABLE CATCH					
Total Run Size	2,515,000	3,732,000	19,883,500	6,367,000	2,110,000
Escapement and other deductions	1,796,000	3,649,400	8,688,600	3,758,100	2,110,000
Total Allowable Catch:	719,000	82,600	11,194,900	2,608,900	567,300
UNITED STATES					
Washington Catch	111,300	20,200	1,181,700	46,200	1,700
Washington Share (excl ds payback) *	118,600	13,600	1,847,100	430,500	93,600
Deviation:	-7,300	6,600	-665,400	-384,300	-91,900
Cumulative Allocation Status:	**0**	**6,600**	**0**	**900****	**900****
CANADA					
Catch	510,400	410,100	8,981,100	187,900	149,200
Share + Aboriginal Exemption	1,000,400	469,000	9,747,800	2,365,600	473,700
Deviation:	-490,000	-58,900	-766,700	-2,177,700	-324,500

* From 2008 - 2016, United States allocation status follows either Commission guidance or Chapter 4 (paragraph 8, c, iv). This language states "The U.S share will not be adjusted for an overage resulting from TAC reductions after the scheduling of the last Fraser River Panel approved U.S fishery of the season". Thus, in circumstances which satisfy the above conditions, the TAC's used to determine allocation status may be different than the TAC based on input data used in post-season calculations. The dates in each year used to calculate run sizes and other deductions for this allocation status table are noted in parathenses under each year. Exceptions to the language in paragraph 8, c, iv are noted below. Washinton shares during this period were calculated according to Annex IV of the Pacific Salmon Treaty: Shall not exceed 16.5% for Fraser River sockeye and 25.7% for Fraser River pink salmon.

** Washington share of the TAC according to Annex IV of the Pacific Salmon Treaty:

2015: By Panel agreement, any U.S. catch of Fraser sockeye after August 7, when the last U.S. sockeye-directed fishery was scheduled, is considered an overage.

2016: No payback was generated in 2016, but by Panel agreement 900 sockeye were carried forward from the 2015 season.

VIII. APPENDICES

APPENDIX A: GLOSSARY OF TERMS AND ABBREVIATIONS

Bayesian Methods and Models: Statistical models which allow pre-season forecasts of run size, diversion rate, and migration timing to be used as priors and then combined with in-season observations as data accumulates over the course of the season. Early in the season, estimates are heavily dependent on these pre-season priors, but this dependence shifts to the collected data as the season progresses. Uncertainty in the in-season estimates of run size, migration timing and diversion rate decreases as more data become available. The name "Bayesian" comes from the frequent use of Bayes' theorem in the inference process which specifies how the prior and in-season data interact in the generation of estimates.

CPUE: Catch per unit of effort. Typically associated with data obtained from test fisheries (e.g. number of fish caught per 100 fathom minutes (a measure of net size and soak time)).

Cycle line: A series of years associated with a cohort of Fraser sockeye assuming spawners are 4 years old. A cycle line of a particular year includes every 4th year (e.g., 2008, 2012, 2016).

Demonstration fishery: A Canadian commercial fishery designed to test particular gear configurations or explore the feasibility of harvests either in non-traditional areas or by non-traditional gear. A limited number of licenses are typically granted to permit the conduct of such fisheries.

Difference between estimates (DBE): Difference between estimates of spawning escapement (PSE) and potential spawning escapement (SE) (DBE=SE-PSE). The potential spawning escapement is defined as Mission escapement minus any in-river catch that occurs between Mission and the spawning areas. Sources for DBEs include en route mortality and errors (bias and imprecision) introduced through the estimates of Mission escapement, spawning ground escapement, First Nations and recreational catches above Mission, and stock composition. Historical DBE values are used to generate Management Adjustment (MA) models, which use estimates of migration timing and river conditions to predict the DBEs likely to be observed in the current year. The proportional DBE (pDBE) is estimated by dividing the difference between estimates by the potential spawning escapement (pDBE = DBE/PSE) and is often shown as a percentage, such that %DBE = 100 * pDBE. The formulas pDBE = (1/(1+pMA))-1, and pMA= (1/(1+pDBE)-1 can be used to convert between pDBEs and pMAs.

Northern Diversion rate: Proportion of the salmon run that migrates through Johnstone Strait (northern approach) as opposed to Juan de Fuca Strait (southern approach). Estimates may be in time steps of a week or a few days, or a value for the entire migration on an annual basis.

Economic Opportunity (EO) fishery: Commercial Fraser River First Nations fishery in the Lower Fraser area.

ESSR: Terminal harvest of salmon that are "Excess Salmon to Spawning Requirements". This term is usually associated with fish that are surplus to those needed to completely seed an artificial spawning channel and in the Fraser are most frequently associated with sockeye and the spawning channel at Weaver Creek.

Fishery-induced Mortality (FIM) or Release Mortality: In fisheries where some component of the catch is released (e.g., non-retention), some proportion of the released fish are expected to die due to the stress of capture and handling. These mortalities are referred to as fishery-induced mortality or release mortality.

Fishery Planning Model: A pre-season model that allows the Panel to evaluate the impacts of various fishery options on the achievement of management objectives, given such pre-season

expectations as abundance, stock composition, migration timing, diversion rate, spawning escapement targets, management adjustments and catch objectives.

Food, Social and Ceremonial (FSC) fishery: Non-commercial First Nations fishery.

Low Abundance Exploitation Rate (LAER): The purpose of managing a sockeye management group in a LAER situation is to permit by-catch of that stock group in fisheries directed at other management groups or species with available surpluses (e.g. Summer-run sockeye, pink salmon). The application of a LAER for a management group has the effect of limiting the exploitation rate (ER) of that group to a small amount (e.g. 10% or 20% of a run timing group). The need to implement a LAER for a particular sockeye management group can be caused by one of the following:

- When the run size is below the lower fisheries reference point as defined by Canada's Spawning Escapement Plan.
- When the escapement goal plus the management adjustment (MA) is greater than the run size.
- When the escapement goal plus the MA is less than the run size but the resulting ER is less than the % LAER.

Management Adjustment (MA): Additional fish added to an escapement target for the purpose of increasing the likelihood of achieving the escapement target. Pre-season, MAs are typically calculated based on historical discrepancies or long range forecasts of river conditions. In-season the MAs for Early Stuart, Early Summer-run and Summer-run sockeye stocks, are calculated using models that relate historical discrepancies to river conditions. Estimates of migration timing and river conditions in the current year are then used to predict the proportional management adjustments (pMA) that are applied to spawning escapement targets. For Late-run stocks, MAs are often calculated based on models that relate historical discrepancies to upstream timing. The pMAs are multiplied by the spawning escapement targets to calculate numerical MAs. MAs are calculated pre-season as inputs for pre-season planning, and at regular intervals during the fishing season based on in-season estimates of migration timing, and observed and forecasted river conditions.

Management group or Run-timing group: Aggregates of sockeye salmon stocks that are used in Fraser Panel management, i.e., Early Stuart, Early Summer-run, Summer-run, and Late-run groups.

Migration date or 50% date: Dates when half (50%) of the total run would have passed a certain geographical location if it is assumed that all fish migrated via that route.

Area 20 date: An index of marine migration timing, assuming the entire run migrated through Canadian fishery management Area 20 in Juan de Fuca Strait.

Mission date: An index of in-river migration timing, defined by when half the total Mission escapement (usually identified by individual stock or stock group) is estimated to have passed Mission.

Reconstructed Mission date: An index of in-river migration timing based on when half of the total reconstructed run to Mission (Mission escapements plus catches seaward of Mission) is estimated to have been available to pass Mission. Reconstructed Mission dates are generally not available for Late-run stocks for which a portion of the run is expected to delay prior to entering the Fraser River.

Mission Escapement or Mission Passage: PSC estimates of the daily number of fish that migrate upstream past the hydroacoustic field station at Mission, B.C. Mission passage is primarily estimated by hydroacoustic methods, but at times (usually early and late in the season) is estimated by dividing the CPUE by catchability using data from in-river test fisheries.

Non-retention: In fisheries where one species is targeted but by-catch of a second species is expected, regulations may specify that the fish of the second species be released. For example,

sockeye salmon were expected to be caught in some pink-directed fisheries in 2015 but there was minimal TAC for Late-run Fraser sockeye remaining, so some fisheries were opened for pink salmon harvest, but under conditions of either mandatory or voluntary non-retention for sockeye. Non-target species that are released are assigned gear-specific fishing induced mortality rates (FIMs; see above), that are accounted for along with landed catches in estimates of total exploitation rates.

Potential Spawning Escapement (PSE)

Potential spawning escapement target: In-season target for PSE by management group, where the PSE is the sum of the spawning escapement target plus the Management Adjustment (MA). May also be called the "Adjusted Spawning Escapement Target". The management objective is to achieve the PSE target in-season as measured by the potential spawning escapement.

Potential spawning escapement: Mission escapement estimate minus in-river catch upstream of Mission. If there were no en route mortalities or estimation errors in Mission escapement, up-river catch, spawning escapement or stock identification, the potential spawning escapement would in theory equal the number of fish estimated to have reached the spawning areas.

Run size: Total abundance or total return of a stock, management group or entire population of Fraser River sockeye or pink salmon.

Run-size Adjustment (RSA): Additions to the total return in cases when there is evidence that more fish returned than were accounted for in catch and escapement, e.g., evidence of en route mortality, evidence of biased or incomplete estimates of catch, Mission escapement or spawning escapement.

Spawning Escapement

Spawning escapement or Net escapement: Spawning escapement of adult male and female spawners and jack spawners (precocious age 3 males) as estimated through assessment programs conducted on the spawning grounds, or projected from other data when such programs are not conducted in all areas (e.g., a portion of Quesnel spawners was not assessed on the spawning grounds in 2002). Such escapement numbers include losses from pre-spawn mortality on the spawning grounds, however, pre-spawn mortality (fraction of females which die but retain some portion of their eggs) is accounted for in estimates of Effective Female spawners.

Spawning escapement target: Target for total adult spawning escapement for each spawning population as defined each year by Canada's Spawning Escapement Plan.

Total Allowable Mortality rule (TAM rule): For each Fraser sockeye management group at different run sizes, Canada's Spawning Escapement Plan specifies the total allowable mortality from all sources, including fishery removals (catch) and en route mortality (represented by the Management Adjustment).

List of abbreviations

ADFG: Alaska Department of Fish and Game AFE: Aboriginal Fishery Exemption ARIS: Adaptive Resolution Imaging Sonar BC: Province of British Columbia DBE: Difference between estimates CPUE: Catch per Unit of Effort DFO: Fisheries and Oceans Canada DIDSON: Dual-frequency IDentification SONar EO: Economic Opportunity ESSR: Excess Salmon to Spawning Requirements FRP: Fraser River Panel FRPTC: Fraser River Panel Technical Committee FRSSI: Fraser River Sockeye Spawning Initiative FSC: "Food, social and ceremonial"	JS: Johnstone Strait LAER: Low Abundance Exploitation Rate LGL: A biological consulting company MA: Management Adjustment MLP: Mandatory Landing Program M-R: Mark-recapture pMA: Proportional Management Adjustment PSC: Pacific Salmon Commission PSE: Potential spawning escapement RSA: Run Size Adjustment SE: Spawning Escapement SET: Spawning Escapement Target TAC: Total Allowable Catch TAM: Total Allowable Mortality WDFW: Washington Department of Fish and Wildlife

APPENDIX B: 2016 PRE-SEASON FORECASTS AND SPAWNING ESCAPEMENT TARGETS FOR FRASER RIVER SOCKEYE AND PINK SALMON

Table B1. Pre-season forecasts for Fraser River sockeye salmon in 2016. (Provided to the Panel by Fisheries and Oceans Canada).

