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Report of the Fraser River Panel to the Pacific Salmon Commission on the 1994 Fraser River Sockeye Salmon Fishing Season

Prepared by the

Pacific Salmon Commission
December, 1997

Pacific Salmon Commission
600-1155 Robson Street
Vancouver, B.C.
V6E 1B5
(604) 684-8081

REPORT OF THE

FRASER RIVER PANEL

TO THE PACIFIC SALMON COMMISSION

ON THE 1994 FRASER RIVER

SOCKEYE SALMON FISHING SEASON

1994 PANEL MEMBERS AND ALTERNATES

UNITED STATES	CANADA
W. Robinson, Chair	A. Lill, Vice-Chair
D. Austin	E. Crey
L. Loomis	M. Forrest
J. Giard	R. Kendall
T. Clocksin	L. Wick
R. Allen	V. Fiamengo
R. Suggs	M. Griswold
	K. McGivney
	M. Medenwaldt
	R. Nugent

Prepared by

FISHERIES MANAGEMENT DIVISION

of the

PACIFIC SALMON COMMISSION

December, 1997

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I. EXECUTIVE SUMMARY

1. Canada and the United States did not agree on a catch sharing arrangement for Fraser River sockeye salmon, so each Party managed its own fisheries in the Panel Area in 1994. Consequently, the Fraser River Panel did not establish pre-season regulations and a management plan, did not manage the sockeye fisheries in the Fraser River Panel Area, and was not responsible for achieving catch allocation and escapement goals. The Parties agreed that PSC staff would conduct normal catch assessment, test fishing, racial analysis and hydroacoustic activities. PSC staff reported the results of their assessments to the national sections of the Panel frequently. The two sections developed domestic regulations and exchanged information on all fishing plans.

2. Pre-season forecasts provided by Canada were for a total run of 19,000,000 Fraser sockeye and a corresponding spawning escapement goal of 5,390,000 adult Fraser River sockeye. The gross escapement goals, set on August 11, were: 380,000 Early Stuart, 480,000 Early Summer-run, 2,574,000 Summer-run and 2,921,000 Late-run sockeye for a total goal of 6,355,000 adult Fraser sockeye.

3. Based on Mission estimates of Early Stuart, Early Summer and Summer-run gross escapement, upriver estimates of Late-run gross escapement and current tabulations of catch, returns of Fraser River sockeye salmon totalled 17,241,000. Although this was 1,759,000 fewer than forecast, it was the second largest run on the cycle since 1958 and the third largest since at least 1902.

4. Catches of Fraser River sockeye salmon totalled 13,322,000 fish in all fisheries. Canadian catches amounted to 11,184,000 fish, of which commercial fishers caught 10,035,000 and 1,111,000 were harvested in First Nations fisheries. United States fishers caught 1,828,000 in Washington and 256,000 in Alaska fisheries. Catches in test fisheries authorized by the Fraser River Panel totalled 54,000 sockeye.

5. The Stock Monitoring program provided in-season assessments of abundance, run timing and diversion rate of Fraser River sockeye stocks throughout the fishing season. Early Stuart and Summer-run sockeye returned at levels below forecasts but Early Summer and Late-run sockeye returns were above the pre-season forecasts. Arrival timing was later than normal for Summer-run stocks while Late-run stocks were earlier than normal for the cycle. Johnstone Strait diversion was estimated at 80% for all Fraser River sockeye in 1994 compared to DFO's pre-season forecast of 68% diversion.

6. The Racial Analysis program provided estimates of stock proportions in commercial and test fishing catches. Discriminant function analysis models provided reliable estimates of stock proportions. Difficulties were experienced in correctly estimating the proportions of co-migrating Seymour/Scotch sockeye and Adams/Lower Shuswap sockeye in marine areas, since both stock groups rear in Shuswap Lake. The presence of the brain parasite (*Myxobolus*) in Quesnel sockeye provided a technique for separating these fish from co-migrating Chilko sockeye.

7. Canada adjusted the gross escapement goals in-season to the final goals of 180,000 Early Stuart, 380,000 Early Summer, 2,411,000 Summer and 3,401,000 Late-run sockeye for a total of 6,372,000 fish. Current estimates of gross escapements are 198,000 Early Stuart, 514,000 Early Summer, 2,509,000 Summer and 1,622,000 Late-run sockeye, for a total of 4,843,000 fish. Mission estimates are considered the "best" estimates for the earlier runs while upriver estimates are used for Late-run sockeye.

8. Spawning escapements to streams in the Fraser River watershed totalled 3,129,000 adult and 4,000 jack sockeye, compared to a final in-season goal of 5,650,000 spawners. Adult escapements by stock group were: Early Stuart - 30,000, Early Summer - 248,000, Summer - 1,352,000 and Late - 1,499,000. These can be compared with final in-season goals of: Early Stuart - 90,000, Early Summer - 300,000, Summer - 2,000,000 and Late - 3,260,000.

9. Mission hydroacoustic estimates of gross escapement were 786,000 fish higher than DFO's upstream estimates (Fraser River Indian fishery catch + spawning escapement) for Early Stuart, Early Summer, and Summer-run sockeye, combined.

10. Canada conducted an investigation into the possible sources of the discrepancy noted above (Fraser River Sockeye Public Review Board). Examination of hydroacoustic estimates, in-river catch, en-route mortality and spawning escapement were included. The Board did not identify specific levels of error in the estimates of escapement at Mission, catch above Mission, spawning escapement or en-route mortality. The Board made a total of thirty-five recommendations for improvements to the management of fisheries, five of which applied directly or indirectly to the operations of the Fraser River Panel.

11. The escapement of Late-run sockeye into the Strait of Georgia was substantially over-estimated by PSC staff in 1994. The final in-season estimate (3,340,000) derived from the subtraction of catch from total run estimates obtained by use of statistical models employed by PSC staff was almost three times the Mission estimate (1,138,000) and twice the upriver estimate (1,622,000). As a result, the PSC staff, Fraser River Panel Technical Committee and other technical experts conducted a review of run-size estimation procedures. The major conclusion of the review was that undetected increases of harvest rates in Johnstone Strait fisheries led to erroneous estimates from the models. Substantive improvements to the methods used by the PSC will be implemented in 1995 and future years.

II. FRASER RIVER PANEL

Since 1986, the Fraser River Panel has been responsible for pre-season planning and in-season management of fisheries targeted on Fraser River sockeye and pink salmon in the Panel Area (Figure 1). Typically, the Panel recommends fishing regulations and a management plan to the Commission before the fishing season begins. The Commission then acts on the recommendations and proposes to the Parties that they adopt the plan. During the fishing season, the Panel regulates Panel Area fisheries to achieve the goals for gross escapement, international allocation and domestic allocation, while addressing the Parties concerns for other species and stocks.

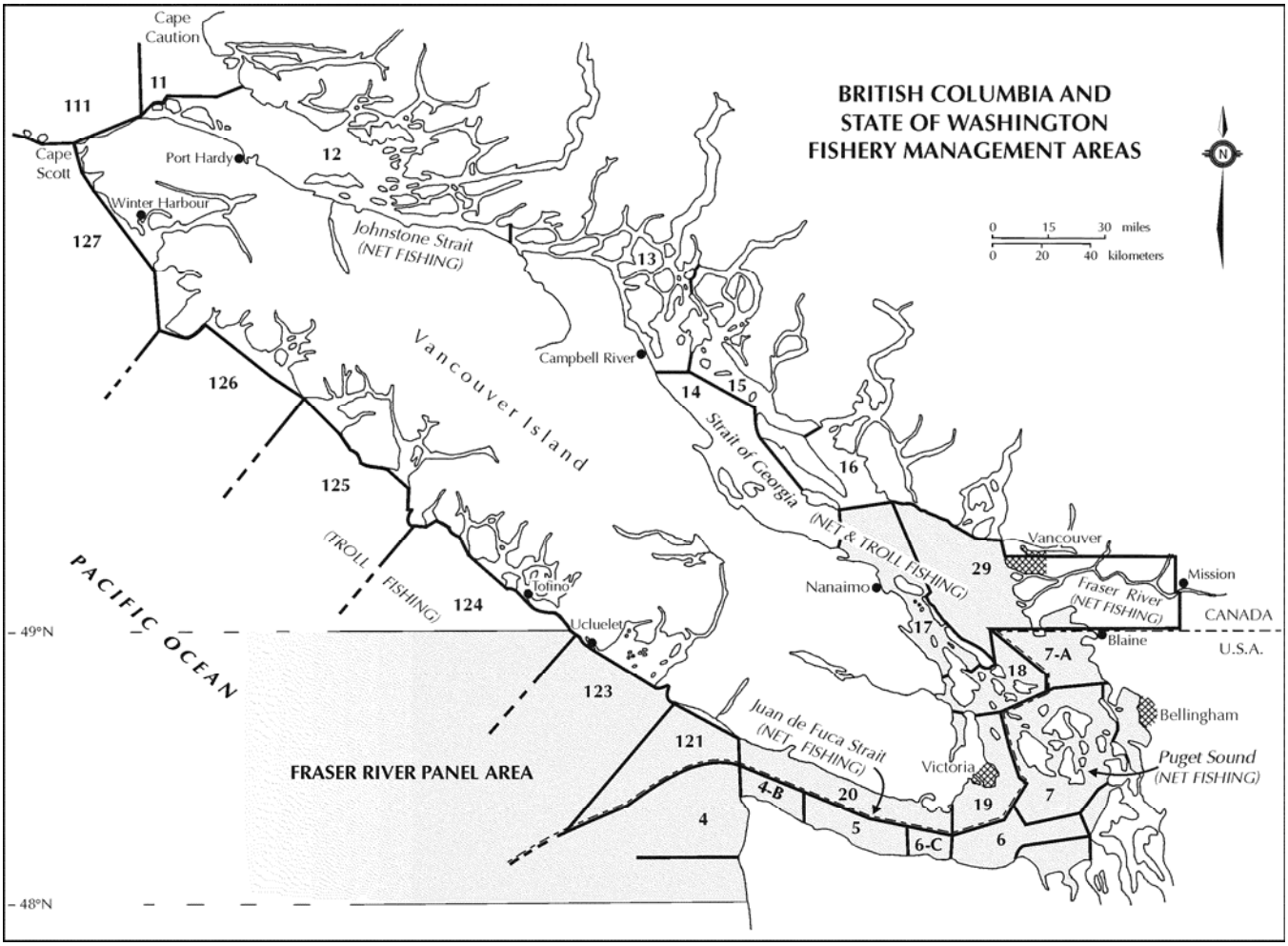

Figure 1. Fishery management areas and commercial gear used in the Fraser River Panel Area and Canadian south coast waters.

In 1994, the Panel did not perform these tasks because the Fraser River sockeye and pink salmon provisions, among others, of Annex IV to the Pacific Salmon Treaty had expired and agreement between Canada and the United States on new arrangements was not reached prior to the season. The Parties agreed that PSC staff would conduct normal catch assessments, test fishing, racial analysis and hydroacoustic activities in 1994. PSC staff reported the results of these assessments to the national sections of the Panel frequently. The two sections developed domestic regulations and exchanged information on all fishing plans.

Membership of the Panel in 1994 was as follows:

UNITED STATES	CANADA
Members	
Mr. W. Robinson, Chair National Marine Fisheries Service	Mr. A. Lill, Vice-Chair Department of Fisheries and Oceans
Mr. D. Austin Washington Department of Fisheries	Mr. E. Crey Fraser River Indian fisher
Ms. L. Loomis Treaty Indian tribes	Mr. M. Forrest Gillnet fisher
Mr. J. Giard Commercial salmon fishing industry	Ms. R. Kendall Freshwater sport fisher
	Mr. L. Wick Purse seine fisher
Alternates	
Ms. T. Clocksin Washington Department of Fisheries	Mr. V. Fiamengo Purse seine fisher
Mr. R. Allen Treaty Indian tribes	Mr. M. Griswold Troll fisher
Mr. B. Suggs Commercial salmon fishing industry	Ms. K. McGivney Department of Fisheries and Oceans
	Mr. M. Medenwaldt Troll fisher
	Mr. R. Nugent Gillnet fisher

III. INTRODUCTION

A. Features of the 1994 Fishing Season

Circumstances surrounding the return of 1994 Fraser River sockeye salmon affected the management of the fisheries in both Canada and the United States. First, Canada and the United States could not agree on sharing arrangements for the harvest of Fraser River stocks, as well as for other fisheries covered by the Pacific Salmon Treaty. Second, the PSC hydroacoustic estimates of escapement for Early Stuart, Early Summer-run and Summer-run sockeye were larger than estimated in upstream catch and spawning escapement. Third, the run size and escapement to the Strait of Georgia of Adams River/Lower Shuswap River sockeye were over-estimated. Canada's Minister of Fisheries appointed the Fraser River Sockeye Public Review Board to investigate the latter two situations. In a separate review, the over-estimation of Late-run abundance was also investigated by PSC staff and technical experts from the two countries.

i. Lack of Agreement on Sharing Arrangements

The absence of an agreement on renewal of the catch-sharing provisions of Annex IV to the Treaty resulted in the Fraser River Panel being unable to meet in bilateral session to implement co-ordinated fishing regulations for Panel Area waters. Through bilateral agreement, PSC staff carried out normal catch estimation, stock monitoring and racial identification functions and estimated the abundance, arrival timing and Johnstone Strait diversion rates (Figure 2) for sockeye stocks returning to the Fraser River. These analyses were transmitted to the national section managers during the fishing season via telephone conference calls. Fishery management bodies in the two countries formulated regulations for fisheries in their respective waters.

