Overview of Fraser River

Sockeye Salmon Harvest Management

November 9, 2010

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Introduction

1. This paper is intended to provide an overview of the harvest management regime for Fraser River sockeye salmon. The paper does not evaluate the effectiveness of the current harvest management model or any of the components of the model.[1]

Harvesting of Fraser River Sockeye

2. Fraser River sockeye are harvested in a number of mixed-stock fisheries as they migrate from their offshore ocean habitat in the North Pacific to their many spawning grounds in the Fraser watershed.[2] The term "gauntlet fishery" is sometimes used to describe this series of fisheries. Fraser sockeye encounter test fishing, commercial seine and gillnet fishing, recreational fishing as well as First Nations Food, Social and Ceremonial ("FSC") fishing in Johnstone and Juan de Fuca Straits. Whether by way of Johnstone or Juan de Fuca Strait,[3] Fraser sockeye then enter the Strait of Georgia where there is also test, FSC, First Nations Economic Opportunity, recreational and commercial fishing. The commercial gillnet fishery in the Fraser River extends no further than the Mission Bridge and is the last major commercial fishery encountered by the sockeye. FSC, First Nations Economic Opportunity and recreational fisheries operate throughout the Fraser watershed.

Management Cycle for Fraser River Sockeye

3. The management process for Fraser sockeye follows an annual cycle of pre-season planning, in-season management and post-season review. Annual pre-

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[1] Note: Where Ringtail Documents are cited to a page number, it is the Ringtail page number and not the original document page number that is provided.

[2] The Fraser River sockeye fishery is a mixed-stock fishery because at any given point in time multiple stocks may be passing through an area in which a fishery is operating. Theoretically, co-migrating stocks are subject to the same harvest rates.

[3] Adult sockeye enroute to the Fraser River diverge in their migration path around the northwest tip of Vancouver Island, some entering Johnstone Strait and some travelling further South along the outside of Vancouver Island until they reach Juan de Fuca Strait. "Diversion rate" refers to the percentage of returning sockeye approaching the Fraser River via the North Coast of Vancouver Island and Johnstone Strait (see "Run-timing and Diversion Rate" section, below).

season abundance, run-timing and diversion rate forecasts are used to prepare fishing plans and guide management decisions early in the fishing season. Once the fishing season has begun, in-season assessment activities are based on data from a variety of sources with varying levels of uncertainty. In-season and post-season escapement estimates are based on a wide range of survey methods and analyses.

4. The annual management cycle for Fraser River sockeye is bracketed by two phases of public consultation, post-season review in the fall and pre-season planning in the spring.[4] These consultations occur as a combination of formal and informal advisory processes.

Fisheries and Oceans Canada: Management Context[5]

5. The Fisheries Renewal Initiative is the current term for the implementation by Fisheries and Oceans Canada ("DFO" or the "Department") of its "vision of a credible, science-based, affordable and effective fisheries program which contributes to the sustainable wealth of Canadians".6

6. The stated objectives of this initiative (as opposed to a framework or policy) are: long-term sustainability, economic prosperity and improved governance.[7]

7. One component of the Fisheries Renewal Initiative directly relevant to Fraser River sockeye harvest management is the Sustainable Fisheries Framework (the "SFF").

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[4] Ringtail Document CAN1854388 at 4.
[5] The Pacific Salmon Commission and *Pacific Salmon Treaty* management context is set out in another Policy and Practice Report: Overview of the *Pacific Salmon Treaty* and the Pacific Salmon Commission Regarding Management of Fraser River Sockeye Salmon.
[6] Fisheries Renewal, online: Fisheries and Oceans Canada <http://www.dfo-mpo.gc.ca/fm-gp/peches-fisheries/fish-ren-peche/index-eng.htm>.
[7] Ringtail Document CAN008879 at 9.

The SFF forms the basis for decision-making in Canadian fisheries.[8] DFO states that:[9]

> The primary goal of the SFF is to ensure that Canada's fisheries are environmentally sustainable, while supporting economic prosperity. This means maintaining a balance between healthy fish stocks and marine environments, while allowing for prosperous fisheries; a balance known as 'sustainable development'.

8. DFO asserts that the SFF is designed to help the Department take a more rigorous, consistent, and transparent approach to decision-making across all key fisheries in Canada. DFO also states that the SFF was developed through engagement with resource users and others with an interest in the resource in a manner that allows for policies and tools to be integrated over time. The SFF and its associated polices are intended to be completed as part of a three-year Fisheries Renewal program planned to conclude in 2011.