Run timing group	Mean Run Size		Probability that Return will be at/or Below Specified Run Size [a]				
Stocks	all cycles[c]	2016 cycle[d]	10%	25%	50%	75%	90%
Early Stuart	**301,000**	**128,000**	**13,000**	**22,000**	**36,000**	**59,000**	**89,000**
Early Summer	--	--	**120,000**	**217,000**	**447,000**	**1,003,000**	**2,703,000**
(total excluding miscellaneous	502,000	423,000	**97,000**	**158,000**	**286,000**	**585,000**	**1,527,000**
Bowron	**37,000**	**29,000**	1,000	2,000	4,000	8,000	13,000
Fennell	**24,000**	**32,000**	6,000	9,000	14,000	23,000	39,000
Gates	**54,000**	**124,000**	24,000	40,000	76,000	138,000	231,000
Nadina	**75,000**	**118,000**	24,000	45,000	90,000	179,000	331,000
Pitt	**71,000**	**78,000**	42,000	60,000	90,000	147,000	212,000
Scotch	**98,000**	**10,000**	300	2,000	12,000	89,000	698,000
Seymour	**143,000**	**32,000**	0	100	400	1,000	3,000
Misc (Early Shuswap)[e]	--	--	2,000	4,000	8,000	13,000	24,000
Misc (Taseko)[e]	--	--	100	400	1,000	1,000	2,000
Misc (Chilliwack)	--	--	17,000	46,000	138,000	378,000	1,101,000
Misc (Nahatlatch)[f]	--	--	4,000	8,000	14,000	26,000	49,000
Summer	--	--	**640,000**	**992,000**	**1,677,000**	**2,962,000**	**5,023,000**
(total excluding miscellaneous	3,866,000	2,620,000	**637,000**	**986,000**	**1,667,000**	**2,942,000**	**4,983,000**
Chilko[g]	**1,405,000**	**1,781,000**	459,000	658,000	1,002,000	1,573,000	2,283,000
Quesnel	**1,324,000**	**55,000**	6,000	9,000	15,000	25,000	40,000
Late Stuart	**544,000**	**175,000**	42,000	86,000	192,000	427,000	880,000
Stellako	**457,000**	**448,000**	86,000	144,000	256,000	454,000	761,000
Harrison[h & i]	**105,000**	**104,000**	33,000	73,000	176,000	425,000	957,000
Raft[h]	**31,000**	**57,000**	11,000	16,000	26,000	38,000	62,000
Misc (N. Thomp. Tribs)[h & j]	--	--	600	1,000	2,000	4,000	9,000
Misc (N. Thomp River)[h & j]	--	--	1,000	3,000	4,000	9,000	19,000
Misc (Widgeon)[k]	--	--	1,000	2,000	4,000	7,000	12,000
Late	--	--	**41,000**	**65,000**	**111,000**	**203,000**	**366,000**
(total exlcuding miscellaneous	3,169,000	689,000	**33,000**	**51,000**	**84,000**	**155,000**	**282,000**
Cultus[g]	**38,000**	**22,000**	1,000	2,000	4,000	9,000	17,000
**Late Shuswap	**2,379,000**	**29,000**	0	100	4,000	25,000	76,000
Portage	**41,000**	**16,000**	0	200	400	1,000	2,000
Weaver	**346,000**	**345,000**	2,000	4,000	8,000	15,000	29,000
[xx]Birkenhead	**365,000**	**277,000**	30,000	45,000	68,000	105,000	158,000
Misc non-Shuswap[k]	--	--	8,000	14,000	27,000	48,000	84,000
TOTAL SOCKEYE SALMON	--	--	**814,000**	**1,296,000**	**2,271,000**	**4,227,000**	**8,181,000**
(TOTAL excluding miscellaneo	**7,838,000**	**3,860,000**	**780,000**	**1,217,000**	**2,073,000**	**3,741,000**	**6,881,000**

a. Probability that return will be at, or below, specified projection.
c. Sockeye: 1953-2012 (depending on start of time series)
d. Sockeye: 1955-2012 (depending on start of time series)
e. Misc. Early Shuswap stocks use Scotch and Seymour R/EFS in forecast; Misc. Taseko uses Chilko R/EFS in forecast
f. Misc. Nahatlach uses Early Summer Run stocks R/EFS in forecast
g. Brood year smolts in columns C & D (not effective females)
h. Raft, Harrison, Miscellaneous North Thompson stocks moved in current forecast to Summer Run timing group due to changes in ru
i. Harrison are age-4 (column C) and age-3 (column D).
j. Misc. North Thompson stocks use Raft & Fennel R/EFS in forecast
k. Misc. Late Run stocks (Harrison Lake down stream migrants including Big Silver, Cogburn, etc.), and river-type Widgeon use Birke

Table B2. Spawning escapement plan for Fraser River sockeye salmon in 2016. (Provided to the Panel by Fisheries and Oceans Canada and based on Fraser River Sockeye Spawning Initiative (FRSSI) guidelines with input from domestic consultations).

Raft North Thompson & Harrison in Summer Run.

	Harvest Rule Parameters				
Management Unit	**Low Abundance ER (LAER)**	**TAM Cap**	**Lower Fishery Reference Point**	**Upper Fishery Reference Point**	**Pre-season pMA**
Early Stuart	10%	60%	108,000	270,000	0.69
Early Summer (w/o misc)	10%	60%	100,000	250,000	0.59
Summer (w/o misc)	10%	60%	640,000	1,600,000	0.11
Late (w/o misc)	20%	60%	300,000	750,000	0.47

Management Unit		**Pre-season Forecast Return**				
		p10	p25	**p50**	p75	p90
Early Stuart	forecast	13,000	22,000	**36,000**	59,000	89,000
	TAM Rule (%)	0%	0%	**0%**	0%	0%
	Escapement Target	13,000	22,000	**36,000**	59,000	89,000
	MA	9,000	15,200	**24,800**	40,700	61,400
	Esc. Target + MA	22,000	37,200	**60,800**	99,700	150,400
	LAER	10%	10%	**10%**	10%	10%
	ER at Return	0%	0%	**0%**	0%	0%
	Allowable ER	10%	10%	**10%**	10%	10%
	available harvest	1,300	2,200	**3,600**	5,900	8,900
	2016 Performance					
	Projected S (after MA	7,000	12,000	**19,000**	31,000	47,000
	BY Spawners	26,233	26,233	**26,233**	26,233	26,233
	Proj. S as % BY S	27%	46%	**72%**	118%	179%
	cycle avg S	35,861	35,861	**35,861**	35,861	35,861
	Proj. S as % cycle S	20%	33%	**53%**	86%	131%

Management Unit		**Pre-season Forecast Return**				
		p10	p25	**p50**	p75	p90
Early Summer (w/o RNT)	*lower ref. pt. (w misc)*	156,000	156,000	156,000	156,000	156,000
	upper ref. pt. (w misc)	390,000	390,000	390,000	390,000	390,000
	forecast (incl. misc)	120,000	217,000	447,000	1,003,000	2,703,000
	TAM Rule (%)	0%	28%	**60%**	60%	60%
	Escapement Target	120,000	156,000	**178,800**	401,200	1,081,200
	MA	70,800	92,000	**105,500**	236,700	637,900
	Esc. Target + MA	190,800	248,000	**284,300**	637,900	1,719,100
	LAER	10%	10%	**10%**	10%	10%
	ER at Return	0%	0%	**36%**	36%	36%
	Allowable ER	10%	10%	**36%**	36%	36%
	available harvest	12,000	21,700	**162,700**	365,100	983,900
	2016 Performance					
	Projected S (after MA	68,000	123,000	**179,000**	401,000	1,081,000
	BY Spawners	276,018	276,018	**276,018**	276,018	276,018
	Proj. S as % BY S	25%	45%	**65%**	145%	392%
	cycle avg S	132,183	132,183	**132,183**	132,183	132,183
	Proj. S as % cycle S	51%	93%	**135%**	303%	818%

Table B2, continued on next page

Table B2, continued.

Management Unit		Pre-season Forecast Return				
		p10	p25	**p50**	p75	p90
Summer	*lower ref. pt. (w misc)*	722,000	722,000	**722,000**	722,000	722,000
(w. RNT & Har)	*upper ref. pt. (w misc)*	1,805,000	1,805,000	**1,805,000**	1,805,000	1,805,000
	forecast	640,000	992,000	**1,677,000**	2,962,000	5,023,000
	TAM Rule (%)	0%	27%	**57%**	60%	60%
	Escapement Target	640,000	722,000	**722,000**	1,184,800	2,009,200
	MA	70,400	79,400	**79,400**	130,300	221,000
	Esc. Target + MA	710,400	801,400	**801,400**	1,315,100	2,230,200
	LAER	10%	10%	**10%**	10%	10%
	ER at Return	0%	19%	**52%**	56%	56%
	Allowable ER	10%	19%	**52%**	56%	56%
	available harvest	64,000	190,600	**875,600**	1,646,900	2,792,800
	2016 Performance					
	Projected S (after MA	519,000	722,000	**722,000**	1,185,000	2,009,000
	BY Spawners	559,387	559,387	**559,387**	559,387	559,387
	Proj. S as % BY S	93%	129%	**129%**	212%	359%
	cycle avg S	656,591	656,591	**656,591**	656,591	656,591
	Proj. S as % cycle S	79%	110%	**110%**	180%	306%

Management Unit		Pre-season Forecast Return				
		p10	p25	**p50**	p75	p90
Late	*lower ref. pt. (w misc)*	396,000	396,000	**396,000**	396,000	396,000
(w/o Har)	*upper ref. pt. (w misc)*	990,000	990,000	**990,000**	990,000	990,000
	forecast	41,000	65,000	**111,000**	203,000	366,000
	TAM Rule (%)	0%	0%	**0%**	0%	0%
	Escapement Target	41,000	65,000	**111,000**	203,000	366,000
	MA	19,300	30,600	**52,200**	95,400	172,000
	Esc. Target + MA	60,300	95,600	**163,200**	298,400	538,000
	LAER	20%	20%	**20%**	20%	20%
	ER at Return	0%	0%	**0%**	0%	0%
	Allowable ER	20%	20%	**20%**	20%	20%
	available harvest	8,200	13,000	**22,200**	40,600	73,200
	2016 Performance					
	Projected S (after MA	22,000	35,000	**60,000**	110,000	199,000
	BY Spawners	61,209	61,209	61,209	61,209	61,209
	Proj. S as % BY S	36%	57%	**98%**	180%	325%
	cycle avg S	134,046	134,046	**134,046**	134,046	134,046
	Proj. S as % cycle S	16%	26%	**45%**	82%	148%
Available Harvest (TF, US, CDN)		85,500	227,500	**1,064,100**	2,058,500	3,858,800
Total projected spawners		616,000	892,000	**980,000**	1,727,000	3,336,000

APPENDIX C: 2016 FRASER RIVER PANEL MANAGEMENT PLAN PRINCIPLES AND CONSTRAINTS (agreed July 19, 2016)

1. Fisheries and Oceans Canada (DFO) has provided the Panel with run-size forecasts for Fraser River sockeye salmon. It is broadly understood that the sockeye run-size forecast is associated with relatively high uncertainty due to considerable variability in annual salmon productivity (e.g. recruits/spawner, recruits/fry) and observation error in the associated data. The 50% probability level forecast for the total Fraser sockeye return is 2,271,000 fish. To put the sockeye run size forecast uncertainty into context, there is a one in four chance that the actual number of returning sockeye will be at or below 1,296,000 fish and there is a one in four chance that the actual number of returning sockeye will be at or larger than 4,227,000 fish. By stock grouping, the median or 50% probability forecasts are 36,000 Early Stuart, 447,000 Early Summer-run, 1,677,000 Summer-run[15], and 111,000 Late-run sockeye. The 50% probability level abundance was used for pre-season planning purposes. When sufficient information is available in-season, the Panel will update the run size estimates of Fraser River sockeye salmon, as appropriate.