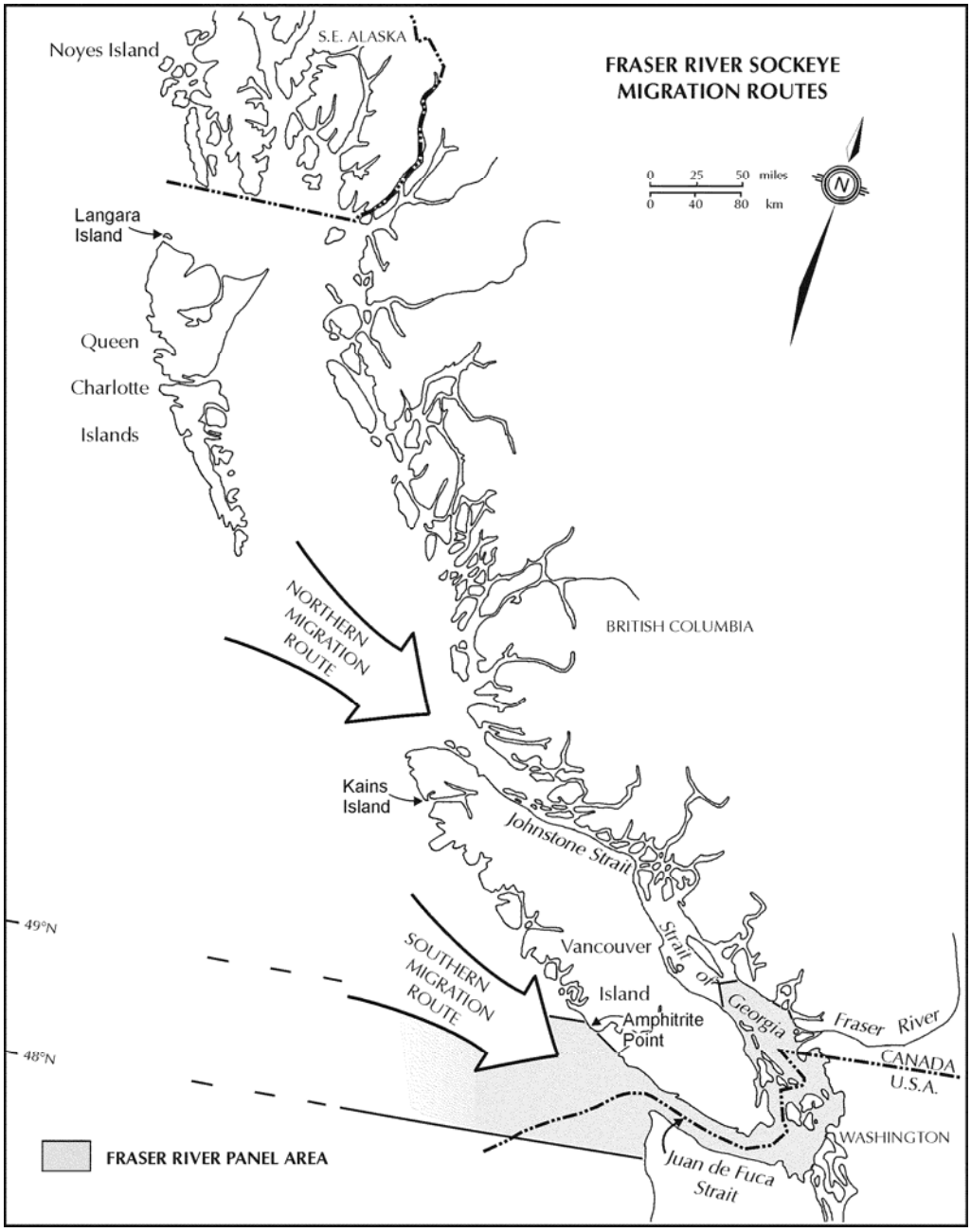

Figure 2. The northern (Johnstone Strait) and southern (Juan de Fuca Strait) routes for sockeye salmon migrating to the Fraser River.

ii. Differences Between Gross Escapement Estimates

In-season estimates of passage at Mission closely approximated Canada's gross escapement goals for Early Stuart, Early Summer and Summer-run stocks. Differences between in-season estimates of gross escapement at the Mission hydroacoustic site and those obtained from upriver catches and spawning ground escapements were not identified until after the fishing season, when spawning escapements were found to be lower than the in-season spawning escapement goals. Therefore, no action to ameliorate this situation could be taken through in-season modification of fishery regulations. The absence of an agreed bilateral fishing plan was not a factor in the spawning escapement shortfall, since both countries regulated their fisheries with the same set of data provided by PSC staff.

iii. Errors in Estimation of Late-run Sockeye Abundance

After all fisheries on Late-run sockeye had closed in early September, PSC estimates of the number of fish available for gross escapement were near DFO's in-season goals. Later in September, hydroacoustic estimates of the abundance of these fish that migrated past Mission were much lower. The timing of this finding, however, occurred too late for management actions to prevent the apparent shortfall in escapement (e.g., via fishery restrictions).

B. Formal Reviews of the 1994 Fishing Season

i. Fraser River Sockeye Public Review Board

In order to determine the causes of the differences between Mission estimates and subsequent upstream estimates of Early Stuart, Early Summer and Summer-run sockeye escapement, and to examine the potential causes of the shortfall in Late-run escapement, Canada's Minister of Fisheries and Oceans appointed and charged the Fraser River Sockeye Public Review Board (FRSPRB) first, to identify the reason(s) for the discrepancies in the expected and actual number of sockeye salmon arriving on the spawning grounds; second, to evaluate the accuracy of the Pacific Salmon Commission's (PSC) methodology for estimating run sizes and sockeye escapement in the Fraser River; and third, to make recommendations on how any deficiencies can be corrected, beginning in 1995.

With respect to the evaluation of Early Stuart, Early Summer and Summer-run escapements, four technical teams were appointed to study: 1) the accuracy of estimates of the number of sockeye salmon that migrated past the PSC's hydroacoustic facility at Mission in 1994, 2) the accuracy of estimates of the catch of sockeye salmon in the Fraser River in 1994, 3) the level of mortality experienced by sockeye salmon in the Fraser River and on the spawning grounds in 1994, and 4) the accuracy of estimates of the number of sockeye salmon on the spawning grounds in 1994 (FRSPRB Terms of Reference). The teams were composed of scientists and engineers from the Canadian Department of Fisheries and Oceans and the Pacific Salmon Commission. Regarding the Late-run escapement shortfall, the Board undertook the examination through interviews with DFO and PSC staff.

The Board held numerous public and private hearings to take testimony from groups and individuals, including both national sections of the Fraser River Panel and Commission staff. Based on the testimonies and technical evidence, the Board reported in March, 1995 (FRSPRB 1995)[1], that

[1] Fraser River Sockeye Public Review Board (Canada). 1995. Fraser River sockeye 1994: problems and discrepancies. 131 p.

problems had been encountered in the management of the 1994 sockeye salmon run. A brief summary of the Board's findings regarding Early Stuart, Early Summer and Summer-run escapements is presented below.

The Mission Hydroacoustic Facility Working Group identified **potential** sources of bias in the daily Mission estimates. Potential sources of **positive bias** noted in the Board's report (FRSPRB 1995, 86) include: 1) *"Fish Travel Speed"* (11-15% bias) – depends on the relative speed of migrating fish and the echosounding boat; 2) *"Fish Swimming Direction"* – includes bias from fish not swimming precisely upstream as well as from "milling"; 3) *"Estimation Formula"* – the estimation formula contains technical sources of bias (6% bias); and 4) *"Stock Discrimination"* – small stocks tend to be overestimated and large stocks overestimated. Potential sources of **negative bias** include: 1) *"Multiple Targets"* – when fish densities are high, more than one target may overlap and appear as one (not likely in 1994); 2) *"Detection problems near the beam edge"* – fish are difficult to detect near the edge of the acoustic beam; 3) *"Fish near the bottom, the surface and river banks"* – fish are difficult to detect in these areas; and 4) *"Avoidance of boat"* – fish may shy away from the echosounding boat, making detection difficult.

With respect to Early Stuart, Early Summer and Summer-run escapements, the Board concluded that *"overall there is a potential for positive bias of around 20 percent or more, and a potential for negative bias of unknown magnitude"* (FRSPRB 1995, 86). However, the Board could not identify a specific level of bias in 1994 estimates.

In addition, the Board concurred with the conclusions and recommendations in the Mission Hydroacoustic Facility Working Group report, the latter of which were stated in the Board Report:

> *The Report* (ed: of the Working Group) *concludes with recommendations stating that the present procedures should not be drastically altered, but that effort be directed at validating and improving the methodology. Specific reference was directly made to using split-beam echo sounding to evaluate fish speed and direction, and supplementing the existing paper recording system with magnetic tape.* (FRSPRB 1995, 85)

The Report of the In-River Catch Estimation Working Group presented a detailed analysis of the 1994 in-river catch data and associated evidence of unreported, misreported and illegal catch. The Working Group developed estimates of reported and unreported catch for each identifiable fisher group in the river. The Board found that *"the accuracy and precision of the catch estimates cannot be determined and that without such information DFO's ability to conserve the stocks has been compromised"* (FRSPRB 1995, 88).

The En-route Mortality Working Group examined the possible effects of environmental conditions on sockeye salmon in the Fraser River during the 1994 spawning migration. They concluded that there were no in-river obstructions to migration in 1994. They then reviewed the known handicaps to sockeye migration such as high temperature and streamflow which could be indicative of high levels of en-route mortality. The En-Route Mortality Working Group report concludes that *"there was significant en-route mortality in 1994 and that up to 15 percent of the fish which entered the Fraser River, or approximately 466,000 fish, died before reaching the spawning grounds"* (FRSPRB 1995, 89). The Board noted, however, that there was *"No direct, quantitative measurement on which to base estimates"* (FRSPRB 1995, 42).

In reviewing DFO programs in 1994, the Spawning Escapement Estimation Working Group concluded that: *"Mark-recapture estimates (accounting for 74 percent of the 1994 estimated summer escapement) were subject to positive bias; that the fence enumerations (18 percent of total estimate) were subject to a minor negative bias; and that the visual surveys (8 percent of total estimate) were subject to negative bias"* (FRSPRB 1995, 91). The Board, in addition, emphasized the following points:

1. *Spawning ground estimation on a system as widespread as the Fraser is very challenging. Unpredictable difficulties will lead unavoidably to estimation errors.*
2. *Sockeye spawning activity is constantly evolving, and the estimation system must continually be adapted to these changing patterns.*
3. *The statistical methodology associated with the visual estimates needs immediate attention.* (FRSPRB 1995, 91)

With regard to the shortfalls of spawning escapement in Late-run stocks, the Board noted that:

> *In 1994, environmental factors contributed to a large diversion of the Summer and Late runs through Johnstone Strait. An unprecedented eastern shift in the migration route bypassed a test fishery near the north end of Vancouver Island. Even though PSC staff incorporate all available catch data when generating their predictions, their models for Johnstone Strait are, by necessity, heavily dependent upon the large catches from two or three seine openings. This situation, coupled with unprecedented numbers of Late run sockeye migrating through the Johnstone Strait, created difficulty in achieving accuracy in the 1994 stock estimates. The factors responsible for the Late stock overestimate are currently under debate and are likely to remain speculative for many years.* (FRSPRB 1995, 30)

The FRSPRB produced a detailed report containing thirty-five recommended actions (Appendix A), five of which referenced the PSC's involvement in Fraser River sockeye management.

ii. PSC Technical Review of Errors in Estimation of Late-run Sockeye Abundance

PSC staff and technical experts from the two countries also undertook a review of the data and methodologies used to estimate Late-run sockeye abundance and the escapement of fish to the Strait of Georgia. A report of the findings of this review has been published (PSC 1995)[2].

The essence of the review findings was that recent changes in the character of the Johnstone Strait net fishery had led to increases in harvest rates that were not detected until after the 1994 season. These changes in harvest rate were manifested in larger removals than were expected during brief, but intense, fisheries in Johnstone Strait during August, 1994. Since a high proportion (75%) of the Fraser sockeye salmon run approached the Fraser River via this route in 1994, the errors of assessment were associated with a high proportion of the run, magnifying the impact of the error on the total run estimate.

As a result of the analysis of 1994 Late-run sockeye data, Commission staff presented a series of recommendations to the Parties, that, if implemented, would reduce the possibility of similar estimation errors occurring in the future. The recommendations were as follows (PSC 1995):

1. Incorporate 1992-94 Johnstone Strait purse seine harvest rates into the reconstructions used for the cumulative-normal model;

2. Purse seine catch and CPUE models should use a natural log transformation of effort and duration variables, in addition to the log of catch and CPUE used in the past. PSC staff intend to adopt this approach beginning in 1995;

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[2] 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.

3. Investigate Bayesian models and other run-size estimation techniques for their application to Fraser River sockeye salmon run-size assessment;

4. Make the assessment of Summer-run harvest rates a primary focus of the Summer-run exploitation rate models. Only the weekly harvest rate model will be used in years when Summer-run delay is identified or suspected;

5. Monitor the escapement of sockeye through the Johnstone Strait fishery by establishing purse seine test fisheries near the south-eastern end of Area 13, beginning in 1995. This test fishery should be conducted each day that the commercial fishery is closed during the migration of Summer-run and Late-run sockeye;

6. Expand the purse seine test fishery in the Robson Bight sector of Area 12 to a minimum of four days per week when the commercial fishery is of one-day duration;

7. That DFO reduce the Johnstone Strait purse seine and gillnet fisheries to a geographical area equivalent to the distance that sockeye salmon travel in two days migration (i.e., approximately 113 km);

8. That DFO reduce purse seine and troll interceptions in migratory areas seaward of the Area 12 purse seine fishery;

9. That DFO devise practical methods for obtaining more accurate temporal and spatial resolution of catches. Also, fish tickets should be modified to accommodate the splitting of catches between fishing areas and DFO's catch database should be modified to accept and process such data; and

10. That PSC and DFO scientists review genetically-based stock identification techniques, including DNA analysis, to determine the potential for applying newly emerging technology to the problem of obtaining accurate in-season analyses of stock composition.