9. The SFF comprises four main elements: conservation and sustainable use policies; economic policies; governance policies and principles; and planning and monitoring tools. The newest of these policies include:[10]

   a. A Fishery Decision-Making Framework Incorporating the Precautionary Approach;
   b. Managing Impacts of Fishing on Benthic Habitat, Communities and Species; and
   c. A Policy on New Fisheries for Forage Species.

10. The Integrated Fisheries Management Plans (the "IFMPs") fall under this framework as an implementation mechanism.[11] IFMPs are the primary resource

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[8] Sustainable Fisheries Framework, online: Fisheries and Oceans Canada <http://www.dfo-mpo.gc.ca/fm-gp/peches-fisheries/fish-ren-peche/sff-cpd/overview-cadre-eng.htm> [SFF]; Ringtail Document CAN163355 at 38.
[9] *Ibid*.
[10] SFF.
[11] Ringtail Document CAN163355 at 39; Ringtail Document CAN027899 at 19-20.

management tool through which the SFF's policies are applied.[12] IFMPs identify goals related to conservation, management, enforcement and science for individual fisheries and they describe access and allocation among various fish harvesters and fleet areas (see "Salmon Integrated Fisheries Management Plan" section, below). The IFMPs are supposed to incorporate biological and socio-economic considerations that are factored into harvest decisions.

11. The precursor to the SFF was the Resource Management Sustainable Development Framework which was presented to all DFO regions and sectors in 2006/2007.[13]

Fisheries and Oceans Canada: Organisational Structure[14]

12. A detailed examination of the Department's over-arching organisational structure is intended to be the subject of another portion of the commission's hearings. However, brief descriptions of specific organisational divisions within DFO that are relevant to the management of annual Fraser River sockeye fisheries are provided below.

13. DFO "sectors" are National Headquarters organisational divisions based on program activities. Until May 3, 2010, the DFO sectors were: Fisheries and Aquaculture Management, Fisheries Renewal, Human Resources & Corporate Services, Science and Oceans, Habitat and *Species At Risk Act* and Policy.[15] As of May 3, 2010, the sectors are: Strategic Policy, Program Policy, Ecosystems

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[12] Application of the Sustainable Fisheries Framework through the Integrated Fisheries Management Planning Process, online: Fisheries and Oceans Canada <http://www.dfo-mpo.gc.ca/fm-gp/peches-fisheries/fish-ren-peche/sff-cpd/ifmp-pgip-back-fiche-eng.htm>.
[13] Ringtail Document CAN011334 at 2; Ringtail Document CAN163355 at 37-38; Ringtail Document CAN002114; and Ringtail Document CAN012894.
[14] The Pacific Salmon Commission organisational structure is set out in another Policy and Practice Report: *Overview of the Pacific Salmon Treaty* and the Pacific Salmon Commission Regarding Management of Fraser River Sockeye Salmon.
[15] Commission Exhibit 15, "Fisheries and Oceans Canada Organizational Structure", dated November 1, 2010 [DFO Organisational Structure].

and Fisheries Management and Oceans and Science.[16] "Branches" generally refer to organisational divisions within each Region that are also grouped by program activities. Each sector has an Assistant Deputy Minister as a sector head. In the regions, the Regional Director Generals are the equivalent management level to the sector Assistant Deputy Ministers.[17]

14. As of November 2010, the branches in the Pacific Region are: Fisheries and Aquaculture Management, Oceans, Habitat and *Species At Risk Act*, Science, Policy and Economics and Communications. Each branch has a Regional Director. Equivalent management divisions to the regional branches are the Conservation and Protection Directorate, the Special Projects Directorate and Area Directors for the North Coast, South Coast, Yukon Transboundary, Lower Fraser and BC Interior Area offices. Directorate Directors and Area Directors are equivalent in management level to the Regional Directors of the branches.[18]

Salmon Team

15. The Salmon Team is comprised of a small group of DFO Regional Headquarter members from Fisheries and Aquaculture Management ("FAM"). Its members are the Lead of the Salmon Team,[19] the Regional Salmon Coordinator (also called the Regional Salmon Resource Manager or the Regional Resource Manager, Salmon; hereinafter called the "Regional Salmon Resource Manager"),[20] the Regional Recreational Coordinator[21] and the Salmon Officer.[22] The Salmon Team Lead