2. The Panel's first priority in 2016 is to achieve spawning escapement goals by stock or stock grouping unless the escapement target of a particular run timing group in combination with the associated management adjustment exceeds the run size of the run timing group. Under these circumstances the particular run timing group will be managed to not exceed the low abundance exploitation rate (LAER) for that group. A coordinated approach to management has been developed that reflects both Parties sharing the burden of conservation. As a result of the pre-season planning and with consideration of the potential for adverse environmental conditions for fish survival and productivity, as well as the projected high diversion rate through Johnstone Strait, it is anticipated that neither Canada nor the US will harvest their full sockeye TAC. Initiation of US Panel water commercial fisheries openings were modeled in response to conservation needs for the Early Stuart and Early Summer sockeye stock groups. At the median pre-season forecast abundance levels, all of the Canadian share of the TAC was required to meet the priority allocation to First Nations for food, social and ceremonial (FSC) purposes.

3. TAC and international shares are calculated according to the 2014 revised Annex IV, Chapter 4, of the Pacific Salmon Treaty, which limits the United States harvest (in Washington State) to 16.5% of the total allowable catches (TACs) of Fraser River sockeye salmon. Based upon the 50% probability levels of abundance, for the purposes of computing TAC by stock management grouping in 2016, the Panel agreed to pre-season Fraser River Aboriginal Exemptions as follows: Early Stuart sockeye, 3,400 fish; Early Summer-run sockeye, 79,400 fish; Summer-run sockeye, 296,200 fish; and Late-run sockeye, 21,000 fish. In situations where the allowable harvest of a management group, according to Total Allowable Mortality rules as defined in Canada's escapement plan, is less than the harvest allowed under the low abundance exploitation rates (LAERs), the Panel will implement LAERs in order to allow access to available TAC in other Fraser sockeye salmon management groups. At the 50% probability forecasts, the LAERs are set at 10% for Early Stuart, Early Summer and Summer-run sockeye, and at 20% for Late-run sockeye. LAERs are not intended to create directed harvest opportunities in mixed stock areas and do not contribute to International TACs. Calculated International TACs that fall below the LAER amount will contribute to the International share.

4. The Panel has adopted a management approach for Late-run sockeye that presumes that similar to recent years, Late-run sockeye will enter the Fraser River earlier than the long-term average, and some proportion will not survive to spawn.

[15] Similar to the 2015 management season, Raft, North Thompson, Widgeon and Harrison sockeye will be managed as part of the Summer-run group in 2016.

5. Given pre-season assumptions about Late-run sockeye marine timing, recent delay behavior, the Panel anticipates a median expected difference between estimates of -32% (%DBE; cycle line average). The low abundance of the Late-run group (excluding the Birkenhead complex) is expected to be too small to permit in-season updates of its abundance. At forecast abundance levels and escapement objectives, the Panel anticipates managing late runs with a LAER approach. As such management decisions will be directed at limiting impacts within the LAER rather than by MA values that are intended to compensate for the expected %DBE.

Regulations

i) If in-season conditions are consistent with pre-season expectations, low impact fisheries would be expected to commence during late July in Panel Waters. The actual start dates and duration of fisheries will depend on in-season estimates of timing, abundance, diversion, and agreed management adjustments.

ii) The Parties' conservation concerns for other species and stocks will be taken into account throughout the 2016 management season.

APPENDIX D: 2016 REGULATIONS

The Fraser River Panel approved regulations for the management of the Fraser River sockeye salmon fishery in Panel Area waters and submitted these to the Pacific Salmon Commission. The Commission approved the Fishery Regime and Regulations and submitted these to the respective national governments for approval on June 24, 2016

In accordance with Article VI, Paragraph 5 of the Pacific Salmon Treaty, the Commission recommends to the Canadian Government the adoption of the following Fishing Regime developed by the Fraser River Panel, namely:

1. a) No person shall commercially fish for sockeye or pink salmon in Pacific Fishery Management Area 20-1, 3 and 4 with nets from the 26th day of June, 2016, to the 3rd day of September, 2016, both dates inclusive.

   b) No person shall troll commercially for sockeye or pink salmon in Pacific Fishery Management Area 20-1, 3 and 4 from the 26th day of June, 2016, to the 3rd day of September, 2016, both dates inclusive.

2. a) No person shall commercially fish for sockeye or pink salmon in Pacific Fishery Management Areas 17 and 18 with nets from the 26th day of June, 2016 to the 1st day of October, 2016, both dates inclusive.

   b) No person shall troll commercially for sockeye or pink salmon in Pacific Fishery Management Area 18-1, 4 and 11 from the 26th day of June, 2016, to the 1st day of October, 2016, both dates inclusive.

3. a) No person shall commercially fish for sockeye or pink salmon with nets in Pacific Fishery Management Area 29 from the 26th day of June, 2016, to the 8th day of October, 2016, both dates inclusive.

   b) No person shall troll commercially for sockeye or pink salmon in Pacific Fishery Management Area 29 from the 26th day of June, 2016, to the 8th day of October, 2016, both dates inclusive.

4. The following Fraser River Panel Area waters are excluded:

   a) High Seas westerly of the Bonilla Point-Tatoosh Island Lighthouse Line.

   b) Pacific Fishery Management Area 19, Area 20-2 and 5 to 7 and Area 29-8.

   c) Commercial troll fishing in Pacific Fishery Management Area 17, Area 18-2, 3 and 5 to 10.

During the 2016 season, the Fraser River Panel will adopt Orders establishing open fishing periods based on a 2016 Management Plan adopted by the Panel. This Plan will be designed to achieve Pacific Salmon Treaty-mandated conservation objectives, international allocations of the catch, and domestic goals of the Parties.

United States Fraser River Panel Area

In accordance with Article VI, Paragraph 5 of the Pacific Salmon Treaty, the Commission recommends to the United States Government the adoption of the following Fishing Regime developed by the Fraser River Panel, namely:

Treaty Indian Fisheries:

1. No Treaty Indian shall commercially fish for sockeye or pink salmon in Puget Sound Salmon Management and Catch Reporting Areas 4B, 5 and 6C with drift gillnets or purse seines from the 26th day of June, 2016 to the 3rd day of September, 2016, both dates inclusive.

2. No Treaty Indian shall commercially fish for sockeye or pink salmon in Puget Sound Salmon Management and Catch Reporting Areas 6, 6A, 7 and 7A with nets from the 26th day of June, 2016, to the 10th day of September, 2016, both dates inclusive.

3. No Treaty Indian shall commercially fish for sockeye or pink salmon with nets in that portion of Puget Sound Salmon Management and Catch Reporting Area 7A lying westerly of a straight line drawn from the low water range marker in Boundary Bay on the International Boundary through the east tip of Point Roberts in the State of Washington to the East Point Light on Saturna Island in the Province of British Columbia from the 11th day of September, 2016, to the 1st day of October, 2016, both dates inclusive.

All-Citizen Fisheries:

1. No person shall fish for sockeye or pink salmon in Puget Sound Salmon Management and Catch Reporting Areas 4B, 5, and 6C with nets from the 26th day of June, 2016, to the 3rd day of September, 2016, both dates inclusive.

2. No person shall fish for sockeye or pink salmon in Puget Sound Salmon Management and Catch Reporting Areas 6, 6A, 7 and 7A with nets from the 26th day of June, 2016, to the 10th day of September, 2016, both dates inclusive.

3. No person shall fish for sockeye or pink salmon with nets in that portion of Puget Sound Salmon Management and Catch Reporting Area 7A lying westerly of a straight line drawn from the low water range marker in Boundary Bay on the International Boundary through the east tip of Point Roberts in the State of Washington to the East Point Light on Saturna Island in the Province of British Columbia from the 11th day of September, 2016, to the 1st day of October, 2016, both dates inclusive.

The following Fraser River Panel Area waters and fisheries are excluded:

Treaty Indian and All-Citizen Fisheries:

1. High Seas westerly of the Bonilla Point-Tatoosh Island Lighthouse Line.

2. Puget Sound Salmon Management and Catch Reporting Areas 6B, 6D, 7B, 7C, 7D and 7E.

During the 2016 season, the Fraser River Panel will adopt Orders establishing open fishing periods based on a 2016 Management Plan adopted by the Panel. This Plan will be designed to achieve Pacific Salmon Treaty-mandated conservation objectives, international allocations of the catch, and domestic goals of the Parties.

APPENDIX E: 2016 Pre-Season Agreement on Test Fishing Deductions and use of the Test Fishing Revolving Fund (Agreed July 26, 2016)

Purpose: The Pacific Salmon Commission (PSC) conducts test fisheries to assess various factors pertinent to the conservation and management of Fraser River sockeye and pink salmon. Revenue for the program is generated through sale of fish retained by test-fisheries. Some of the fish retained are either unavoidably killed in the conduct of test fishing operations or required for biological samples, and the retention of additional fish ("pay fish") provides revenues to offset larger program costs. The PSC maintains a "Test-Fishing Revolving Fund" created by contributions from Canada and the United States. The purpose of the fund is to ensure that sufficient funds are available to cover the cost of the test-fishing program in the event that conservation needs prevent taking adequate numbers of sockeye, pink, and saleable by-catch. For 2016, the forecast and pre-season plans identify limited Total Allowable Catch (TAC) such that there is not to be adequate Fraser sockeye TAC to fully meet First Nations allocations for Food, social and ceremonial (FSC) purposes in Canada. This creates an allocation issue within Canada with respect to retention of "pay fish". For this reason, and to address this issue for 2016 only, the Parties have agreed to the following approach for the 2016 season, without prejudice to future arrangements:

1. That only those salmon (and other incidentally caught fish) that are unavoidably killed or required for biological samples in Panel-approved test fisheries will be landed and sold, unless otherwise specified below or agreed by the Parties.