In summary, the review concluded that improving the quality of in-season catch and racial data, reducing the harvest rate in Johnstone Strait fisheries, and improving the run-size models would reduce the future likelihood of such large estimation errors as were experienced in 1994. Commission staff also urged the adoption of the view that commercial fisheries on Fraser River sockeye stocks serve two important purposes. One is to provide fishers the economic gains derived from harvesting the fish. The second is to provide the data that are necessary to manage the fisheries with enough precision to meet both spawning escapement and catch goals without compromising the conservation of the stocks.

IV. MANAGEMENT ACTIONS

A. Pre-season Forecasts, Goals and TAC

Canada provided the Panel with run-size forecasts and pre-season spawning escapement goals for Fraser River sockeye salmon on February 9, 1994 (Appendix B). The total run was forecast to be 18,965,000 adults (Table 1), with a spawning escapement goal of 5,390,000 adults. Gross escapement goals, which totalled 6,355,000 adults, were provided on August 11, 1994.

PSC staff provided expected daily abundance curves (Figure 3) that were based on historical timing patterns and the pre-season abundance forecasts.

Table 1. Pre-season goals for gross[1] and spawning[2] escapement, and forecasts[2] of run size and catch of Fraser River sockeye salmon runs for 1994, provided by DFO.

Run	River & Ocean Catch *	Goal		Total Run
		Spawning Escapement	Gross ** Escapement	
Early Stuart	28,000	200,000	380,000	408,000
Early Summer	637,000	400,000	480,000	1,117,000
Summer	7,762,000	2,010,000	2,574,000	10,336,000
Late	4,183,000	2,780,000	2,921,000	7,104,000
Total Adults	12,610,000	5,390,000	6,355,000	18,965,000
Jacks	15,000	19,000	20,000	35,000
Total Sockeye	12,625,000	5,409,000	6,375,000	19,000,000

1 Provided August 11, 1995.
2 Provided February 9, 1995.
* Includes catches in commercial, test and other fisheries, excluding Fraser River Indian fisheries.
** Gross ecapement = Fraser River Indian catch + spawning escapement.

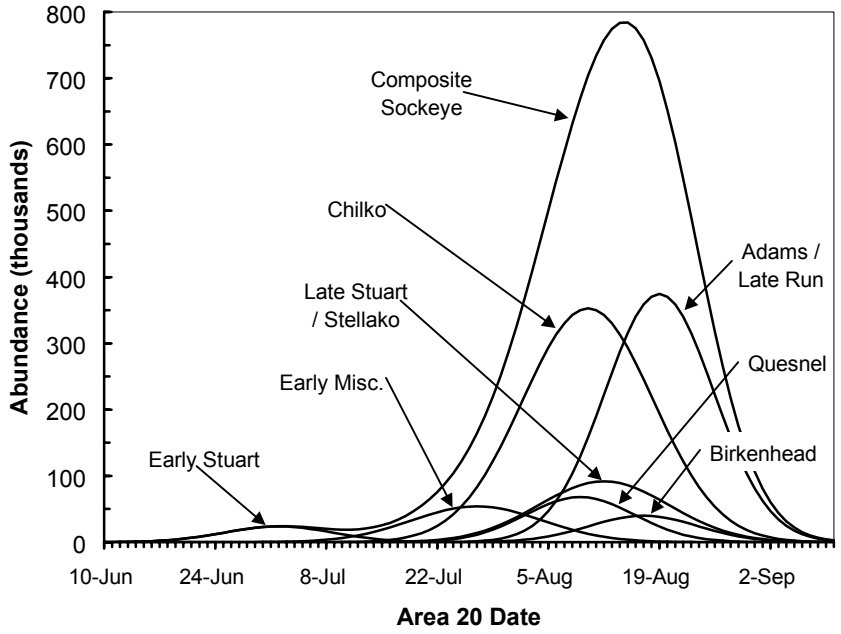

Figure 3. Expected daily abundance curves for migrating Fraser River sockeye salmon in 1994 (Area 20 date), based on historical timing patterns and pre-season abundance forecasts.

B. In-season Regulations

Lack of PSC agreement on international shares meant that the Fraser River Panel could not manage the fisheries in 1994. Consequently, the Panel did not formulate pre-season or in-season regulations and was not responsible for achieving gross escapement goals, international and domestic catch allocations, or for addressing conservation concerns for other species and stocks. In managing their own fisheries, each Party took into account desired escapement objectives for Fraser sockeye and conservation concerns for other stocks and species.

Fishing times for the major net fisheries in 1994, as provided by the Parties, are summarized in Appendix C.

Canada provided gross escapement goals to United States fishery managers and PSC staff on August 11, 1994 and updated the goals four times during the season. The first update occurred on August 11 when the Early Stuart goal was decreased from 380,000 to 180,000 and the Early Summer-run goal was decreased from 480,000 to 380,000. The second update occurred on August 19 when the Summer-run goal was reduced from 2,574,000 to 2,411,000. The third update occurred on August 26 when the Late-run goal was increased from 2,921,000 to 3,101,000 fish. The Late-run goal was increased again on September 2 to 3,401,000 fish. These changes resulted from run-size updates provided by PSC staff during the season.

V. CATCH SUMMARY

Based on Mission estimates of Early Stuart, Early Summer and Summer-run gross escapements, upriver estimates of Late-run gross escapement and current tabulations of catch, the estimated total return was 17,241,000 Fraser sockeye (Table 2). Although this was 1,759,000 fish less than forecast (Table 1), it was the second largest run on the cycle since 1958 and the third largest since at least 1902 (Figure 4).

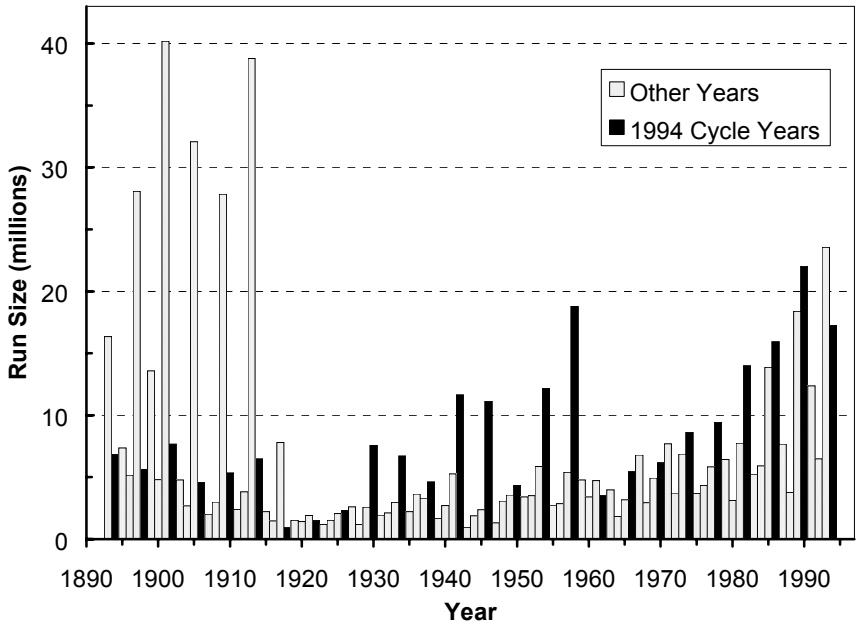

Figure 4. Total run sizes of Fraser River sockeye salmon between 1893-1994. Returns on the 1994 cycle are highlighted.

This large run permitted substantial catches in 1994. Catches totalled 13,322,000 fish in all fisheries. Canadian catches amounted to 11,184,000 sockeye. United States fishers caught 1,828,000 in Washington waters and 256,000 in Alaska. Catches in test fisheries authorized by the Fraser River Panel totalled 54,000 sockeye. Spawning escapements totalled 3,133,000 sockeye salmon. In addition, 786,000 of the sockeye estimated to have migrated upstream at Mission were not accounted for in upstream catch or spawning escapement estimates and are identified as the "Difference Between Estimates" in this report (see Stock Monitoring section, p 19, for explanation).

Table 2. Preliminary estimates of fishery catches and total run of Fraser River sockeye salmon during the 1994 fishing season, by country and area.

		Number of Fish	% of Run
CANADA			
COMMERCIAL CATCH			
Fraser River Panel Area			
Areas 121-124 Troll	*	233,000	
Area 20 Net		846,000	
Areas 17-18 and 29 Troll		352,000	
Area 29 Net		1,298,000	
Total		2,729,000	15.8%
Non-Panel Areas			
Areas 1-10 Troll and Net		1,145,000	
Areas 11-16 Troll and Net		6,042,000	
Areas 124-127 Troll	*	119,000	
Total		7,306,000	42.4%
Commercial Total		10,035,000	58.2%
FIRST NATIONS			
Marine Areas			
Areas 12-16, 18, 20, and 123-126		97,000	
Area 29-1 to 7		86,000	
Total		183,000	1.1%
Fraser River			
Below Sawmill Creek	**	648,000	
Above Sawmill Creek	**	280,000	
Total		928,000	5.4%
First Nations Total		1,111,000	6.4%
NON-COMMERCIAL CATCH			
Charters/Miscellaneous		24,000	
Recreational Fishery		14,000	
Non-Commercial Total		38,000	0.2%
CANADIAN TOTAL		11,184,000	64.9%
UNITED STATES			
COMMERCIAL CATCH			
Fraser River Panel Area			
Areas 4B, 5 and 6C Net		119,000	
Areas 6 and 7 Net		317,000	
Area 7A Net		1,392,000	
Total		1,828,000	10.6%
Non-Panel Areas			
Alaska Net		256,000	1.5%
Commercial Total		2,084,000	12.1%
NON-COMMERCIAL CATCH			
Ceremonial and Test Fishing		0	0.0%
UNITED STATES TOTAL		2,084,000	12.1%
TEST FISHING			
COMMISSION			
Areas 123-127, 20 and 29 Test Fishing		38,000	
Areas 7 and 7A Test Fishing		2,000	
Commission Total		40,000	0.2%
CANADA			
Area 12 Test Fishing		14,000	0.1%
TEST FISHING TOTAL		54,000	0.3%
TOTAL CATCH		13,322,000	77.3%
SPAWNING ESCAPEMENT		3,133,000	18.2%
DIFFERENCE BETWEEN ESTIMATES	***	786,000	4.6%
TOTAL RUN		17,241,000	100.0%

* Troll catches in Area 124 are divided between Panel and non-Panel Areas.

** Catch estimates from the report of the In-river Catch Estimation Work Group to the Fraser River Sockeye Public Review Board, 1994.

*** Mission gross escapement minus spawning escapement and Fraser River Indian catch above Mission, for Early Stuart, Early Summer- and Summer-run sockeye.

Fraser sockeye in 1994 were smaller than average for this cycle. Weights of age 4_2 fish sampled from commercial purse seine catches in Areas 12 and 20 averaged 2.71 kg (5.98 lb). For sockeye (combined ages) in Area 20 commercial seine fisheries, the average weight was 2.66 kg (5.86 lb). Respective cycle averages have been 2.83 kg and 2.94 kg (1978-90).

The gross landed value of the commercial catch (32,000,000 kg) was approximately $204,000,000 (Can).

A. Canada

Canada's catch of 11,184,000 Fraser sockeye was distributed as follows: 10,035,000 in commercial fisheries, 1,111,000 in First Nations fisheries and 38,000 in recreational and DFO charter fisheries (Table 2). Of commercial catches, only 2,729,000 fish were caught in Panel Areas compared to 7,306,000 in non-Panel Areas. The largest catches by far occurred in net fisheries in Johnstone Strait (Areas 11-16), followed by Fraser River and Strait of Georgia fisheries (Areas 17, 18 and 29) and northern troll and net fisheries (Areas 1-11). Purse seines caught the largest share (47.4%), followed by gillnets (28.5%), outside trollers (20.2%) and inside trollers (3.9%) (Table 3). Weekly catches in Canadian Panel Areas are shown in Appendix D (Tables 1-4). The high proportion of Canada's catch taken in Johnstone Strait was a reflection of the high proportion of the run that migrated toward the Fraser River via the northern approach in 1994 (Figure 2).

Table 3. Preliminary estimates of Canadian commercial catches* of Fraser River sockeye salmon by gear type and area during the 1994 fishing season.

Areas	Inside Troll	Outside Troll	Purse Seine	Gillnet	Total
1-10	0	710,000	428,000	7,000	1,145,000
11-16	202,000	804,000	3,868,000	1,168,000	6,042,000
121-127	0	352,000	0	0	352,000
20	0	0	462,000	384,000	846,000
17, 18, 29	186,000	166,000	0	1,298,000	1,650,000
Total Catch	388,000	2,032,000	4,758,000	2,857,000	10,035,000
% of Catch	3.9%	20.2%	47.4%	28.5%	100.0%

* Preliminary catch data from fish sales slips from DFO.

Most Canadian First Nations catches (1,111,000) were taken in Fraser River fisheries (928,000[3]) conducted under Canada's Aboriginal Fisheries Strategy. Of this total, 648,000 were taken in fisheries below Sawmill Creek (located above Yale) and 280,000 in main-stem Fraser and tributary fisheries above Sawmill Creek. Reported Fraser River Indian fishery catches in each in-river area are shown in Appendix D (Table 5). First Nations catches in marine areas totalled 183,000 sockeye.

Non-commercial catches totalling 38,000 sockeye were taken in recreational (14,000) and charter (24,000) fisheries.

[3] Fraser River Sockeye Salmon Management Review Team. In-river Catch Estimation Working Group. 1995. Catches of sockeye salmon in the Fraser River, 1994: report to Fraser River Sockeye Public Review Board. Vancouver, B.C. 59 p.