2. Where in-season the Fraser River Panel determines that sockeye aggregate harvestable surplus (defined as the sum of run sizes minus escapement targets, minus management adjustments, and minus the agreed test fishing deductions for each stock management group) is sufficient to support an international total allowable catch (TAC; as defined in paragraph 3, Annex IV, Chapter 4 of the Pacific Salmon Treaty), but insufficient to support the full allocations to Canada's First Nations for food, social, and ceremonial (FSC) purposes (1,079,000 Fraser River sockeye), the Parties agree that any resulting funding deficits in the test fishing program will be paid from the PSC Test Fishing Revolving Fund (TFRF). The Secretariat will maintain timely records of the deficits incurred, and apportion those deficits between the Parties in proportion to their Fraser River sockeye TAC shares (i.e. 16.5% to the United States and 83.5% to Canada) after the conclusion of the sampling season.

3. Where in-season the Fraser River Panel determines aggregate sockeye harvestable surplus is sufficient to support both an international TAC and the full FSC allocations to Canada's First Nations, the Panel will prioritize the harvest, landing, and sale of salmon in Panel-approved test fisheries beyond those identified in paragraph 1, with the goal of recovering revenues to offset some or all of costs incurred in the 2016 season. Any fish so harvested will be added to the existing test fishing harvests and deducted from the international TAC as per normal practice. The Secretariat will maintain timely records of the deficits incurred, and apportion those deficits between the Parties in proportion to their Fraser River sockeye TAC shares (i.e. 16.5% to the United States and 83.5% to Canada) after the conclusion of the sampling season.

4. Where in-season the Fraser River Panel determines that aggregate sockeye harvestable surplus is insufficient to generate an international TAC, any shortfalls in revenues relative to program costs will be recovered from the TFRF. When there is no TAC for international sharing the costs of test fisheries will be shared 50:50 between the two countries.

APPENDIX F: 2016 FRASER RIVER PANEL IN-SEASON ORDERS

To provide for adequate escapement of the various stocks of Fraser River sockeye salmon and for the prescribed allocation of catch: (a) internationally, between the United States and Canada and (b) domestically, among the commercial user groups in Canada and the United States, the Fraser River Panel formulated the following orders to regulate Panel Area fisheries.

July 22, 2016
United States
Treaty Indian Fishery
Areas 4B, 5 and 6C
Open to drift gillnets from 12:00 p.m. (noon), Saturday, July 23, 2016 to 12:00 p.m. (noon) Wednesday, July 27, 2016.

July 26, 2016
United States
Treaty Indian Fishery
Areas 4B, 5 and 6C
Extended for drift gillnets from 12:00 p.m. (noon) Wednesday, July 27, 2016 to 12:00 p.m. (noon), Saturday, July 30, 2016.

July 29, 2016
United States
Treaty Indian Fishery
Areas 4B, 5 and 6C
Extended for drift gillnets from 12:00 p.m. (noon) Saturday, July 30, 2016 to 12:00 p.m. (noon), Wednesday, August 3, 2016.

August 2, 2016
United States
Treaty Indian Fishery
Areas 4B, 5 and 6C
Extended for drift gillnets from 12:00 p.m. (noon) Wednesday, August 3, 2016 to 12:00 p.m. (noon), Saturday, August 6, 2016.

August 26, 2016
United States
Areas 6, 6A and 7
The Fraser River Panel relinquished regulatory control of U.S. Panel Area Waters, Areas 6, 6A, 7 and a portion of Area 7A, at 11:59 p.m. (midnight) Saturday, September 3, 2016.

Fraser River Panel control of Canadian Panel Areas was relinquished in accordance with the pre-season Regulations (Appendix D) as follows: Area 20 on September 3; Areas 17 and 18 on October 1; and Area 29 on October 8. Panel control of United States Panel Areas were relinquished as follows; Areas 4B, 5 and 6C on September 3 in accordance with the pre-season Regulations; Areas 6, 7 and portions of 7A on September 3 by in-season order; and the remaining portions of Area 7A on October 1 in accordance with the pre-season Regulations.

APPENDIX G: PSC STAFF ACTIVITIES: STOCK MONITORING, IDENTIFICATION AND ASSESSMENT, AND MANAGEMENT ADJUSTMENTS

Stock Monitoring

Stock monitoring programs assess the abundance and migration timing of Fraser River sockeye and pink salmon at different points along their migration routes. The Stock Monitoring Group uses test fishery data from marine and freshwater areas, hydroacoustic abundance estimates collected in the Fraser River at Mission, B.C., and visual observations at Hells Gate. In addition to providing estimates of daily and cumulative passage in marine areas and at Mission, stock monitoring analyses provide projections of the number of fish migrating between marine areas and Mission, and estimates of diversion rates through Johnstone Strait. Stock composition information from the Stock Identification Group is used to apportion total estimates to sockeye stocks or stock groups and Fraser and non-Fraser origin pink salmon. This information is required for the development of fishing plans that aid in meeting spawning escapement and catch allocation objectives.

A. Test Fishing

Test fisheries provide much of the data used to assess the migration of Fraser sockeye and pink salmon, including abundance-related data such as catch-per-unit-effort (CPUE) and biological samples from which stock composition estimates are obtained. While Table 3 in the main body of the report summarizes the locations and temporal patterns of Panel-approved test fisheries, Table G1 summarizes more detailed information about the nets and sampling strategies employed.

Table G1. Sampling details for Panel-approved test fisheries conducted in 2016.

Area	Name	Gear	Number of Vessels	Net Length (m)	Net Depth (meshes)	Mesh Size (mm)	Mesh Size (in)	Number of Sets	Set Duration (minutes)
Canadian Panel Areas									
20	Juan de Fuca Str.	Gillnet	1	547	90	130	5 1/8	2	300
20	Juan de Fuca Str.	Purse Seine	1	n/a	875	95	3 3/4	6	20
29-14	Fraser R. (Cottonwood)	Gillnet	1	292	Variable	Variable		1	30
29-16	Fraser R. (Whonnock)	Gillnet	1	319	Variable	Variable		2	20
	Fraser R. (Qualark)	Gillnet	1	30	Variable	Variable		6	5
United States Panel Areas									
7	San Juan Islands	Reefnet [1]	3	n/a	n/a	n/a		n/a	n/a
Canadian Non-Panel Areas									
12	Queen Charlotte Str. (Round Is.)	Gillnet [2]	1	365	60-90	130	5 1/8	4	100
12	Johnstone Str. (Blinkhorn)	Purse Seine	1-2	401	575	95	3 3/4	6	20

1 Reefnet observations are made during periods of favorable tides. Fish are counted as they swim through the gear but are not harvested.

2 Round Island vessels used a 60 mesh nylon net and Naka Creek vessels a 90 Mesh Alaska twist net.

Information pertaining to the migration of Fraser River sockeye and pink salmon through marine areas is provided primarily by test fisheries in Area 20 (Juan de Fuca Strait) and Areas 12 and 13 (upper and lower Johnstone Strait), but is augmented during the early part of the season by test fisheries in U.S. Areas 4B and 5 (Juan de Fuca Strait) and Area 7 (San Juan Islands). For Fraser River pink salmon, CPUE and stock composition data from the seine test fisheries in Areas 20 and 12 are particularly important for estimating total abundance. Test fisheries in the Fraser River (Area 29) are used to assess species and stock composition for application to Mission passage estimates. When the Mission hydroacoustic program is not active or when high

abundances of pink salmon confounds estimates of sockeye proportions migrating upstream, lower river (Area 29) test fisheries provide passage estimates through the use of CPUE models.

In 2016, the Fraser River Panel tried to minimize test fishing catches as well as the duration and cost of assessment fisheries. As a result of the low forecasted return for Early Stuart sockeye in 2016 (p50 of 36,000 sockeye), the Whonnock gillnet test fishery start date was delayed until June 30 and marine gillnet test fisheries start dates were delayed until July 11, after which most of the Early Stuart sockeye were thought to have migrated past the test fishery sites. Similarly, the expected low return of Late-run sockeye resulted in earlier end dates of in-river test fisheries and marine test fisheries with in-river gillnet test fisheries ending one week earlier than scheduled and marine gillnet test fisheries also ending earlier than the scheduled end date of August 10. Marine purse seine test fisheries ended as scheduled on August 12. The test fishing program was reduced for 2016 to reflect what was considered to be the main assessment fisheries required for quantitative in-season run size assessments. The number of Area 20 gillnet test fishing vessels was reduced from two to one, the Area 12 Naka Creek gillnet test fishery was cancelled, the number of reef net observation days was reduced to operate only prior to potential US commercial fishery openings and the Area 4B,5,6C U.S gillnet test fishery was cancelled for 2016.

Early in the season, daily marine gillnet catches were similar to brood year catches, but remained below the cycle year average. Later in the season, purse seine test fishery catches were also low compared to the brood years as well as the cycle year average. In the Fraser River, test fishing catches were lower than the brood and cycle year averages with Cottonwood catches not exceeding 40 sockeye/set, except on July 27, and Whonnock total catch from both sets not exceeding 60 sockeye, except on August 3 and August 5. At Cottonwood, additional non-assessment sets were made throughout the season to increase the daily sample sizes. Only sockeye caught in gillnet test fisheries and those retained for biological samples were retained and sold for revenue. The total number of Fraser River sockeye retained from all Panel approved test fisheries was approximately half of what was forecasted to be retained from gillnets and for biological samples and approximately one quarter of what was required to pay for the 2016 test fishing programs.

2016 was the first year of a three year Southern Endowment and Enhancement Committee approved project[16] (SF-2016-I-10). The project utilizes Global Positioning Satellite tracking technology to collect tide and current data and evaluate the effects of tide and current, in upper Johnstone Strait in the vicinity of the Area 12 Blinkhorn purse seine test fishery, on Fraser sockeye run-size assessments. The project goal is to improve run-size abundance estimates derived from marine test fishery data. The data collected will augment other test fishery data that are used to assess Fraser sockeye run sizes. This project is supported by the PSC Secretariat and DFO assessment staff.

B. Mission Hydroacoustics

PSC staff operates a hydroacoustic facility upstream of the Mission Railway Bridge from July through September to provide timely in-season estimates of sockeye and pink salmon escapement through the lower Fraser River. Since 2011, Staff have implemented a standardized sampling method to estimate daily salmon passage using a combination of split-beam and imaging

[16] Forrest, K., C. McConnell, R. Goruk, and C. Michielsens. 2016. Deployment of ocean surface current trackers in upper Johnstone Strait for the collection of local tide and current data to explain variability in marine catch data and improve daily abundance and run size estimates of Fraser River Sockeye & Pink salmon: A project report to Southern boundary restoration and enhancement fund. Pacific Salmon Commission, Vancouver, British Columbia. November, 2016.

sonars[17,18]. The sonar systems operate 24 hours a day to collect information on the density, direction of travel, speed, and size distributions of fish targets. For 2016, daily salmon passage was estimated using a side-looking split-beam sonar system on the left bank of the river, a downward-looking split-beam sonar mounted on a vessel transecting the river, and a DIDSON imaging sonar on the right bank of the river (Figure G1). A second DIDSON was operated on the left bank directly adjacent to the split-beam sonar to verify the split-beam estimates.