B. United States

United States catches of Fraser sockeye totalled 2,084,000 fish, 1,828,000 in Panel Areas and 256,000 in Alaska net fisheries (Table 2). Most Washington State catches were taken in net fisheries in Areas 6, 7 and 7A. Weekly catches in United States Panel Areas are shown in Appendix D (Table 6). The Area 7A (Point Roberts) catch totalled 1,392,000 fish (76.1%) while 317,000 (17.3%) were caught in Areas 6 and 7. A high fraction of the Area 7A catch was of sockeye which had migrated to the Strait of Georgia via Johnstone Strait.

Treaty Indian catches were 119,000 in Areas 4B, 5 and 6C and 832,000 in Areas 6, 7 and 7A, for a total of 951,000 fish (Table 4). All Non-Indian catches occurred in Areas 7 and 7A and totalled 877,000 sockeye. Among Non-Indian gear, 67.3% were caught by purse seines, 30.8% by gillnets and 1.9% by reefnets.

Table 4. Preliminary estimates of United States catches* of Fraser River sockeye salmon by user group, gear type and area during the 1994 fishing season.

Areas	Test and Ceremonial	Purse Seine	Gillnet	Reefnet	Total
Treaty Indian					
4B, 5 and 6C	0	0	119,000	0	119,000
6 and 7	0	72,000	109,000	0	181,000
7A	0	397,000	254,000	0	651,000
6, 7 and 7A Total	0	469,000	363,000	0	832,000
% of Catch	0.0%	56.4%	43.6%	0.0%	100.0%
Total Catch	0	469,000	482,000	0	951,000
% of Catch	0.0%	49.3%	50.7%	0.0%	100.0%
Non-Indian					
4B, 5 and 6C		0	0	0	0
7		44,000	75,000	17,000	136,000
7A		546,000	195,000	0	741,000
Total Catch		590,000	270,000	17,000	877,000
% of Catch		67.3%	30.8%	1.9%	100.0%
United States					
Panel Area Total	0	1,059,000	752,000	17,000	1,828,000
Alaska (District 104) Catch					256,000
Total Catch					2,084,000

* Preliminary Washington catch data from Washington Department of Fisheries "soft system" totals.

VI. STOCK MONITORING

The purpose of the stock monitoring program is to assess run size, daily abundance, migration timing and diversion rates of Fraser River sockeye stocks during the fishing season. These data are required for developing fishing plans to attain annual escapement and catch allocation objectives. Commercial catches provide much of the data used in the analyses. In addition, test fisheries (Table 5) conducted by the Commission or by DFO at the request of the Commission provide important data before and after the commercial fishing season and between fishing periods. Information about the upstream migration in the river is obtained by echosounding at Mission and visual observations at Hells Gate.

Table 5. Test fishing operations that were approved by the Fraser River Panel for the 1994 fishing season.

Area	Gear	Dates	Operated by
Canadian Panel Areas			
123-124	Troll	July 25 - July 30	PSC
20	Purse Seine	July 31 - August 12	PSC
20	Gillnet	June 21 - July 30	PSC
29-13	Gillnet	June 29 - October 10	PSC
29-16	Gillnet	June 23 - October 10	PSC
29-1 to 6	Troll	August 11 - September 22	PSC
Canadian non-Panel Areas			
125-127	Troll	July 22 - July 29	PSC
12	Gillnet	July 12 - August 13	DFO
12	Purse Seine	July 27 - September 2	DFO
United States Panel Areas			
7	Gillnet	July 25 - August 1	PSC

The upstream passage of sockeye was monitored by echosounding at Mission between June 24-October 13. A wide-beam, 50 kHz echosounder was used during the entire migration period. Estimates of daily gross escapements of sockeye were derived by combining Mission echosounding data with estimates of species composition from the Whonnock (Area 29-16) variable mesh gillnet test fishery.

Visual observations were made daily at Hells Gate between July 4-October 13. Observed numbers of sockeye provided information on the success of upstream fish passage.

Run-size estimation for Fraser River sockeye salmon by stock group is based primarily on catch, effort, racial composition and diversion rate data, which are analyzed using catch and catch-per-unit-effort (CPUE), cumulative-normal and cumulative passage-to-date models. CPUE models relate run sizes in previous years to commercial or test fishing catch and effort data from purse seine fisheries in Canadian Area 20 and Johnstone Strait. These regression models assume that run size is directly related to the magnitude of the largest daily or weekly catch of a particular stock group in each year, and that the migration pattern is consistent from year to year. Consequently, CPUE estimates are sensitive to unusual migration patterns. In-season, the current best estimates of catches, effort and racial composition are entered into these models to generate run-size estimates.

Cumulative-normal models are essentially a combination of "accounting" and linear regression methods. Estimates of catches and escapements for each stock group are accumulated for each day of migration. The number of these accounted fish are compared, using regression models, to estimates from a suite of normally-distributed simulated migrations which differ in abundance and timing parameters. For each stock group, the simulated migration that most closely matches the observed abundance pattern represents estimates of both run size and timing. As with the CPUE models, the estimates are sensitive to unusual migration patterns. Cumulative-normal model estimates often fluctuate prior to the run peak but tend to stabilize approximately one week after the peak.

Cumulative-passage-to-date models utilize historical daily catch and escapement data by stock, which are adjusted to a common timing date (i.e., arrival date at Mission). Numerical reconstructions of daily abundance are then calculated. The average daily percent reconstructed abundance is calculated for all available years referenced to a common mean peak date. The cumulative percent

complete data are then calculated. During the season, daily catch and escapement data by stock are fed into the reference model. The run accounted to date (referenced to Mission) is used along with the best in-season assessment of timing to generate an estimate of total run by stock. Accurate assessments of timing are required in order for accurate run-size estimates to be produced. These models can only be used for stocks which usually do not exhibit significant delay, i.e., Early Stuart, Early Summer, and Summer-run sockeye.

Escapements of Early Stuart, Early Summer and Summer-run stocks are monitored daily at the Mission hydroacoustic site. However, because Late-run sockeye delay off the mouth of the Fraser River for three to six weeks, in-season estimates of escapement to the Strait of Georgia are used to manage the fisheries. Estimation techniques are simply the subtraction of outside catch from the estimate of daily, weekly or total run of Late-run abundance. Later, when these fish migrate upstream, estimates of daily abundance are made at Mission.

As in 1992 and 1993, Canada forecast that a high proportion (68%) of Fraser River sockeye would migrate via Johnstone Strait in 1994. The first indication of a higher than normal diversion was evident in the comparisons between CPUE data from the Area 12 and Area 20 test fisheries. From the end of July through the first week in August, the estimate of diversion rate by test fishing was about 60%. By the end of the second week of August, the diversion rate had increased to 80% and the abundance of fish on the west coat of Vancouver Island had declined to very low levels as evidenced by low catches in the Canadian troll fishery. By the third week of August the diversion rate had climbed to approximately 90% of the arriving fish and at the end of August to over 95%. Approximately 80% of the 1994 return of Fraser sockeye were estimated to have approached via Johnstone Strait, based on assessments of commercial fishery catches in Johnstone Strait, Juan de Fuca Strait and Puget Sound.

Each year, the first Fraser River sockeye stock to arrive in coastal waters is the Early Stuart run. In 1994, assessments began in early July. Initial indications were that the run was either significantly later than normal or smaller than forecast. Estimates from a regression model based on reconstructed run to July 4 indicated that the run was approximately 249,000 fish versus the forecast of 500,000. The cumulative normal model also gave pessimistic results: 112,000 on July 8, and 186,000 on July 12. The models based on the historical passage of the run past Mission were also indicating estimates at less than 50% of the forecast. By July 14, Bayesian model estimates which incorporated data from test fishing CPUE and cumulative-abundance-to-date models were indicating a run of 190,000. The run peaked in the lower Fraser River (Cottonwood test fishing site) on July 10-11, approximately three days later than normal. By the end of the migration, accumulated catch plus Mission escapement indicated a total run of 202,000. Post-season estimates of Early Stuart gross escapement were 198,000 fish based on Mission echosounding data, and 70,000 fish based on upriver data (Fraser River Indian fishery catches plus spawning escapements), a difference of 128,000 fish (Table 6).

Table 6. Comparison of Mission and upriver (spawning escapement + Fraser River Indian fishery catch) gross escapement estimates by run for adult Fraser River sockeye salmon in 1994.

	Gross Escapement Estimates		
Run	Mission *	Upriver	Difference
Early Stuart	198,000	70,000	(128,000)
Early Summer	514,000	370,000	(144,000)
Summer	2,509,000	1,995,000	(514,000)
Sub Total	3,221,000	2,435,000	(786,000)
Late	1,138,000	1,622,000	484,000
Total	4,359,000	4,057,000	

* Using post-season racial estimates and including Fraser River Indian catch below Mission.

Assessment of the Early Summer sockeye migration began in mid July. Initial assessments were complicated by uncertainties in stock identification, particularly between the Fennel-Bowron and Chilko-Horsefly stock groupings. In addition, the individual stock components showed quite variable timing, confounding estimates that would be derived from the cumulative normal model. Until the Scotch/Seymour group developed in abundance, the indicated return was considerably smaller than forecast. When the Scotch-Seymour group arrived in the lower Fraser River, the estimated run size based on in-season accounting stabilized. In part, the uncertainty was due to the difficulty in estimating the relative contribution of Scotch/Seymour sockeye versus the later arriving Adams/Lower Shuswap stocks, which were numerically dominant and racially similar. By the end of the season the Early Summer-run stock group was estimated at 932,000. Mission and upriver estimates of Early Summer-run gross escapement were 514,000 and 370,000 fish, respectively, a difference of 144,000 fish (Table 6).

The pre-season forecast of Summer-run stocks was 10,336,000, with a peak timing of August 18 (Area 20 date). On August 4, because of stronger than expected abundance of Summer-run stocks to date, the cumulative normal model predictions indicated that the peak timing of the Summer-run return would be earlier than forecast (August 12 in Area 20). The first estimate of the return abundance of Summer-run stocks was made on August 11, at 5,000,000 to 8,000,000 fish and peak timing of August 7. This was based in part on calculations of abundance from harvest rates applied to catches on daily migration blocks in the Area 12-13 fishery. By August 16, the estimate of abundance was 6,000,000 to 7,000,000, with a peak arrival timing of August 10. Summer-run sockeye abundance estimates fluctuated between 6,500,000 and 7,100,000 over the following weeks. The final in-season estimate of the Summer-run return was 7,100,000 fish. Post-season catch and racial data indicated a total return of 7,356,000 or about 3,000,000 less than forecast. Mission estimates of gross escapement totalled 2,509,000 adult Summer-run sockeye (Table 6). Upriver estimates totalled 1,995,000 fish, resulting in a difference between estimates of 514,000 fish.

The pre-season forecast of Late-run sockeye abundance in 1994 was 7,104,000 fish. In-season estimation of run size and escapement of Late-run sockeye is complicated by the lack of direct estimates of escapement during the period of active management of the migratory area fisheries. To estimate the potential escapement of Late-run sockeye, measures of harvest rate were either used directly (in the case of the cumulative normal model) or implied (by subtraction of catch from total run size derived from the models using purse seine catch data). On August 18, the total return of Late-run sockeye was estimated at approximately 8,000,000 fish. This was revised to 9,200,000 on August 26 and to 9,300,000 on September 2. The escapement to the Strait of Georgia (less catch in the area) by September 5 was estimated at 3,250,000 to 3,500,000. Estimates converged during the assessments in September, with the final in-season estimate of gross escapement to the Strait of Georgia being 3,340,000 fish. Post-season estimates place the total return of Late-run stocks at approximately 8,414,000 fish, 1,300,000 more than the pre-season forecast and approximately 900,000 less than estimated in-season.

During September and early October, Late-run sockeye escapements into the Fraser River were estimated by hydroacoustic methods at 1,077,000 fish (includes post-season racial estimates), plus a Fraser River Indian fishery catch of 61,000 fish below Mission. This total (1,138,000) was very much lower than the in-season estimate of 3,340,000 remaining in the Strait of Georgia after the completion of all commercial fisheries. Upriver accounting of gross escapement totalled 1,622,000 Late-run sockeye (Table 6), 1,878,000 less than the in-season estimate of escapement to the Strait of Georgia and 484,000 fish more than the Mission estimate.

Hydroacoustic estimates of daily sockeye salmon passage at Mission can be compared with CPUE data from in-river test fisheries. Data from the Cottonwood test fishery site located near Steveston are lagged one day for travel time to Mission. The comparison (Figure 5) shows generally good correspondence between the two independent measures of daily sockeye salmon abundance. A change in the relationship between the two measures of abundance from that observed in July and August occurred in early September. Early in their migration, Late-run sockeye were apparently holding in the lower river and not reaching Mission (September 8-10). Later, when the migration

resumed (September 18-October 6), the test fishing pattern more closely matched that of Mission one day later.

Data presented to the FRSPRB showed that between 1977 and 1991, Mission hydroacoustic estimates of sockeye salmon abundance were similar to estimates of upstream catch and spawning escapements (Figure 6). Large discrepancies between these estimates in 1992 and 1994 prompted intense scrutiny of the data.

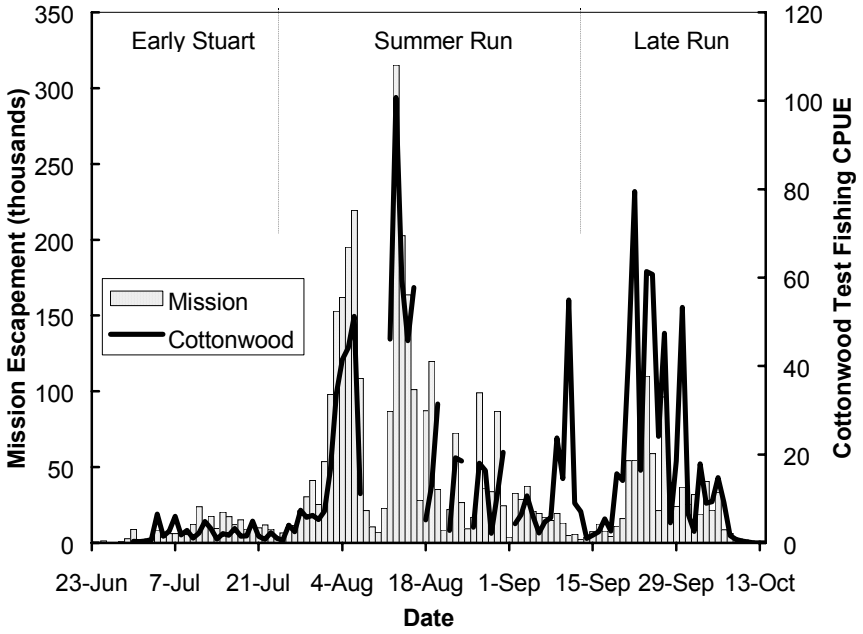

Figure 5. Daily escapements of sockeye salmon estimated at Mission by echosounding compared with prior-day test fishing CPUE at Cottonwood during 1994.

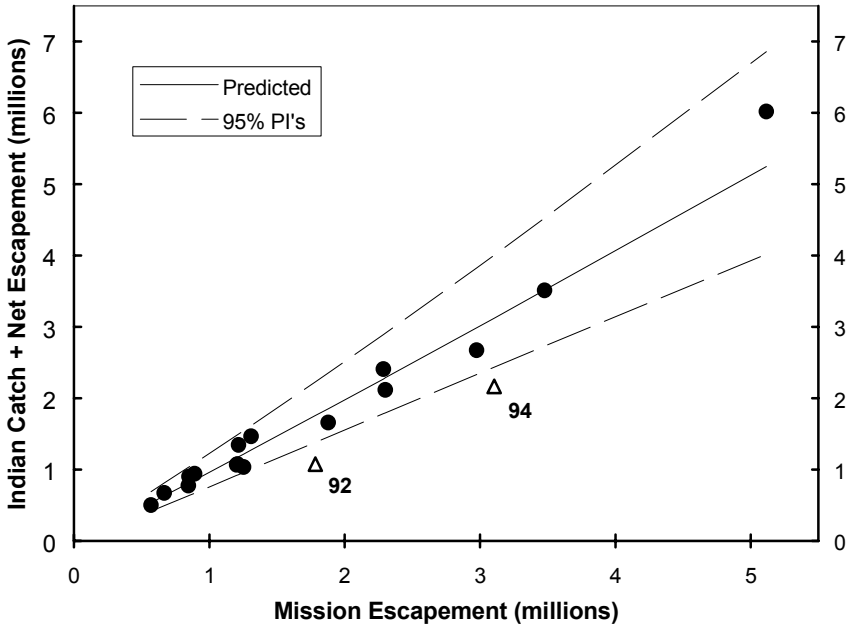

Figure 6. Mission versus upriver estimates of gross escapement (excluding Indian fishery catch below Mission) for Early Stuart, Early Summer and Summer-run sockeye stocks, combined. Data for 1977-91 and 1993 were used to generate the regression line and 95% prediction intervals. 1992 and 1994 data are plotted separately.

Upriver estimates of gross escapement are normally considered to be the most accurate (1992 was an exception[4]). As a result of the FRSPRB investigation, however, Mission hydroacoustic-based estimates in 1994 (Table 6) were deemed the best estimates of Early Stuart, Early Summer and Summer-run gross escapement. Thus, the final gross escapement estimates used in this report are 198,000 Early Stuart, 514,000 Early Summer, 2,509,000 Summer and 1,622,000 Late-run sockeye, for a total of 4,843,000 fish. With upriver estimates for Early Stuart (70,000 fish), Early Summer (370,000 fish) and Summer-run (1,995,000 fish) stocks totalling 2,435,000 (Table 6), differences between the Mission and upriver estimates of gross escapement are 128,000 Early Stuart, 144,000 Early Summer and 514,000 Summer-run sockeye, for a total of 786,000 fish (Tables 6 and 10). These differences, which are incorporated into the final run-size estimates, are referred to as the "Difference Between Estimates".

Counts of sockeye salmon at Hells Gate in 1994 indicated that relatively few fish arrived at Hells Gate in the second half of July. The latter portion of the Early Stuart run and the early portion of the Early Summer run migrated during this period, which was characterized by high water temperatures in the river. Arrivals of Summer-run sockeye during August followed the patterns of abundance at Mission three to four days earlier, although Hells Gate counts were generally lower than expected. Conversely, Late-run sockeye counts were higher than expected based on hydroacoustic estimates at Mission.

VII. RACIAL IDENTIFICATION

Pacific Salmon Commission staff conducted programs in 1994 designed to identify the contribution of each stock of Fraser River sockeye salmon in commercial and test fishing catches. Data collected from the racial identification program provided information on the abundance and timing of Fraser River sockeye stocks as they migrated to the Fraser River. The data were also used to account for international and domestic catches of Fraser River sockeye salmon in coastal waters, and to apportion the daily Mission sockeye escapement estimates into discrete stock groups.

Identification of sockeye stocks in mixed-stock fishery samples is conducted annually using scale pattern analysis. Stock-specific baseline standards are developed for the two dominant age-classes in Fraser River sockeye (age 4_2's and 5_2's). In 1994 the age 4_2 baseline standards consisted of ten stock groups. Each stock group was formed by one or more individual stocks exhibiting similar scale traits and migratory timing.

Stock-specific baseline standards used for in-season racial analysis models come from two sources. First, age 4_2 standards are constructed using scales from the preceding year spawning ground returns of age 3_2's (jacks), and similarly, age 5_2 standards are created using scales from preceding year age 4_2 returns. Second, when preceding year jack or 4_2 data are unavailable, baseline standards are developed using data for the same age class in previous years. In recent years, low returns of age 3_2 Fraser sockeye has prevented their use in the development of age 4_2 baseline standards, except for a few stocks. Reliance on age 4_2 standards created from past years' age 4_2 scales can reduce the accuracy of in-season baseline standards compared to years where large numbers of preceding year age 3_2 scales are available.

Linear discriminant function analysis (DFA) is used to distinguish among baseline standards and to combine individual sockeye stocks into stock groups. Subsequently, the contribution rates of each

[4] Pearse, P. H. 1992. Managing salmon in the Fraser: report to the Minister of Fisheries and Oceans on the Fraser River salmon investigation with scientific and technical advice from Peter A. Larkin. Canada. Department of Fisheries and Oceans, Vancouver, B.C. 36 p.

stock group in mixed-stock fishery samples are determined using linear DFA. Linear DFA is the technique of choice for the following reasons: it has proven to be useful in applications involving scale data; computer programs for linear DFA are readily available; and our scale data generally conform to the assumptions required for linear DFA.

Stock groups in samples of unknown mixture composition were differentiated in 1994 using four scale variables: circuli count to the first freshwater annulus, circuli count in the freshwater spring growth zone, distance from the focus to the fifth circulus, and distance from the focus to the first freshwater annulus. Supplementary data used in stock identification assessments include information on age composition, fish length, incidence of parasites, and historical patterns of stock-specific timing and behaviour.

Scale analyses of commercial and test fishing catches were conducted daily, beginning in late June and continuing through mid-October. Commission staff sampled commercial sockeye landings at sites in Bellingham and Blaine in Washington State, and Vancouver, Steveston, Port Renfrew, Port Hardy, Ucluelet, Winter Harbour and Prince Rupert in British Columbia. Finally, the Alaska Department of Fish and Game (ADF&G) obtained scale samples from the District 104 net fishery at landing sites in Petersburg and Ketchikan. In total, approximately 46,000 sockeye scales were aged and digitized by PSC staff in 1994.

In addition to the sampling of traditional commercial fisheries as outlined above, DFO in recent years has attempted to arrange for weekly scale sampling at six fishing areas from the Fraser River Indian fishery: Chilliwack, Yale, Lytton, Bridge River, Williams Lake and mainstem areas below Prince George. The number of scales obtained by individual site in 1994 include: 67 scales from the Yale fishing area, 798 scales from the Lytton fishing area, 502 scales from the Bridge River fishing area and 258 scales from the Williams Lake fishing area. Subject to the constraints of the small sample sizes, post-season analyses will compare the stock composition estimates derived from the scale samples with those generated through reconstruction modelling techniques.

Table 7. Individual stocks comprising the stock groups used in 1994.

Stock Group	Component Stocks
Early Stuart	Early Stuart stocks
Fennell	Fennell, Bowron, Chilliwack, Nahatlatch, Raft
Gates	Gates, Nadina, Pitt
Seymour	Seymour, Scotch, Momich, Upper Adams, miscellaneous early South Thompson stocks
Chilko/Quesnel	Chilko, south end Chilko Lake, Taseko, Upper and Lower Horsefly, McKinley, Mitchell
Stellako	Stellako, Late Stuart stocks
Birkenhead	Birkenhead, Big Silver
Adams	Adams, Lower Shuswap, Middle Shuswap, miscellaneous Shuswap Lake stocks
Weaver	Weaver, Cultus, Harrison, Portage, Widgeon

In 1994, the numerically dominant stocks were Seymour/Scotch, Chilko, Quesnel, Late Stuart, Stellako, Birkenhead, Adams/Lower Shuswap, and Weaver. These stocks, in combination with other

numerically smaller stocks, were pooled during the in-season management period to form ten stock groups (Table 7): Early Stuart, Fennell, Gates, Seymour, Chilko, Quesnel, Stellako, Birkenhead, Adams and Weaver. For most of the period of active commercial fishing in 1994, the ten stock groups were incorporated into two categories of in-season models: 1) models with Early Summer-run and Summer-run stock complexes, 2) models with Summer-run and Late-run stock complexes.

Classification matrices developed from the 1994 in-season DFA models show that the Seymour stock group (the dominant Early Summer-run stock group) was well differentiated from Summer-run stocks with an 88% expected classification accuracy (Table 8). To correct for misclassifications between stock groups, bias correction was applied.

Table 8. Summary of expected classification matrices of in-season models based on in-season standards for 1994.

Summer Run Period					
To	**From Stock Group**				
Stock Group	Seymour	Chilko	Quesnel	Stellako	Birkenhead
Seymour	**88%**	5%	12%	1%	2%
Chilko	2%	**63%**	34%	2%	1%
Quesnel	8%	27%	**54%**	4%	2%
Stellako	0%	1%	0%	**75%**	16%
Birkenhead	2%	4%	0%	18%	**79%**
Total	100%	100%	100%	100%	100%

Summer-Late Run Period						
To	**From Stock Group**					
Stock Group	Chilko	Quesnel	Stellako	Birkenhead	Adams	Weaver
Chilko	**60%**	34%	1%	1%	1%	0%
Quesnel	34%	**64%**	5%	3%	4%	0%
Stellako	0%	0%	**70%**	13%	0%	10%
Birkenhead	3%	0%	16%	**66%**	0%	13%
Adams	3%	2%	0%	2%	**95%**	0%
Weaver	0%	0%	8%	15%	0%	**77%**
Total	100%	100%	100%	100%	100%	100%

Notwithstanding the generally good expected performance of the in-season models, some significant problems were anticipated in their use. For example, the matrices showed that misclassification rates of 27 - 34% were expected between two Summer-run stock groups, namely Chilko and Quesnel. To address this problem the Chilko and Quesnel stock groups were pooled in models used for all commercial fisheries. However, differences in the escapement goals for the two stocks necessitated that their escapement past Mission be assessed separately. To estimate escapement uniquely for each of the two stock groups, data on the incidence of the brain parasite, *Myxobolus articus*, were collected from test fishery samples during the season. From past years' samples, *Myxobolus* was found to be present in a high percentage (62-86%) of Quesnel sockeye while absent or present in a low percentage in Chilko and other co-migrating stocks. By matching scale and *Myxobolus* data from test fishery samples, separate escapement estimates were made for Chilko and Quesnel stock groups.

In addition to the concern for the potential misclassifications between the Chilko and Quesnel stock groups, the separation of the Seymour stock group from the Adams stock group was also of concern in 1994. These stocks rear in Shuswap Lake and can not be distinguished on the basis of their freshwater scale characteristics. However, differences in arrival timing and river entry exhibited by the two stocks provide a means by which they can be differentiated. The Seymour stock group is

an Early Summer-run stock with an average peak timing of July 28 in Area 20, and of August 3 in Area 29. The Seymour stock group does not typically delay off the mouth of the Fraser River prior to its' upstream migration. In contrast, the Adams stock group is a Late-run stock with an average peak timing of August 18 in Area 20. Also of significance, Adams sockeye delay for a period of three to four weeks off the mouth of the Fraser River prior to migrating upstream. Consequently, while these two stock groups are jointly intercepted in marine fisheries, their timing does not overlap in the Fraser River.

The differences in behaviour were used to generate separate estimates for the Seymour and Adams stock proportions in the following manner. For all Area 29 commercial and test fishery samples analyzed from mid-July through to the end of August, a percentage was estimated for the Seymour stock group. In addition, a percentage was estimated for the pooled Chilko and Quesnel stock groups. The ratio of the Seymour stock group to the Chilko/Quesnel stock groups was then calculated. In marine area fisheries, the pooled contribution of the Chilko and Quesnel stock groups was estimated, as was the proportion of the Seymour/Adams stock complex. Using appropriate lag times, the Area 29 Seymour to Chilko/Quesnel ratio was used to estimate proportion of Seymour in the combined Seymour/Adams proportion in individual marine area fishery samples. The remaining portion of Seymour/Adams in each sample was assigned to the Adams stock group.