The left bank split-beam (S1) began operating on July 8 using a side-looking transducer with an elliptical beam width of 2°×10°. The transducer was attached to a rotator to control its pan and tilt, allowing stratified sampling of the water column by the narrow, vertical beam aperture. The stratified sampling design consisted of six non-overlapping, 2° vertical fan-shaped sectors with each sector sampled for 10 minutes each hour up to a range of 60 metres. This sampling design was intended to maximize the portion of water column insonified by the sonar, therefore minimizing unsampled areas where migratory abundance must be estimated by extrapolation. The aim and orientation of the transducer were monitored and verified with a motion reference unit (Thinksensor TSR-100). The transducer was deployed towards the far end of an extendable fish-deflection weir which prevented fish from swimming behind or too close to the transducer.

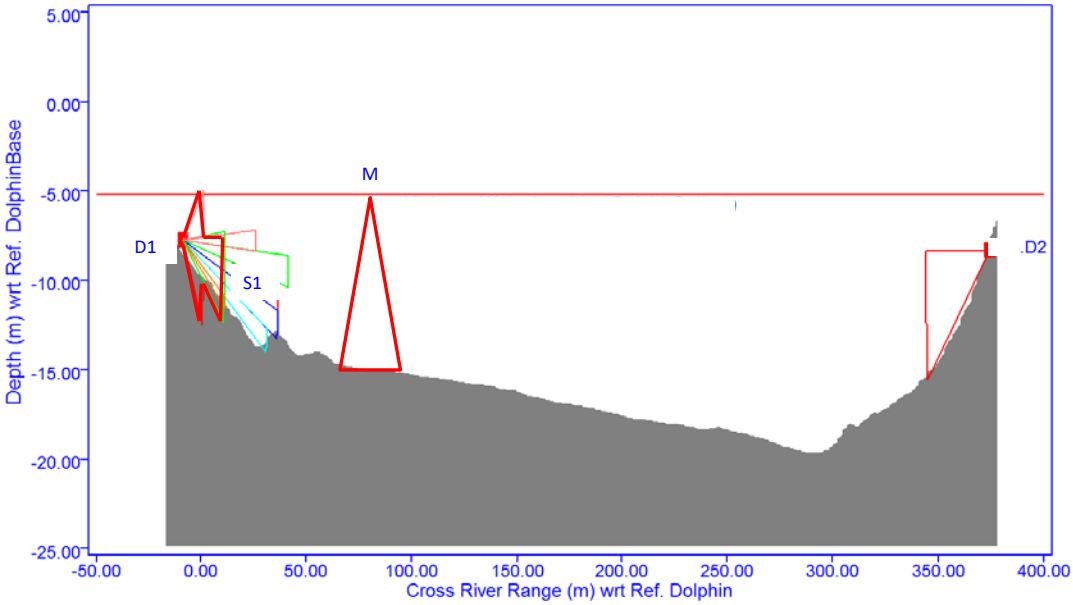

Figure G11. Cross-river view of the sampling geometry of the four sonar systems operated 24 hours per day at the Mission hydroacoustics site. The four systems include the left bank DIDSON near shore (D1), left bank split-beam (S1), mobile split-beam (M), and the right bank inshore DIDSON (D2). The dark gray filled area represents the cross-river bottom profile.

From July 11 to August 3, a left bank inshore DIDSON (D1) was also operated in parallel to the left bank split-beam. This system was deployed on a rotator unit that allowed it to cycle through multiple vertical aims for full sampling coverage of the water column up to a range of 20 metres.

[17] Xie, Y., A. P. Gray, F. J. Martens, and J. D. Cave. 2007. Development of a shore-based hydroacoustics system on the right bank of the Lower Fraser River to monitor salmon passages: A project report to Southern boundary restoration and enhancement fund. Pacific Salmon Commission, Vancouver, British Columbia. April, 2007.

[18] Xie, Y., F. J. Martens, C. G. Michielsens, J. D. Cave. 2013. Implementation of Stationary Hydroacoustic Sampling Systems to Estimate Salmon Passage in the Lower Fraser River: A final project report to the southern boundary restoration and enhancement fund. Pacific Salmon Commission, Vancouver, British Columbia. May, 2013.

Data collected by this DIDSON was not used to generate the daily estimate of salmon passage, but assisted in validating the information collected by the left bank split-beam.

The vessel-based split-beam system (M) started operating July 6 using a downward-looking transducer with a 6° circular beam. The vessel transected the river every five minutes to obtain cross-river fish density data with an average of 175 transects carried out each day. Information on the direction of travel and speed of fish targets cannot be obtained from a moving transducer, so behavioural statistics observed from the left bank split-beam sonar were applied to the vessel-based density data to estimate offshore fish passage[19]. To validate estimated offshore fish passage by the mobile sampling system, a vessel-based DIDSON was also deployed for approximately 6 hours per day from anchored positions near the left or right bank (three hours at each station). The DIDSON was aimed offshore for stationary sampling of fish passage over a 20 metre range from the vessel.

The right bank inshore DIDSON (D2) commenced data collection on July 13 and was included in subsequent daily estimates of salmon passage. Similarly to the left bank split-beam, the D2 was deployed near the end of a fish deflection weir to prevent fish from swimming behind or too close to the sonar. The near-shore bottom on the right bank follows a slightly concave profile that fits well to the vertical beam shape of the DIDSON, allowing the sonar to sample the entire water column up to 30 metres from the shoreline using a single, fixed aim pointing approximately 5° downwards.

To determine salmon passage through areas sampled by the DIDSONs, a subset of the imaging data was manually counted by experienced technicians. Technicians counted the number of fish targets and their direction of travel for 5 to 10 minutes of each hour. These counts were then expanded to estimate the hourly passage of fish in both the upstream and downstream directions. Since these counts included small, resident fish, a mixture model was applied to apportion the salmon passage from the total passage of fish for each day. The mixture model was updated daily using a subset of length data estimated from the same imaging data that produced the fish counts.

To determine salmon passage from the split-beam systems, targets were tracked using an alpha-beta tracker[20] and then classified as fish or noise (e.g. debris, air bubbles) by a discriminate function analysis[21]. This treatment also removes small, non-salmonid fish targets from the estimation data by filtering out tracks with a lower target strength. The integrity of statistically identified fish tracks was further verified by trained staff that reviewed the echogram data with editing software to remove misclassified targets. This processing procedure was performed each day for the data collected from both the left bank and vessel-based split-beam systems providing information on the density and position of fish targets within the areas sampled by the split-beam systems. Processed fish tracks from the stationary left bank system also provided information on the velocity and direction of travel of fish targets.

The daily total salmon passage through the lower Fraser River at Mission was estimated by adding the salmon passage estimates for the left bank split-beam, the vessel-based split-beam and

[19] Xie, Y., A. P. Gray, F. J. Martens, J. L. Boffey and J. D. Cave. 2005. Use of dual-frequency identification sonar to verify salmon flux and to examine fish behaviour in the Fraser River. Pacific Salmon Comm. Tech. Rep. No. 16: 58 p. Vancouver, B.C.

[20] Blackman, S. S. and R. Popoli. Design and Analysis of Modern Tracking Systems. Artech House, Boston, 1999.

[21] Xie, Y., C.G.J. Michielsens, and F.J. Martens. 2012. Classification of fish and non-fish acoustic tracks using discriminant function analysis. – ICES Journal of Marine Science, doi:10.1093/icesjms/fsr198

the right bank inshore DIDSON. If areas were sampled by both the vessel-based and the shore-based systems, the vessel-based GPS data and sampling ranges from the shore based systems were used to ensure that data from only one system was applied to an area. Since fish densities estimated from the vessel-based mobile split-beam are the least accurate among all the sonar systems for the program, data from this system was limited to abundance estimates in offshore areas beyond the effective sampling ranges of the inshore systems. Daily salmon passage estimates were further apportioned into species and stocks based on species composition and stock identification information obtained from the daily test-fishing programs.

For the 2016 season, with the funding support from Southern Boundary Restoration and Enhancement Fund, an ARIS (Adaptive Resolution Imaging Sonar) system was tested in an experimental capacity on both banks at the site[22]. From July 12 to August 2, the ARIS was deployed directly adjacent to the right bank DIDSON for comparisons of fish density, size distributions and other information collected by the two sonars. From August 3 to August 29, the ARIS was deployed in parallel to the left bank split-beam to acquire comparable information. The 2016 hydroacoustics program also included data exchanges with DFO to compare passage estimate differences obtained from the hydroacoustics sites at Qualark Creek (DFO) and Mission.

Stock Identification

PSC staff conduct programs designed to identify the stock proportions of Fraser River sockeye and pink salmon in commercial, test, First Nations and recreational catches. Coupled with abundance indices from stock monitoring programs, these data provide information on the abundance and timing of sockeye and pink salmon as they migrate to their natal rivers in the Fraser watershed. Stock identification data are also used to account for Fraser sockeye and pink salmon wherever they are caught, and to apportion the daily estimates of sockeye escapement past Mission into discrete stock groups. Stock identification methods for sockeye salmon in 2016 used DNA and scale pattern analyses from fish caught in marine and in-river fisheries. No stock composition estimates were produced for pink salmon in 2016 because the Fraser River pink salmon run is virtually non-existent in even numbered years.

A. Sockeye Salmon

Stock identification methods for sockeye salmon relied on DNA[23] (using the program CBAYES2[24]) and scale pattern analyses[25]. Both techniques involve comparing the attributes of individuals in mixture samples (e.g., from mixed-stock fisheries) to the attributes of pure samples obtained from the spawning grounds of each of the named stocks (i.e., “standards” or “baselines”).

Samples from test fishery catches were analyzed daily, beginning in early July and continuing to mid-September. PSC staff sampled sockeye from most test fishery catches and commercial fishery landings. Sampling locations included Port Renfrew and the lower Fraser River in British

[22] C.R. Lagasse, M. Bartel-Sawatzky, J.L. Nelitz, and Y. Xie. 2017. Assessment of Adaptive Resolution Imaging Sonar (ARIS) for fish counting and measurements of fish length and swim speed in the lower Fraser River, year two: A final project report to the Southern Boundary Restoration and Enhancement Fund. Pacific Salmon Commission. June 2017.

[23] Beacham, T.D., M. Lapointe, J.R. Candy, B. McIntosh, C. MacConnachie, A. Tabata, K. Kaukinen, L. Deng, K.M. Miller and R.E. Withler. 2004. Stock identification of Fraser River sockeye salmon using microsatellites and major histocompatibility complex variation. Trans. Am. Fish. Soc. 133: 1117-1137.