A re-analysis of Fraser River sockeye salmon catches and escapements by stock group was conducted after the season. Revised DFA models were developed using baseline standards derived from 1994 spawning ground scale samples (Table 9).

Table 9. Summary of expected classification matrices of post-season models based on post -season standards for 1994.

Summer Run Period

	From Stock Group			
To Stock Group	Seymour	Chilko/ Quesnel	Stellako	Birkenhead
Seymour	**96%**	1%	0%	0%
Chilko	4%	**94%**	12%	4%
Stellako	0%	5%	**77%**	10%
Birkenhead	0%	0%	11%	**86%**
Total	100%	100%	100%	100%

Summer-Late Run Period

	From Stock Group				
To Stock Group	Chilko/ Quesnel	Stellako	Birkenhead	Adams	Weaver
Chilko	**95%**	12%	4%	1%	0%
Stellako	4%	**74%**	11%	0%	2%
Birkenhead	0%	9%	**79%**	1%	12%
Adams	1%	0%	0%	**98%**	1%
Weaver	0%	5%	6%	0%	**85%**
Total	100%	100%	100%	100%	100%

The stock groups were the same in the post-season and in-season DFA models, with one exception: due to significant overlap in the baseline standards, the Chilko and Quesnel stocks were pooled into one stock group in the post-season models. As during the in-season management period, the incidence of *Myxobolus* was used to estimate the gross escapements of the Quesnel and the Chilko stock.

The classification matrices presented in Tables 8 and 9 show that the expected classification accuracy of the Early Summer-run and Summer-run post-season DFA models increased relative to the in-season models. In the post-season DFA models, Summer-run stocks were, in general, accurately identified from Late-run stocks.

In order to obtain an early indication of the presence of Fraser River sockeye, data on the incidence of the body cavity parasite, *Philonema oncorhynchi*, were collected from sockeye harvested in north coast fisheries. In 1994, *Philonema* data were used in conjunction with scale based age composition data to provide in-season estimates of Fraser River sockeye contribution rates to north coast fisheries. From past years data it has been shown that the results from the *Philonema* based analyses compare favourably with post-season DFA estimates generated from scale data.

Early Stuart sockeye arrived two to three days later than the long term average date for this stock. The total return of approximately 202,000 fish was one-half the pre-season forecast of 408,000. Recorded catches for this stock included 4,000 in Commission test fisheries and 40,000 in Fraser River Indian fisheries. The total recorded catch in all areas of 44,000 represents an exploitation rate of 22% (Table 10).

Table 10. Catches, escapements and exploitation rates for Fraser River sockeye salmon by stock group in 1994.

		Gross Escapement							
	River & Ocean	Fraser Indian		Difference** Between	Run Size		Portion of Total	Exploitation Rate River	All
Stock Group	Catch *	Catch	Spawning Escapement	Estimates	Adults	Jacks	Run	& Ocean	Areas
Early Stuart	4,000	40,000	30,000	128,000	202,000	400	1%	2%	22%
Early Summer-run									
Fennell	14,000	14,000	26,000	37,000	91,000	0	1%	15%	31%
Gates	26,000	21,000	15,000	5,000	67,000	1,100	0%	38%	69%
Seymour	714,000	87,000	207,000	102,000	1,110,000	0	6%	64%	72%
Total	754,000	122,000	248,000	144,000	1,268,000	1,100	7%	59%	69%
Summer-run									
Chilko/Quesnel	3,985,000	537,000	1,137,000	251,000	5,910,000	5,500	34%	67%	76%
Stellako	864,000	106,000	215,000	263,000	1,448,000	1,400	8%	60%	67%
Total	4,849,000	643,000	1,352,000	514,000	7,358,000	6,900	43%	66%	75%
Late-run									
Birkenhead	465,000	4,000	40,000	0	509,000	200	3%	91%	92%
Adams	5,795,000	116,000	1,371,000	0	7,282,000	1,300	42%	80%	81%
Weaver	521,000	3,000	88,000	0	612,000	100	4%	85%	86%
Total	6,781,000	123,000	1,499,000	0	8,403,000	1,600	49%	81%	82%
Total Adults	12,388,000	928,000	3,129,000	786,000	17,231,000	10,000	100%	72%	77%
Total Jacks	6,000	0	4,000	0	10,000				
Total	12,394,000	928,000	3,133,000	786,000	17,241,000				
	71.9%	5.4%	18.2%	4.6%	100.0%				

* Includes catches in commercial, test and other fisheries, excluding Fraser River Indian fisheries.

** The discrepancy between gross escapement estimates of Early Stuart, Early Summer-run and Summer-run fish are the PSC gross escapement estimates at Mission, minus spawning escapements and reported Indian catches. Pitt River sockeye estimates were derived from DFO spawning escapement estimates.

The Early Summer-run stocks arrived significantly later than normal, and returned at near the pre-season forecast level of abundance. These early-timed stocks had a total return of 1,268,000 adults including a catch of 754,000 in commercial fishing areas and 122,000 in Fraser River Indian fisheries. The exploitation rate of the Early Summer stocks was 69% (Table 10).

Like the Early Summer-runs, the Summer-run stocks were later than normal in their arrival timing but earlier than forecast by DFO. In 1994, the Chilko and Quesnel stock groups dominated the production of Summer-run sockeye, with a total return of 5,910,000 adults. The Stellako stock group had a total return of 1,448,000 adults. In total, the Summer-run production was 7,358,000 adult fish, 2,978,000 below the pre-season forecast of 10,336,000. The catch in commercial fishing areas was approximately 4,849,000, while the catch in the Fraser River Indian fishery was 643,000. The exploitation rate for the Summer-run stocks in all fisheries was 75% (Table 10).

The arrival timing of Late-run stocks (Area 20 peak on August 18) was close to the long-term average, but Adams/Lower Shuswap sockeye were approximately four days earlier than the dominant cycle average (August 22). Approximately 509,000 Birkenhead adults returned along with 612,000 fish from the Weaver stock group. The dominant Adams/Lower Shuswap stock group produced a return of approximately 7,282,000 adult fish. In total, 8,403,000 Late-run sockeye were estimated to have arrived, 1,299,000 above the forecast abundance of 7,104,000. The estimated catch of all Late-run stocks in commercial fishing areas was 6,781,000 adults plus a catch of 123,000 in the Fraser River Indian fishery. The exploitation rate for the Late-run stocks was 82% (Table 10).

The total 1994 return of Fraser River sockeye was estimated to be 17,231,000 adults. Catches in all fisheries accounted for 77% of the fish while 18% reached the spawning grounds. The remaining portion of the total return, approximately 5%, is the portion of the gross escapement which was estimated to have passed Mission but is not accounted in catch or spawning escapement. Of the 77% harvest component, commercial fisheries harvested 70% while Fraser River First Nations fisheries accounted for approximately 5% (Table 10).

VIII. ESCAPEMENT

Annually, DFO conducts extensive monitoring of sockeye salmon arrivals at spawning grounds in the Fraser River watershed (Figure 7). These data are provided to the Fraser River Panel for assessment of total returns and to evaluate fishery management by the Panel. Escapements to most Fraser River sockeye stocks in 1994 were below the levels recorded in the brood year (1990), which was the largest cycle-year escapement on record for many stocks. In total, 3,129,000 adult and 4,100 jack sockeye were estimated to have reached their spawning grounds in 1994 (Appendix D, Table 7). Total adult spawner escapements were substantially below Canada's in-season goal of 5,650,000 adult sockeye. However, this escapement was close to the average of recent cycle-year escapements (1970-1990 cycle average = 3,289,000, range: 1,657,000-6,061,000). Escapements of Summer-run stocks were 25% below 1990 levels while Late-run sockeye escapements were 61% below the brood year.

The Early Stuart (A; Figure 7) sockeye spawning escapement totalled 30,000 in 1994, much reduced from the 1990 parent escapement of 97,000. However, the 1994 escapement was similar to the 1986 brood on the cycle, when 28,600 fish were estimated to have arrived on the grounds. These fish occupy a number of streams in the upper portion of the Stuart River watershed, primarily spawning in small tributaries of Takla Lake, Middle River and Trembleur Lake. Historically on this cycle, the largest portion of the population has spawned in Middle River tributaries. In 1994, approximately 17,100 fish (57%) spawned in four streams tributary to Middle River.

Also spawning in the Stuart River watershed, the Late Stuart sockeye run migrates through the lower Fraser River in late July to mid August, about a month later than the Early Stuart run. In 1994, the escapement estimate was 76,000 fish, a reduction of 60% from the 1990 escapement estimate of 189,000. The large majority of these fish spawn in Middle and Tachie Rivers. In 1994, there were 43,000 sockeye in Tachie River and 30,000 in Middle River. The remainder spawned in tributaries to these two streams and to Stuart Lake.

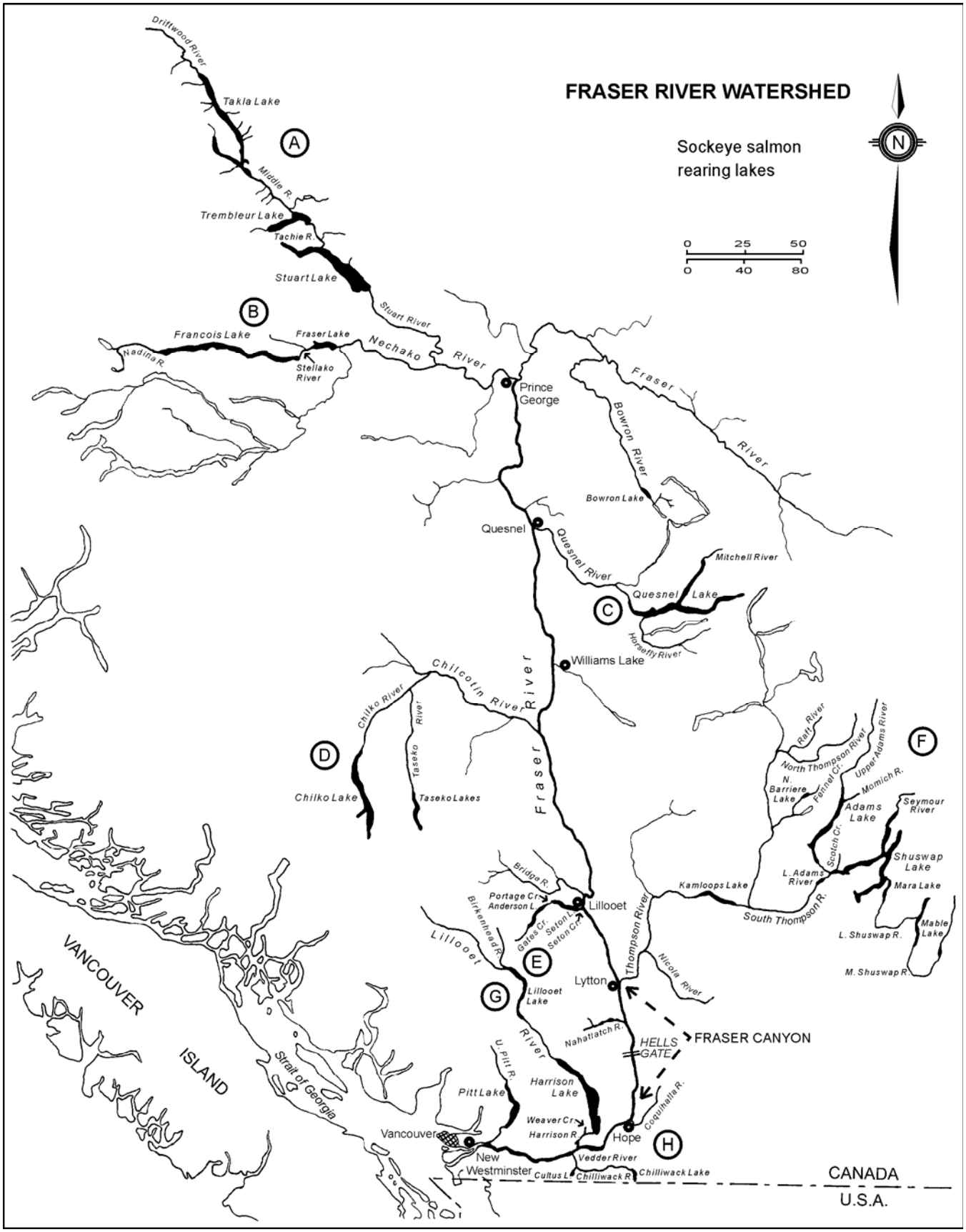

Figure 7. Sockeye salmon spawning grounds in the Fraser River watershed.

In the Nechako River watershed (B; Figure 7), the Late Nadina sockeye escapement totalled 2,000 fish, down from 6,000 in 1990. However, the Stellako River population showed an increase of 45% at 138,000 spawners compared to 94,000 in 1990. This was the largest escapement to the Stellako River on the 1994 cycle since 1954.

Returns of Quesnel Lake area stocks (C; Figure 7) in 1994 were the largest on record for this, the sub-dominant cycle. The large total return produced the largest escapement on the cycle at 686,000 adult spawners. This was a 41% increase in the number of spawners compared to the brood year (1990). The escapement was also the fifth largest of all years since 1909. The majority of sockeye spawned in the Horsefly River and tributaries (550,000) and in Mitchell River (129,000). Significant, as well, was the estimate of 98.6% success of spawning in the female population. This was the highest spawning success recorded on years of large escapement.

Escapements of adult sockeye salmon to spawning areas in Chilko River and Lake (D; Figure 7) were 45% below that recorded in the brood year, 1990. However, the escapement of 451,000 spawners was the second largest on the cycle and the thirteenth largest of 57 escapements recorded in this system since 1938. No separation of the escapement estimate into river and lake spawning stocks was conducted.

Seton-Anderson system (E; Figure 7) sockeye escapements showed declines in 1994 from brood year levels. The spawning population in the Gates Creek spawning channel was 3,360 adult sockeye, which was 23% below the 1990 escapement (4,400). The Late-run sockeye that spawn in Portage Creek also showed a significant decrease in abundance with 9,300 fish, 49% below 1990 (18,300).

Historically, the largest escapements in the Fraser River watershed on the 1994 cycle are those to the South Thompson drainage (F; Figure 7). The spawning populations are divided into Early and Late-run stocks. In total, the early run component declined 47% from 388,000 in 1990 to 207,000 in 1994. Moreover, there was a much different distribution of escapements in 1994. In 1990, the Seymour River, which typically supports the largest population of early-timed spawners, had a record high 272,000 spawners. However, in 1994, only 64,000 fish arrived at the Seymour River spawning grounds. Similarly, in 1990, 25,000 sockeye spawned in Anstey River but only 7,400 arrived in 1994. In contrast, 73,000 sockeye returned to Scotch Creek in 1994 compared to 83,000 in the brood year and the population in Eagle River increased substantially from 4,100 in 1990 to 54,000 in 1994. Escapement of sockeye to the Upper Adams River remained stable at 600 spawners in 1994.

The late-timed segment of the South Thompson run is composed of the Lower Adams River, Little River and Shuswap Lake tributaries and beach areas and the Lower and Middle Shuswap River sockeye populations. The combined spawning populations of these areas declined 63% from 3,715,000 in 1990 to 1,371,000 in 1994. Whereas the 1990 Late-run escapement to these streams had been the largest on record, the 1994 escapement was the smallest since 1974. Escapements to the Lower Adams River, Little River and associated stocks, which are generally referred to as the "Adams run", amounted to 970,000 in 1994 compared with 2,635,000 in 1990. Similarly, the escapements to the Lower Shuswap and Middle Shuswap Rivers declined to 400,000 in 1994 from 1,080,000 in 1990.

In the North Thompson River watershed, the Fennell Creek and Raft River sockeye stocks typically do not return in abundance on the 1994 cycle. The Fennell Creek sockeye escapement dropped to 5,900 fish in 1994 from 12,000 in the brood year. Raft River sockeye increased from 600 in 1990 to 1,700 in 1994.

Late-run sockeye salmon escapements to the Harrison-Lillooet River system (G; Figure 7) showed substantial variation from brood year levels. The Birkenhead River population declined 77% from 167,000 in 1990 to 39,000 in 1994. This stream experienced severe flooding in the fall of 1990 after the sockeye had spawned, possibly affecting the survival of eggs. In contrast, the Weaver Creek sockeye escapement increased from 16,000 in 1990 to 65,000 in 1994. Approximately, 45,000 of these sockeye entered the Weaver Creek spawning channel where the developing eggs are less at risk

from the negative effects of flood events. Escapement to the late-timed Harrison River sockeye population increased from 4,500 in 1990 to 9,500 in 1994.

Escapements to lower Fraser tributary stocks (H; Figure 7) in 1994 were similar to brood year levels. The Nahatlatch River escapement was estimated at 6,000 fish compared to 7,000 in 1990. The Upper Pitt River spawning population declined from 12,000 in 1990 to 9,500 in 1994. However, the Chilliwack River sockeye escapement increased from 2,200 in 1990 to 8,000 in 1994. Late-run Cultus Lake sockeye also increased in abundance to 4,400 in 1994 from 1,900 in the brood year.

The escapement of female sockeye in 1994 (1,596,000) experienced a high success of spawning (98%), giving an estimated total "effective" female population of 1,564,000 fish. This was 52% of the number recorded in the brood year (1990 - 3,023,000). However, this number compares favourably with "effective" female populations on the cycle prior to 1990 (1970-1986: 917,000-2,039,000).

IX. ACHIEVEMENT OF OBJECTIVES

Since the Fraser River Panel was not responsible for the management of fisheries in Panel Area waters in 1994, we cannot evaluate the achievement of objectives by the Panel in this report.

X. ALLOCATION STATUS

The international allocation status for Fraser River sockeye salmon cannot be determined.

XI. APPENDICES

APPENDIX A: FRASER RIVER SOCKEYE PUBLIC REVIEW BOARD: SUMMARY OF RECOMMENDATIONS

MANAGEMENT

Risk Aversion Management

1. We recommend that DFO retain and exercise its constitutional conservation responsibilities and not in any way abrogate its stewardship of resources under federal jurisdiction. Conservation must be the primary objective of both fisheries managers and all others participating in the fishery. The conservation ethic must prevail throughout and be adhered to by all.

2. We recommend that DFO take immediate steps to initiate a process of planning for the future of the fishery, addressing all critical problems affecting conservation and sustainability, throughout an ongoing consultative forum. Among the problems to be considered would be over-capitalization, user-group allocation and ensuring equitable treatment under the law.

3. We recommend that DFO and PSC adopt a risk aversion management strategy because of the great uncertainty in stock estimates, in-season catch estimates and environmental problems. Conservation goals must be achieved before any other priorities are addressed.

4. We recommend that DFO, in conjunction with provincial authorities, First Nations, commercial and recreational fishery groups, implement (both in marine and in-river areas) a revised system to ensure that catch information is timely and reliable, given that accurate counting and timely reporting of catch are fundamental to conservation. The system must also include a more stringent paper trail wherein there must be stricter control of landing and sales slips and a mandatory retention of sales slips with fish through to retail sale or export.

5. We recommend that DFO explore the application of new technology to collect information on stock levels in ocean areas in order to supplement catch statistics.

Institutional Arrangements

6. We recommend that DFO develop better co-ordinated inter-party communication among its staff and between its staff and PSC, First Nations, commercial and recreational fishing groups, with a greater degree of co-operation aimed at enhanced in-season management and post-season evaluation and at fostering closer working arrangements among all parties, and facilitate clearer and more transparent management and allocation policies.

7. We recommend that DFO and PSC give First Nations greater and more meaningful access to, and involvement in, the management process.

8. We recommend that DFO, PSC, First Nations and user groups institute a formalized pre-season review of each season's management plans and strategies, to be followed by a post-season performance analysis. Independent experts should be invited to assist in extending the range of expertise and in promoting transparency in the management process.

9. We recommend that the Canadian section of the Fraser River Panel be vested with responsibility for in-season management for Fraser River sockeye and pink salmon fisheries in Canadian waters beyond the current PSC Convention area. Further, to facilitate communication and understanding (between DFO and PSC) of the in-season run and stock size estimates, a member of the DFO Stock Assessment Division be assigned to work closely with PSC during planning, estimation and evolution of run estimating procedures. There is also a need for practical arrangements for in-season communications between the U.S. and Canadian sides of the Fraser River Panel, whether or not there is formal diplomatic agreement.

10. We recommend that an independent Pacific Fisheries Conservation Council be established to act as a public watchdog for the fishery, to report to ministers and the public annually and from time to time as is appropriate.

Quality Management Principles

11. We recommend that DFO make a commitment to quality management principles in the management of fish stocks by Pacific Region and, in this context, that a third-party quality auditing organization be contracted to provide ongoing services.

ENFORCEMENT

12. We recommend that enforcement be recognized once again as an essential element of the fishery management process.

13. We recommend that, for the 1995 fishing season, DFO institute a plan to ensure that an effective and credible enforcement level is re-established.

14. We recommend that DFO review the regulations pertaining to the various fisheries and implement changes needed to ensure they are enforceable.

15. We recommend that DFO undertake an in-depth investigation of 1994 abuse of fishing laws.

16. We recommend that DFO revisit its policy of non-criminal administrative sanctions (which include licence suspensions) with a view to making such a policy more workable and expanding its application.

17. We recommend that DFO establish an enforcement branch in DFO Pacific Region, headed by a director with extensive law enforcement experience, to report to the Regional Director-General and be responsible for developing and maintaining enforcement capability at a level of competence and coverage which would ensure that the Minister's mandated duty to conserve and protect Canada's Pacific fisheries resources will be fulfilled properly.

18. We recommend that DFO institute an "observe, record, report" program with a communications centre that operates 24 hours per day and seven days per week.

ABORIGINAL FISHERIES STRATEGY

19. We recommend that DFO ensure that AFS agreements clearly identify the Minister's responsibility for conservation, and that final authority to regulate and protect fish habitats remains vested in DFO.

20. We recommend that DFO expedite the implementation of an effective training program to develop fisheries management, enforcement and administrative capacity within First Nation communities.

21. We recommend that DFO, in consultation with First Nations, separate food and commercial fish in time and space to promote more effective enforcement.

22. We recommend that all AFS agreements contain a dispute resolution mechanism and, when feasible, be cast within multi-year frameworks.

23. We recommend that the pilot sales project not be expanded at present.

24. We recommend that, in those AFS agreements having a pilot sales component:
    - No sale of fish or payments to First Nations for AFS purposes be permitted until agreements are completed and signed;
    - The agreements specify that DFO Fishery Officers and Aboriginal Fishery Officers be responsible to and directed by a DFO official;
    - Landing sites be clearly identified;
    - The agreements require that fish landings and the sale of fish be documented; and
    - Any sale of fish other than that recorded and documented at a designated landing station be deemed to be an illegal sale.

25. We recommend that, in First Nation territories where there are no AFS agreements, DFO implement plans to improve the quality of catch estimates.

26. We recommend that DFO pursue a policy of purchasing licences in the commercial sector and transferring these to First Nation communities, not for traditional Aboriginal fisheries, but to increase their participation in established commercial fisheries in a manner consistent with the laws and regulations pertaining thereto.

THE ENVIRONMENT

27. We recommend that DFO urge the Greater Vancouver Regional District and the province of British Columbia to install, without further delay, at Annacis Island the secondary sewage treatment facility which has long been under consideration.

28. We recommend that DFO develop a predictive water temperature model, supported by adequate observation systems, for the Fraser River and its major sockeye tributaries. Information on water temperatures should be used for in-season risk aversion management.

29. We recommend that federal, provincial and local governments join forces to develop effective policies and plans in the Fraser River basin designed to:
    - Better treat and control the discharge of effluent into the Fraser River watershed;
    - See to the implementation of responsible forestry practices in line with the new provincial Forest Practices Code;
    - Continue to remove in-river obstacles which impede the migration and spawning of anadromous species; and

- Regulate urban development in the Fraser River watershed so as to be compatible with environmental priorities.

30. We recommend that DFO conduct further research on:
    - The effects of logging on the water temperature and flow regime in the Fraser River;
    - Means by which to mitigate adverse water temperature and flow fluctuations;
    - The effect of multiple, sublethal stresses on migrating salmon;
    - Means by which to improve anadromous species survival at all stages of the life cycle in the face of natural fluctuations and predation;
    - Environmental effects on the Johnstone Strait diversion rate; and
    - Such matters as the potential of gene banking and altered fishing techniques as means by which to promote the enhancement of anadromous species' genetic diversity.

USER GROUP VIEWS AND RESPONSIBILITIES

31. We recommend that industry participants in the salmon fishery develop and implement in conjunction with DFO a self-sustaining, user-pay, landing verification system, as already exists in other West Coast fisheries (for example, halibut, sablefish and groundfish).

32. We recommend that industry participants in the salmon fishery develop and implement, in conjunction with DFO, a peer group system for reporting to DFO, the illegal catch, sale and transportation of fish.

33. We recommend that industry participants in the salmon fishery and DFO work together to investigate means of dealing with excessive fishing capacity.

34. We recommend that a user fee be assessed on fishers and processors to increase funding available to DFO, if it can be assured that all monies collected will be used only for local fisheries management.

35. We recommend that, in the interest of conservation, DFO ban monofilament nets, gaffing and other fishing gear which may be wasteful of the resources harvested.

APPENDIX B: 1994 PRE-SEASON FORECASTS AND ESCAPEMENT GOALS FOR FRASER RIVER SOCKEYE AND PINK SALMON. (Provided to the Panel by Canada Department of Fisheries and Oceans).

Run	Stock	Forecast Return	Spawning Escapement Target
Early Stuart		408,000	200,000
Early Summer		1,117,000	400,000
Summer			
	Horsefly	1,172,000	585,000
	Chilko	7,268,000	825,000
	Late Stuart	1,896,000	600,000
	Total	10,336,000	2,010,000
Late			
	Birkenhead	682,000	290,000
	Adams/Lower Shuswap	5,976,000	2,350,000
	Miscellaneous	446,000	140,000
	Total	7,104,000	2,780,000
	Total Adult	18,965,000	5,390,000
	Jacks	35,000	19,000
	Total Sockeye Return	19,000,000	5,409,000

APPENDIX C: ACTUAL FISHING TIMES IN MAJOR CANADIAN (days) AND UNITED STATES (hours) NET FISHERIES IN THE FRASER RIVER PANEL AREA IN 1994. (Fishing times were provided by the Parties).

CANADA

	Area 20 *		Area 29 **
Date	Purse Seine	Gillnet	Gillnet
Jul. 10-16	0	0	0
Jul. 17-23	0	0	0
Jul. 24-30	0	0	0
Jul. 31-Aug. 6	2	6	0
Aug. 7-13	4	7	2
Aug. 14-20	4	4	2
Aug. 21-27	2	2	2
Aug. 28-Sep. 3	0	0	1
Sep. 4-10	0	0	0
Sep. 11-17	0	0	0
Total	12	19	7

* Area 20 fishing times are measured in 12- or 13-hour days to correspond with the duration of openings.