[24] Neaves, P.I., C.G. Wallace, J.R. Candy, and T.D. Beacham. 2005. CBAYES: Computer program for mixed stock analysis of allelic data, v5.01. Department of Fisheries and Oceans (Canada). Available: http://www.pac.dfo-mpo.gc.ca/science/facilities-installations/pbs-sbp/mgl-lgm/apps/index-eng.htm (January 2012).

[25] Gable, J. and S. Cox-Rogers. Stock identification of Fraser River sockeye salmon: methodology and management application. PSC Tech. Rep. No. 5, October, 1993.

Columbia, and Bellingham in Washington. DFO provided samples from test fisheries in Johnstone Strait and from in-river test fisheries at Albion and Qualark. Alaska's Department of Fish and Game collected samples for the PSC from District 104 purse seine landings in Ketchikan and Petersburg, and Langara Fishing Adventures provided samples from recreational catches near Haida Gwaii. DFO and First Nations personnel obtained samples from Fraser River First Nations catches when available.

Sockeye catches in District 104 totaled 381,800 of which preliminary DNA analyses suggest 34,000 were of Fraser origin.

Table G2 summarizes age composition (based on scale readings by PSC Staff of fish classified to stock group by DNA) of caught sockeye compared to the pre-season forecast. The Early Stuart forecast for four year old proportions is similar to the percentage of age 4 fish sampled in-season. In-season Early Summer sockeye samples were pre-dominantly four year olds with the exception of Taseko and Nahatlatch, but the forecast age of return for these stock group included important contributions of other ages. The forecast Summer run included a large return of four year olds, predominantly Chilko. In-season, the return of age 4 Chilko fish was much lower than forecast which is consistent with the low run size observed in-season. The Late run forecast included a small return of age 4 fish but, based on Birkenhead, which was forecast to have the largest run size and a low number of age 4 fish, the in-season age readings for this group has age 4 proportions that were similar to the forecast.

Table G2. Summary of the 2016 forecast and the in-season age composition of sampled sockeye, based on scale readings of fish classified to stock group by DNA.

Sockeye stock/timing group	2016 Fraser Sockeye Forecasts			2016 In-season	
	FOUR YEAR OLDS p50[a]	TOTAL p50	FOUR YEAR OLD PROPORTION	Total Sampled	% Age -4
Earyl Stuart	**36,000**	**36,000**	**100%**	**49**	**94%**
Early Summer	**334,000**	**447,000**	**75%**	**1090**	**87%**
Bowron	200	4,000	5%	19	84%
Upper Barriere (Fennell)	8,500	14,000	61%	19	89%
Gates	61,000	76,000	80%	235	94%
Nadina	88,000	90,000	98%	158	93%
Pitt	18,000	90,000	20%	374	83%
Early S. Thompson	14,400	20,400	71%	26	62%
Misc (Taseko)	300	600	50%	12	25%
Misc (Chilliwack)	137,000	138,000	99%	230	97%
Misc (Nahatlatch)	7,000	14,000	50%	17	24%
Summer	**1,462,000**	**1,677,000**	**87%**	**2475**	**57%**
Chilko	976,000	1,002,000	97%	1346	64%
Quesnel	1,000	15,000	7%	26	23%
Late Stuart/Stellako	424,000	448,000	95%	438	82%
Harrison	48,000 (age-4)	176,000	27% (age-4)	439	12%
Raft	11,000	26,000	42%	85	72%
Misc (N. Thomp. Tribs)	1,200	6,200	19%	139	45%
Misc (Widgeon)	1,000	4,000	25%	2	100%
Late	**31,000**	**111,000**	**28%**	**306**	**50%**
Cultus	4,000	4,000	100%	48	88%
Late Shuswap	0	4,000	0%	2	100%
Portage	300	400	75%	1	100%
Weaver	5,000	8,000	62%	18	83%
Birkenhead	16,000	68,000	24%	203	34%
Misc Lillooeet-Harrison	6,000	27,000	22%	34	68%
Total	**1,863,000**	**2,271,000**	**82%**	**3920**	**65%**

a. Probability that actual return will be at or below specified run size

Stock Assessment

Assessment of Fraser River sockeye abundance by stock group is primarily based on catch, effort, escapement and stock composition data. Stock assessment methods mainly rely on catch and CPUE data from test fishing vessels and hydroacoustics estimates of Mission passage to assess abundances by stock group. These data are analysed using Bayesian stock assessment models[26, 27]. These models compare the reconstructed daily migration pattern to ideal run-timing curves, assuming the run is normally distributed. By assuming the run follows this idealized pattern, the run size can be estimated once the 50% migration date (i.e., the date 50% of the run has migrated past the reference location, which corresponds to the peak of the normal distribution) has been identified, by doubling the abundance up to that date. Prior to observing the peak of the run, there is considerable uncertainty about the run size. Based on initial observations before the peak of the run, the estimates can indicate the run to be either earlier, and smaller than forecast, or later, and larger than forecast.

The uncertainty about the actual size of the run is estimated using Bayesian methodology. The Bayesian version of the cumulative normal model relies on additional information (pre-season forecasts of run size based on historic stock-recruit data and timing based on sea-surface temperature (SST) and eastward current speed index in the Gulf of Alaska, expected duration of the run, average historical expansion line estimates and pre-season forecasts of diversion rate based on SST) to reduce the uncertainty and keep the run size estimates within realistic bounds. This prior information is incorporated within the Bayesian model through the use of prior probability distributions (priors). These priors indicate a range of values that are assumed plausible for the various model parameters and depending on the shape of the prior probability distribution indicate which parameter values are assumed more plausible than others. Theoretically the Bayesian version of the cumulative normal model should provide more stable estimates since it relies on both in-season as well as historical data. Retrospective analyses have confirmed that incorporating prior knowledge is especially advantageous before the 50% migration date is known. Bayesian stock assessment models are especially useful around the 50% migration date of the run as well as immediately after. After this period, when the run size will depend on the remainder of the run still to come, the run size can be estimated by adding the Bayesian estimate of the tail of the normal distribution to the accounted run-to-date.

Figures G2a, b, c and d provide an overview of the run size estimates from the stock assessment model and the accounted run size at various dates during the season (median and 80% probability interval). These estimates can be compared against the Panel adopted in-season run size estimates used for management purposes and against the final in-season estimates of the accounted run-to-date. In 2016, pre-season forecasts overestimated the run size for all management groups but especially for Summer-run. Based on the pre-season forecast distribution, there was an 11% chance that the total Fraser sockeye run size would be as low as observed. The timing of the run was similar to expectations for Early Stuart and Early Summer-run, but earlier than expected for Summer-run and Late-run sockeye salmon.

[26] Pacific Salmon Commission. 1995. Pacific Salmon Commission run-size estimation procedures: An analysis of the 1994 shortfall in escapement of Late-run Fraser River sockeye salmon. Pacific Salmon Comm. Tech. Rep. No. 6: 179 p.

[27] Pacific Salmon Commission. 1998. Report of the Fraser River Panel to the Pacific Salmon Commission on the 1995 Fraser River sockeye and pink salmon fishing season. Vancouver, B.C., 64 p.

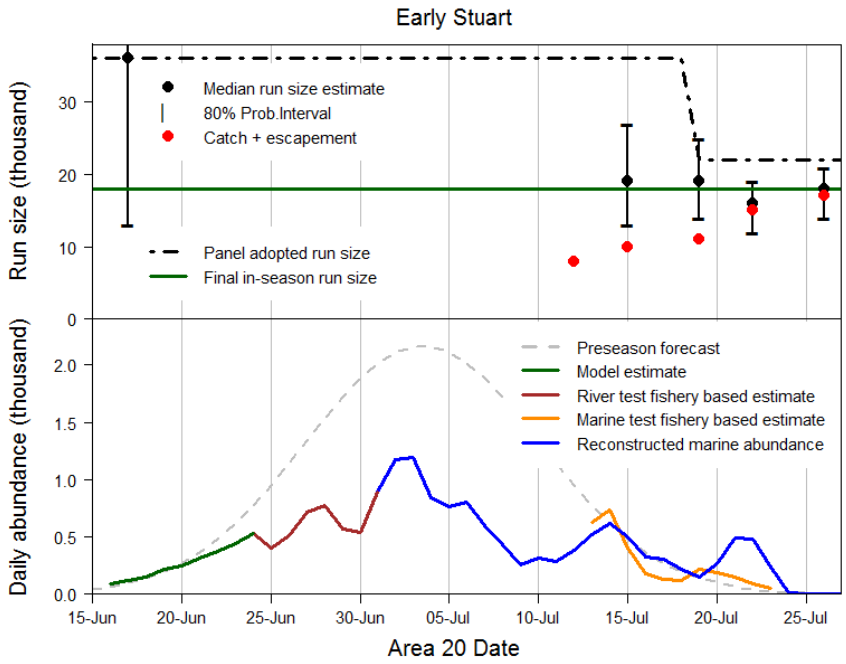

Figure G2 a: Daily reconstructed abundance estimates for Early Stuart and corresponding run size estimates at different times during the season

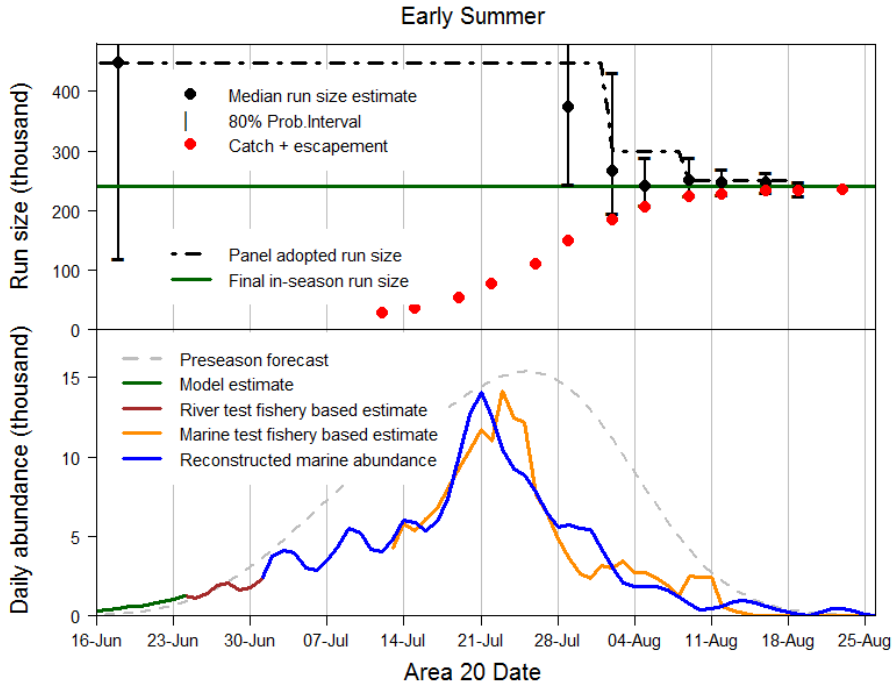

Figure G2 b: Daily reconstructed abundance estimates for Early Summer-run salmon and corresponding run size estimates at different times during the season

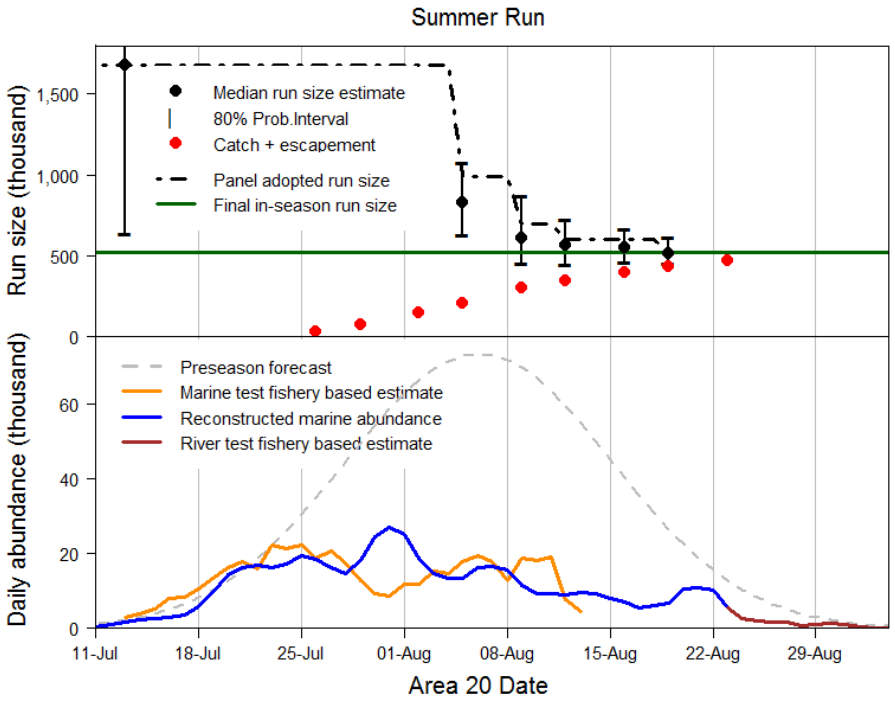

Figure G2 c: Daily reconstructed abundance estimates for Summer-run salmon and corresponding run size estimates at different times during the season

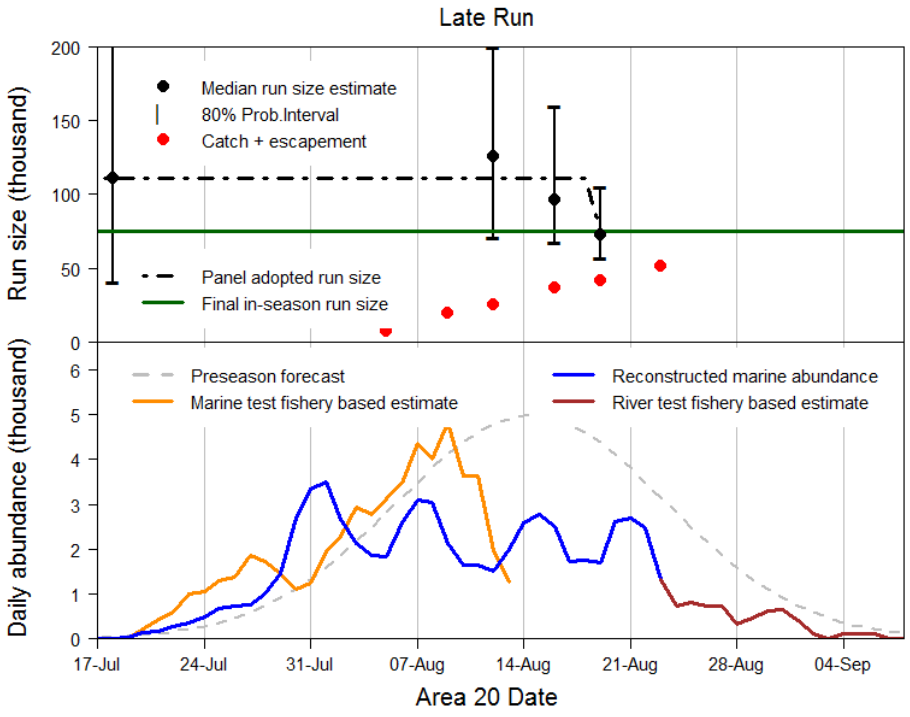

Figure G2 d: Daily reconstructed abundance estimates for Late-run salmon and corresponding run size estimates at different times during the season

Management Adjustment and DBE

For pre-season planning, the Environmental Watch program at DFO presented a long-range forecast of Fraser River environmental conditions that suggested a rapid drop in discharge due to an early and low peak freshet. Low discharge would make the river highly vulnerable to air temperature fluctuations. After a warm winter and spring, above average air temperatures were forecasted for July and August. Staff used the environmental forecasts in Management Adjustment (MA) models developed jointly by DFO and the PSC to predict how many additional Early Stuart-run, Early Summer-run and Summer-run sockeye should be allowed to escape to increase the probability of achieving spawning escapement objectives (see references in the MA section of the Management Information section). The Panel chose not to adopt any of the proportional Management Adjustments (pMAs) predicted by the environmental MA models based on these long-range forecasts of river conditions (Table G3).

Given the 2016 forecast for abundances for Early Stuart, the Panel used the historic median proportional Management Adjustment (pMA) of 0.69 (Table G3) for Early Stuart for pre-season planning purposes. In-season fisheries decisions that could impact Early Stuart sockeye were based on Low Abundance Exploitation Rate (LAER) limits of 10%. For Early Summer run, the Panel decided to adopt the historical median (Table G3 for details) pMA of 0.57 (Table G3) for the non-Pitt and non-Chilliwack Early Summer component. The Chilliwack and Pitt components were treated uniquely (see Table G3 and G4 for details). For the Summer-run group, the Panel adopted the historical median pMA of 0.09 for Summer-run without Harrison and the fixed pMA of 0.40 (the median pMA for 2004-2015) for Harrison (Table G3).

In 2016, the Panel approved the revised weighted pDBE calculations for management groups comprised of two or more components. The revised method substitutes pDBE for pMA in the weighted average calculation of the components of a management group. This method ensures that spawning escapement targets of the management group will be achieved and not exceeded. Based on the revised calculation, the Early Summer run aggregate pDBE was the weighted average of the pDBE for the non-Pitt and non-Chilliwack Early Summer component, the pDBE for the Pitt component and the pDBE of the Chilliwack component based on the p50 abundance level forecasts. For the Summer-run aggregate, the pDBE was the weighted average of the pDBE for the non-Harrison Summer-run component and the pDBE for the Harrison component, based on the p50 abundance level forecasts. These forecast abundance levels were replaced with in-season estimates as the season progressed.

Given the 2016 forecast for abundances for Late run sockeye, the Panel used the historical 2016 cycle line median proportional Management Adjustment (pMA) of 30.91 (Table G3) for Late run without Birkenhead and the median of all years for Birkenhead (see Table G3) for pre-season planning purposes. The Late-run aggregate pDBE was the weighted average of the pDBE for the non-Birkenhead Late-run component and the pDBE for Birkenhead group, based on their p50 abundance level forecasts. In-season fisheries decisions that could impact Late-run sockeye were based on Low Abundance Exploitation Rate (LAER) limits of 20%.

See Table G4 for a detailed summary of the Management Adjustment approaches by stock group.

Table G3. Summary of the MA model predictions and adopted values for the different components used pre-season and in-season to generate the pMA for Early Stuart, Early Summer, Summer and Late-run Management groups**.**

Description	Early Stuart[2]		Early Summer (excld. Pitt and Chw.)		Pitt[1]		Chilliwack[1]		Summer (excld. Harrison)		Harrison[1]		Lates[2] (excld. Birk.)		Birkenhead[2]	
	%DBE	pMA	%DBE	pMA	%DBE	pMA	%DBE	pMA	%DBE	pMA	%DBE	pMA	%DBE	pMA	%DBE	pMA
Pre-season MA Model Predictions	-34%	0.52	-33%	0.50	NA	NA	NA	NA	-13%	0.15	NA	NA	NA	NA	NA	NA
Pre-season Adopted	NA	NA	-36%	0.57	-15%	0.18	-53%	1.13	-8%	0.09	-29%	0.40	NA	NA	NA	NA
In-season MA Model Predictions	-52%	1.08	-35%	0.55	NA	NA	NA	NA	-23%	0.30	NA	NA	-90%	8.64	NA	NA
In-season Adopted	NA	NA	-36%	0.57	-15%	0.18	-53%	1.13	-8%	0.09	-29%	0.40	NA	NA	NA	NA

1 The pMAs adopted preseason for these stocks remained fixed in-season.

2 Given the 2016 forecasts of abundances, fisheries decision that could impact Early Stuart and Late-run sockeye management groups were based on Low Abundance Exploitation Rate (LAER) limits of 10% and 20%, respectively.

Table G4. Summary of the pre-season and in-season MA models and assumptions used during 2016 for each management group. In-season timing refers to the final updated date for each group. Details regarding assumptions for pre-season timing can be found in the Pre-season Planning section of the report under the section Panel Management Activities.

Management Group	Pre-season Predictor Variables	In-season Predictor Variables	Cycle lines Used	Excluded Years
Early Stuart	Historical Median[2]	NA [2]	All	1977, 1980, 1982, 1984, 1986, 2015
Early Summer w/o Chilliwack and Pitt	Historical Median	19-day temp and discharge[1]	All	1993
Chilliwack	Historical Dom/Subdom Cycle Median since 2004	Historical Dom/Subdom Cycle Median since 2004	2016 & 2017	years with DNA n<30 fish identified as Chilliwack
Pitt	Historical Median, using inseason data for 1998, 2000-2004	Historical Median, using inseason data for 1998, 2000-2004	All	1982, 1983, 1999, 2005, 2006
Summer	Historical Median	19-day temp and discharge[1]	All	2002
Harrison	Historical Median 2004-2015	Historical Median 2004-2014	All	NA
Birkenhead	Median of all years[2]	Median of all years[2]	All	1979
Late	Historical Cycle Line Median[2]	NA [2]	2016	pre 1996, 2006

[1] $\ln(DBE) = a + b_1T + b_2T^2 + b_3Q + b_4Q^2$ where T = 19-day (3-days before and 15-days after the Hells Gate 50% date) temperature and Q = 19-day (3-days before and 15-days after the Hells Gate 50% date) discharge.

[2] Given the 2016 pre-season forecasts of abundances, fisheries decisions that could impact Early Stuart and Late-run sockeye management groups were based on Low Abundances Exploitation (LAER) limits and no MA was adopted for the management group

APPENDIX H: HISTORICAL CATCH, ESCAPEMENT AND PRODUCTION DATA

Table H1. Catch by user group, spawning escapement, difference between estimates and run size of Fraser River sockeye salmon for cycle years 2004-2016.