** Area 29 fishing times are measured in 24-hour days.

UNITED STATES

	Treaty Indian		Non-Indian		
	Areas	Areas	Areas 7 and 7A		
Date	4B, 5, 6C	6, 7, 7A	Purse Seine	Gillnet	Reefnet
Jul. 10-16	0	0	0	0	0
Jul. 17-23	108	0	0	0	0
Jul. 24-30	132	0	0	0	0
Jul. 31-Aug. 6	126	28	15	19	30
Aug. 7-13	168	78	42	52	60
Aug. 14-20	168	72	58	49	75
Aug. 21-27	60	92	37	39	105
Aug. 28-Sep. 3	0	113	25	30	105
Sep. 4-10	0	20	0	0	0
Sep. 11-17	0	0	0	0	0
Total	762	403	177	189	375

APPENDIX D: TABLES 1-7

Table 1. Commercial net catches of Fraser River sockeye salmon in Canadian Area 20 (Juan de Fuca Strait) by week for cycle years 1982-1994.

Date *	1982	1986	1990	1994
Jul. 3-Jul. 9	700	0	0	0
Jul. 10-Jul. 16	1,000	0	0	0
Jul. 17-Jul. 23	3,100	0	0	0
Jul. 24-Jul. 30	6,300	0	0	0
Jul. 31-Aug. 6	6,600	0	0	399,000
Aug. 7-Aug. 13	401,200	207,800	1,000	378,000
Aug. 14-Aug. 20	568,800	960,800	787,000	69,000
Aug. 21-Aug. 27	691,400	719,300	2,163,000	0
Aug. 28-Sep. 3	700	115,000	428,000	0
Sep. 4-Sep. 10	1,700	600	0	0
Sep. 11-Sep. 17	0	0	0	0
Sep. 18-Sep. 24	0	0	0	0
Sep. 25-Oct. 1	0	0	0	0
Total	1,681,500	2,003,500	3,379,000	846,000

* Dates for 1994. For other years, data from the nearest week were used.

Table 2. Commercial net and troll catches of Fraser River sockeye salmon in Canadian Areas 17, 18 and 29 (Strait of Georgia and lower Fraser River) by week for cycle years 1982-1994.

Date *	1982	1986	1990	1994
Jul. 3-Jul. 9	300	0	0	0
Jul. 10-Jul. 16	300	100	0	0
Jul. 17-Jul. 23	500	200	0	0
Jul. 24-Jul. 30	25,300	2,000	0	0
Jul. 31-Aug. 6	33,300	507,700	0	104,000
Aug. 7-Aug. 13	161,200	306,500	310,000	472,000
Aug. 14-Aug. 20	134,300	138,800	960,000	454,000
Aug. 21-Aug. 27	62,500	178,700	738,000	279,000
Aug. 28-Sep. 3	11,600	142,800	866,000	341,000
Sep. 4-Sep. 10	41,300	33,100	467,000	0
Sep. 11-Sep. 17	2,000	200	9,000	0
Sep. 18-Sep. 24	171,100	966,600	1,000	0
Sep. 25-Oct. 1	220,300	467,300	5,000	0
Total	864,000	2,744,000	3,356,000	1,650,000

* Dates for 1994. For other years, data from the nearest week were used.

Table 3. Commercial troll landings of Fraser River sockeye salmon in Canadian Areas 121 to 127 (west coast of Vancouver Island) by week for cycle years 1982-1994. The landing dates shown lag an average of five days behind catch dates.

Date *	1982	1986	1990	1994
Jul. 3-Jul. 9	1,700	2,400	0	0
Jul. 10-Jul. 16	5,000	4,100	0	0
Jul. 17-Jul. 23	21,500	700	4,000	0
Jul. 24-Jul. 30	342,800	27,700	2,000	0
Jul. 31-Aug. 6	297,100	344,200	0	171,000
Aug. 7-Aug. 13	658,600	1,029,900	57,000	146,000
Aug. 14-Aug. 20	644,200	328,500	1,359,000	27,000
Aug. 21-Aug. 27	97,400	25,000	461,000	7,000
Aug. 28-Sep. 3	19,100	0	13,000	1,000
Sep. 4-Sep. 10	4,900	0	7,000	0
Sep. 11-Sep. 17	8,400	0	2,000	0
Sep. 18-Sep. 24	12,800	0	1,000	0
Sep. 25-Oct. 1	5,900	0	0	0
Total	2,119,400	1,762,500	1,906,000	352,000

* Dates for 1994. For other years, data from the nearest week were used.

Table 4. Commercial net and troll catches of Fraser River sockeye salmon in Canadian Areas 11 to 16 (Johnstone Strait and northern Strait of Georgia) by week for cycle years 1982-1994.

Date *	1982	1986	1990	1994
Jul. 3-Jul. 9	5,200	1,600	0	0
Jul. 10-Jul. 16	3,900	800	0	0
Jul. 17-Jul. 23	32,800	3,200	1,000	0
Jul. 24-Jul. 30	120,100	3,900	3,000	0
Jul. 31-Aug. 6	32,100	118,100	27,000	93,000
Aug. 7-Aug. 13	520,000	353,800	135,000	1,324,000
Aug. 14-Aug. 20	659,000	858,400	824,000	2,509,000
Aug. 21-Aug. 27	273,000	800,200	817,000	1,574,000
Aug. 28-Sep. 3	31,000	98,600	807,000	526,000
Sep. 4-Sep. 10	0	1,500	117,000	14,000
Sep. 11-Sep. 17	0	5,200	4,000	2,000
Sep. 18-Sep. 24	0	500	3,000	0
Sep. 25-Oct. 1	0	2,500	0	0
Total	1,677,100	2,248,300	2,738,000	6,042,000

* Dates for 1994. For other years, data from the nearest week were used.

Table 5. Catches of Fraser River sockeye salmon in the Canadian Fraser River Indian fishery by area (Fraser River mainstream or tributary areas) for cycle years 1982-1994. *

Fishing Area		1982	1986	1990	1994 **
Fraser River Mainstem					
Steveston		41,973	25,162	70,753	147,579
Deas to Mission		9,023	12,406	34,420	103,253
Mission to Hope		113,876	142,339	252,686	194,940
Hope to Sawmill Creek	*1*	101,976	165,181	232,826	201,818
Sawmill Creek to Kelly Creek	*1*	67,395	86,393	108,999	232,170
Kelly Creek to Naver Creek	*2*	20,465	16,139	22,375	10,618
Above Hixon		3,591	3,899	2,334	1,461
Total		358,299	451,519	724,393	891,839
Tributaries					
Harrison/Lillooet System		10,230	10,794	n/a	n/a
Thompson System		31,480	9,975	12,415	3,398
Chilcotin System		14,950	39,396	57,030	27,189
Nechako System		11,798	17,101	8,325	3,668
Stuart System		3,042	5,374	5,455	1,602
Total		71,500	82,640	83,225	35,857
Total Catch		429,799	534,159	807,618	927,696

* Data supplied by DFO.

** Catch estimates from the report of the In-river Catch Estimation Work Group to the Fraser River Sockeye Public Review Board, 1994.

1 Prior to 1993, the divisions were Hope to North Bend, and North Bend to Churn Creek.

2 Prior to 1994, the divisions were Churn Creek to Hixon.

Table 6. Commercial net catches of Fraser River sockeye salmon in United States Areas 4B, 4, 6, 6C, 7, 7A and 7B (Juan de Fuca Strait and northern Puget Sound) by week for cycle years 1982-1994.

Date *	1982	1986	1990	1994
Jul. 3-Jul. 9	0	0	0	0
Jul. 10-Jul. 16	100	400	0	0
Jul. 17-Jul. 23	36,300	3,600	100	12,000
Jul. 24-Jul. 30	132,100	6,200	18,000	65,000
Jul. 31-Aug. 6	465,800	387,500	10,000	220,000
Aug. 7-Aug. 13	479,500	551,500	443,000	269,000
Aug. 14-Aug. 20	712,800	714,100	0	320,000
Aug. 21-Aug. 27	509,600	592,600	711,000	205,000
Aug. 28-Sep. 3	469,200	372,300	542,000	669,000
Sep. 4-Sep. 10	52,500	700	426,000	68,000
Sep. 11-Sep. 17	200	100	0	0
Sep. 18-Sep. 24	0	0	0	0
Sep. 25-Oct. 1	0	104,300	6,000	0
Total	2,858,100	2,733,300	2,156,100	1,828,000

* Dates for 1994. For other years, data from the nearest week were used.

Table 7. Escapements of sockeye salmon to Fraser River spawning areas for cycle years 1982, 1986, 1990 and 1994. *

DISTRICT	1994 Period of	Estimated Number of Adult Sockeye				Jacks
Stream/Lake	Peak Spawning	1982	1986	1990	1994	1994
NORTHEAST						
Upper Bowron River		1,647	3,118	7,860	4,380	35
STUART						
Early Runs						
Takla Lake Streams	Aug.5-9	438	4,820	25,197	6,847	82
Middle River Streams	Aug.2-6	3,595	19,882	55,114	17,094	305
Trembleur Lake Streams	Aug.5-11	524	3,882	16,723	5,890	46
Early Stuart Total		4,557	28,584	97,034	29,831	433
Late Runs						
Middle River	Sept.18-24	7,450	9,940	76,500	29,573	151
Tachie River	Sept.18-24	7,528	13,617	94,570	42,571	97
Miscellaneous		1,780	5,158	17,979	4,318	5
Late Stuart Total		16,758	28,715	189,049	76,462	253
NECHAKO						
Nadina River (Late)		194	130	359	86	4
Nadina Channel	mid Sept.	2,155	3,415	5,674	1,922	85
Stellako River	mid Sept.	69,420	77,177	93,920	137,982	196
QUESNEL						
Horsefly River	Sept.8-12	30,317	144,751	398,468	494,552	7
Horsefly Channel		-	-	29,274	19,597	0
McKinley Creek	Sept.8-12	5,657	5,635	11,743	35,747	0
Mitchell River	Sept.12-18	3,829	30,827	43,755	129,235	0
Miscellaneous	Sept.15-20	38	254	4,404	7,280	0
Quesnel Total		39,841	181,467	487,644	686,411	7
CHILCOTIN						
Chilko River & Lake	mid Sept.	249,578	293,804	815,904	448,815	1,477
Chilko Channel	early Sept.	-	-	9,934	1,930	17
SETON-ANDERSON						
Gates Creek		101	394	993	0	0
Gates Channel	Sept.8-12	829	3,178	4,381	3,360	998
Portage Creek	Nov.6-12	23,867	14,291	18,336	9,270	0
NORTH THOMPSON						
Raft River	late Aug.	2,992	2,095	630	1,712	0
Fennell Creek	late Aug.	1,132	6,024	11,862	5,919	0
SOUTH THOMPSON						
Summer Runs						
Seymour River	Aug.30-Sept.3	63,271	126,166	272,041	64,038	0
Scotch Creek	late Aug.	4,709	26,624	83,388	73,180	3
Anstey River	Sept.4-8	767	7,080	25,297	7,380	0
Eagle River	Sept.1-4	1,642	7,138	4,147	53,796	0
Late Runs						
Adams/Little Rivers	Oct.15-20	2,309,158	1,551,867	2,432,828	878,381	237
Adams Channel	Oct.15-20	-	-	6,824	2,031	0
Lower Shuswap River	Oct.17-20	513,897	600,370	983,481	367,661	0
Middle Shuswap River	Oct.17-22	40,300	80,529	96,441	31,806	3
Misc. Late Runs		196,880	112,464	198,099	90,799	12
Late South Thompson Total		3,060,235	2,345,230	3,717,673	1,370,678	252
HARRISON-LILLOOET						
Birkenhead River	Sept.25-Oct.1	119,738	335,630	166,773	39,234	211
Harrison River	mid Nov.	9,189	7,265	4,515	9,515	0
Weaver Creek	Oct.14-30	236,288	65,846	5,969	20,017	33
Weaver Channel	Oct.14-30	57,795	44,892	10,396	44,939	37
LOWER FRASER						
Nahatlatch River/Lakes	Sept.5-9	2,734	8,996	7,044	6,042	0
Cultus Lake	early Dec.	16,725	3,256	1,860	4,399	23
Upper Pitt River	Sept.9-14	8,708	29,177	12,202	9,500	1
Chilliwack Lake	mid Sept.	3,980	1,164	2,230	7,966	15
MISCELLANEOUS		8,868	6,882	7,170	9,766	16
ADULTS		4,007,720	3,657,738	6,064,285	3,128,530	4,096
JACKS		16,541	59,706	20,546	4,096	
TOTAL SPAWNING ESCAPEMENT		4,024,261	3,717,444	6,084,831	3,132,626	

* 1982 data are from the PSC. Estimates for 1986 to 1994 are from DFO.

APPENDIX E: STAFF OF THE PACIFIC SALMON COMMISSION IN 1994

EXECUTIVE OFFICE

Mr. I. Todd, Executive Secretary
Ms. T. Tarita, Librarian/Records Administrator
Ms. J. Abramson, Secretary
Ms. V. Ryall, Meeting Planner

FINANCE AND ADMINISTRATION

Mr. K. Medlock, Comptroller
Ms. B. Dalziel, Accountant

FISHERIES MANAGEMENT DIVISION STAFF

Dr. J. Woodey, Chief

BIOMETRICS / CATCH STATISTICS GROUP

Mr. I. Guthrie, Head
Mr. D. Stelter, Catch Statistician

COMPUTER SERVICES GROUP

Ms. K. Mulholland, Computer System Manager

RACIAL IDENTIFICATION GROUP

Mr. J. Gable, Head
Mr. M. Lapointe, Sockeye Racial Analysis Biologist
Mr. B. White, Pink Racial Analysis Biologist
Ms. C. Lidstone, Senior Scale Analyst
Ms. J. Parkin, Scale Analyst
Ms. H. Derham, Scale Lab Assistant
Mr. K. Forrest, Racial Data Biologist (Term)

STOCK MONITORING GROUP

Mr. J. Cave, Head
Mr. P. Cheng, Hydroacoustics Biologist
Ms. V. Craig, Test Fishing Biologist