	Fraser Sockeye Salmon			
	2004	2008	2012	2016
CANADIAN CATCH	**2,006,700**	**481,100**	**510,300**	**149,200**
Commercial Catch	**1,057,600**	**16,200**	**0**	**0**
Panel Area	256,800	11,600	0	0
Non-Panel Areas	800,800	4,600	0	0
First Nations Catch	**890,500**	**447,300**	**508,100**	**148,400**
Marine FSC	256,200	31,900	53,200	32,300
Fraser River FSC	634,300	415,400	454,900	116,100
Economic Opportunity	0	0	0	0
Non-commercial Catch	**58,600**	**17,600**	**2,200**	**800**
Marine Recreational	4,800	100	0	0
Fraser Recreational	50,300	16,400	0	0
Charter (Albion)	0	1,200	2,200	800
ESSR	3,500	0	0	0
UNITED STATES CATCH	**258,800**	**51,000**	**118,100**	**1,700**
Washington Total	**195,600**	**49,400**	**111,300**	**1,700**
Commercial catch	**195,500**	**48,000**	**105,200**	**850**
Treaty Indian	114,400	39,000	72,800	850
Non-Indian	81,100	9,000	32,300	0
Non-commercial Catch	**100**	**1,400**	**6,100**	**850**
Ceremonial	100	1,400	6,100	850
Recreational	0	0	0	0
Alaska*	**63,300**	**1,600**	**6,800**	**na**
TEST FISHING CATCH	**73,400**	**41,300**	**33,900**	**8,800**
PSC (Panel Areas)	**24,100**	**36,200**	**26,200**	**6,400**
Canada	24,100	26,900	17,000	6,400
United States	0	9,300	9,200	0
Canada (non-Panel Areas)	**49,400**	**5,100**	**7,700**	**2,400**
TOTAL RUN	**4,184,900**	**1,741,100**	**2,219,200**	**858,300**
Total Catch in All Fisheries	2,339,000	573,400	662,300	159,700
Adult Spawning Escapement	524,500	815,600	920,400	484,500
Jack Spawning Escapement	900	1,500	4,300	2,300
Difference between estimates	1,320,600	350,500	632,100	211,700
Percentage of Total Run	**100%**	**100%**	**100%**	**100%**
Total Catch in All Fisheries	56%	33%	30%	19%
Adult Spawning Escapement	13%	47%	41%	56%
Jack Spawning Escapement	0%	0%	0%	0%
Difference between estimates	32%	20%	28%	25%

*2016 Alaska catch of 34,000 sockeye is preliminary

Table H2. Escapements of sockeye salmon to Fraser River spawning areas for cycle years 2004-2016.*

DISTRICT / Stock Group / Stream/Lake	Year 2004	2008	2012	2016
NORTHEAST				
Upper Bowron R.	916	1,005	59	143
STUART				
Early Stuart				
Driftwood R.	398	683	234	38
Takla L. Streams	3,005	5,476	4,218	1,203
Middle R. Streams	3,822	17,330	18,020	6,060
Trembleur L. Streams	2,041	6,378	3,758	1,269
Miscellaneous	15	0	0	38
Late Stuart				
Kazchek Cr.	207	194	241	43
Kuzkwa Cr.	2,198	7,268	5,630	1,147
Middle R.	12,938	5,616	13,147	2,071
Tachie R.	60,838	122,929	68,557	5,197
Miscellaneous	7,237	10,562	5,544	949
NECHAKO				
Nadina R. (Late)	14,276	32,724	22,840	16,671
Nadina Channel	8,327	33,251	8,102	9,961
Stellako R.	86,738	159,737	137,992	30,119
QUESNEL				
Horsefly R.	4,379	5,324	536	4
Horsefly Channel	0	0	0	0
McKinley Cr.	124	77	0	0
Mitchell R.	5,452	1,564	58	264
Miscellaneous	267	126	11	132
CHILCOTIN				
Chilko R. & L.	91,909	249,863	245,522	154,918
Chilko Channel	0	0	0	0
Taseko L.	320	60	100	164
SETON-ANDERSON				
Gates Cr.	757	5,420	12,600	4,914
Gates Channel	8,849	9,418	15,884	3,674
Portage Cr.	1,287	97	25	48
NORTH THOMPSON				
North Thompson R.	1,964	3,879	1,096	6,437
Raft R.	5,611	10,406	10,003	8,147
Fennell Cr.	2,763	2,270	1,967	1,152
SOUTH THOMPSON				
Early Summer-run				
Scotch Cr.	783	654	2,005	961
Seymour R.	1,323	1,350	822	374
Upper Adams / Momich / Cayenne	1,090	1,257	256	42
Miscellaneous	692	1,727	411	159
Late-run				
Adams R.	2,672	149	0	36
Little R.	175	2	2	2
Lower Shuswap R.	144	11	9	7
Miscellaneous	3	2	1	4
HARRISON-LILLOOET				
Birkenhead R.	37,617	19,500	55,321	36,402
Big Silver Cr. & misc. Birk. types	22,386	2,763	3,722	4,640
Harrison R.	2,106	6,717	70,904	65,758
Weaver Cr.	912	1,309	345	15
Weaver Channel	24,467	1,447	573	318 [1]
LOWER FRASER				
Nahatlatch R. & L.	1,097	573	4,065	1,896
Cultus L.	90 [1]	499 [1]	1,098 [1]	2,594 [1]
Upper Pitt R.	60,942	16,921	78,038	57,832
Chilliwack L./Chilliwack R., upper	40,329	67,822	126,164	57,928
MISCELLANEOUS [2]	1,030	1,271	551	809
ADULTS	524,496	815,631	920,431	484,540
JACKS	851	1,548	4,331	2,347
TOTAL NET ESCAPEMENT	525,347	817,179	924,762	486,887

* Estimates are from DFO.

1 Cultus estimates include 38 fish in 2004, 159 in 2008, 263 in 2012, 207 in 2016 and Weaver estimates include 59 fish in 2016 removed for broodstock.

2 'Miscellaneous' category includes fish from small stocks throughout the Fraser watershed.

Table H3. Detailed calculation of total allowable catch (TAC) and achievement of international catch shares for Fraser sockeye (by management group) salmon in 2016. Calculations are based on the in-season estimates of abundance, spawning escapement target and Management Adjustment at the time the Panel relinquished control of the last U.S Panel Area (October 1), in accordance with Annex IV, Chapter 4 of the Pacific Salmon Treaty.

	Fraser Sockeye					
	Early Stuart	Early Summer	Summer	Late	Total	
RUN STATUS, ESCAPEMENT NEEDS & AVAILABLE SURPLUS						
In-season Abundance Estimate	**18,000**	**240,000**	**528,000**	**70,000**	**856,000**	
Adjusted Spawning Escapement Target *	**18,000**	**240,000**	**528,000**	**70,000**	**856,000**	
Spawning Escapement Target (SET)	18,000	156,000	528,000	70,000	772,000	
%SET from TAM rules	*100%*	*65%*	*100%*	*100%*		
Management Adjustment (MA)	NA	92,000	58,100	NA	150,100	
Proportional MA (pMA)	*NA*	*0.59*	*0.11*	*NA*		
Test Fishing Catch (TF, post-seas. est.)	200	2,500	5,700	600	8,800	
Surplus above Adjusted SET & TF *	**0**	**0**	**0**	**0**	**0**	
DEDUCTIONS & TAC FOR INTERNATIONAL SHARING						
Aboriginal Fishery Exemption (AFE)	**1,500**	**24,300**	**117,100**	**5,500**	**148,400**	
Total Deductions (Adj.SET + TF + AFE)	19,600	266,800	650,800	76,000	1,013,200	
Available TAC (Abundance - Deductions)	**0**	**0**	**0**	**0**	**0**	
UNITED STATES (Washington) TAC						
Propor. distrib. TAC - Payback	**0**	**0**	**0**	**0**	**0**	
Proportionally distributed TAC **	0	0	0	0	0	16.5%
U.S. Payback	0	0	0	0	-900	
Washington Catch	0	600	900	100	1,700	
Deviation from TAC - Payback	**0**	**-600**	**-900**	**-100**	**-1,700**	
CANADIAN TAC						
Propor. distrib. TAC + Payback + AFE	**1,500**	**24,300**	**117,100**	**257,100**	**148,400**	
Propor. distrib. TAC + U.S. Payback	0	0	0	0	0	83.5%
AFE	1,500	24,300	117,100	257,100	148,400	
Canadian Catch excluding ESSR Catch	1,500	24,500	117,700	5,600	149,200	
Deviation from TAC + Payback + AFE	**0**	**-100**	**-600**	**-100**	**-800**	
TOTAL						
Available TAC + U.S. Payback + AFE	**1,500**	**24,300**	**117,100**	**5,500**	**148,400**	
Total Catch excluding ESSR Catch	1,500	25,100	118,600	5,600	150,900	
Deviation from TAC + U.S. Payback + AFE	**0**	**-800**	**-1,500**	**-200**	**-2,500**	

* The surplus cannot exceed the estimated abundance.

** Washington sockeye and pink shares according to Annex IV, Chapter 4 of the Pacific Salmon Treaty.

APPENDIX I: MEMBERS OF THE FRASER RIVER PANEL TECHNICAL COMMITTEE IN 2016

Canada	United States
A. Huang, Co-Chair *Fisheries and Oceans Canada*	R. Conrad, Co-Chair *Northwest Indian Fisheries Commission*
S. Grant *Fisheries and Oceans Canada*	A. Dufault *Washington Department of Fish and Wildlife*
R. Goruk *Fisheries and Oceans Canada*	P. Mundy *National Marine Fisheries Service*
J. Scroggie *Fisheries and Oceans Canada*	
M. Staley *First Nations Advisor*	

APPENDIX J: STAFF OF THE PACIFIC SALMON COMMISSION IN 2016

EXECUTIVE OFFICE

John Field, Executive Secretary

John Son, Information Technology Manager

Amanda D'Silva, Secretary/Receptionist

Kim Bartlett, Meeting Planner

Teri Tarita, Records Administrator/Librarian

FINANCE AND ADMINISTRATION

Ilinca Manisali, Controller

Bonnie Dalziel, Senior Accountant

Witty Lam, Accountant

Angus Mackay, Manager, Restoration & Enhancement Funds

Victor Keong, Program Assistant, Restoration & Enhancement Funds

Miki Shimomura, Administrative Assistant, Restoration & Enhancement Funds

FISHERIES MANAGEMENT DIVISION STAFF

Mike Lapointe, Chief Biologist

Stock Assessment Group

Catherine Michielsens, Director, Modelling and Data Management

Erica Jenkins, Quantitative Fisheries Biologist (Acting)

Keith Forrest, Manager, Test Fishing Biologist

Kent Collens, Database Manager

Stock Identification Group

Fiona Martens, Director, Coordination and Stock Identification

Maxine Forrest, Manager, Scale Lab

Steve Latham, Manager, Stock Identification

Julie Sellars, Senior Scale Analyst

Catherine Ball, Scale Lab Technician

Brittany Jenewein, Stock Identification Biologist (Term)

Stock Monitoring Group

Yunbo Xie, Hydroacoustic Scientist

Cory Lagasse, Manager, Hydroacoustic Operations

Jacqueline Nelitz, Hydroacoustic Technician

Mike Bartel Sawatzky, Hydroacoustic Technician