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[16] *Ibid.*
[17] Ringtail Document CAN185519.
[18] DFO Organisational Structure.
[19] As of November 2010, Brent Hargreaves is the Acting Lead, Salmon Team. The prior Lead was Paul Ryall (2003-2009).
[20] As of November 2010, Jeff Grout.
[21] As of November 2010, Devona Adams.
[22] As of November 2010, Kelly Binning.

reports to the Regional Director of FAM who reports to the Regional Director General of the Pacific Region.[23]

16. The Salmon Team develops, implements and operationalises policy with respect to Pacific salmon. It is responsible for putting together salmon IFMPs in the Pacific Region. It also signs-off on salmon fisheries notices and is involved in the salmon Integrated Harvest Planning Committee (the "IHPC"). Most of its work focuses on Fraser sockeye and Skeena salmon. The Salmon Team leads the Pacific Region Strategic Plan implementation (Marine Stewardship Council certification would be part of this, for example). It is also the Salmon Team's responsibility to implement the Wild Salmon Policy.[24]

Fraser River Sockeye and Pink Salmon Integrated Management Team

17. DFO's Fraser River Sockeye and Pink Salmon Integrated Management Team ("FRIMT") is the administrative group that manages Fraser River sockeye and pink salmon in conjunction with the Fraser River Panel (the "FRP") of the Pacific Salmon Commission (the "PSC").[25] FRIMT provides overall direction to the three DFO Area Offices that manage Fraser River sockeye (South Coast, Lower Fraser and BC Interior).

18. Specifically, FRIMT:[26]

    a. Reviews, clarifies and provides direction on the implementation and integration of regional, national and Pacific Salmon Treaty (the "Treaty")27 policies and guidelines relating to Fraser River sockeye and pink salmon fisheries

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[23] As of November 2010, Sue Farlinger.
[24] Ringtail Document CAN002495 [Wild Salmon Policy].
[25] Ringtail Document CAN007968 at 1. For further information on the role and responsibility of the Fraser River Panel in Fraser sockeye management, see the commission's Policy and Practice Report: Overview of the *Pacific Salmon Treaty* and the Pacific Salmon Commission Regarding Management of Fraser River Sockeye Salmon.
[26] Ringtail Document CAN007968 at 1-2.
[27] Commission Exhibit 65 [Treaty]. For further information on the Treaty, see the commission's Policy and Practice Report: Overview of the *Pacific Salmon Treaty* and the Pacific Salmon Commission Regarding Management of Fraser River Sockeye Salmon.

management including licensing, regulations, stock assessment, catch monitoring, data management, enhancement, habitat and enforcement and provides recommendations for changes to these policies and guidelines;

b. Reviews, clarifies and co-ordinates implementation and integration of Area-based, Regional and Treaty management strategies for Fraser River sockeye and pink salmon fisheries;

c. Implements scientific advice, as required, relating to Fraser River sockeye and pink salmon like advice from the Centre for Science Advice – Pacific Salmon Sub-Committee;

d. Identifies and recommends Fraser River sockeye and pink salmon research priorities to DFO's Salmon Working Group;

e. Reviews and provides recommendations to Canada's Chief Commissioner to the PSC regarding improvements to programs designed to implement agreements under the Treaty;

f. Recommends Fraser River sockeye and pink salmon assessment, management, production, enhancement and enforcement needs;

g. Makes recommendations to managers about the programs necessary for Fraser River sockeye and pink salmon fisheries management for inclusion in the salmon business-planning process; and

h. Co-ordinates the development of Fraser River sockeye and pink salmon management plans into the South Coast salmon IFMP.

22. Prior to the FRP meetings, FRIMT coordinates with all DFO programs that provide input into the management of Fraser River sockeye. The linkage from FRIMT to DFO's Salmon Team is through the Salmon Team's Salmon Officer.

19. Membership of FRIMT is completely internal to DFO. The core members of FRIMT include the FRP's Canadian Chair and Alternate, Area Chiefs of Resource Management and Conservation and Protection, Area Directors for the South Coast, Lower Fraser and BC Interior, Lead of the Salmon Team, the Regional

Salmon Officer, other FAM Resource Management staff as needed and DFO's FRP Technical Committee (the "FRPTC") members.[28]

20. Other staff are invited to attend as required.[29] Such staff include people from FAM at National Headquarters, the Regional Salmon Resource Manager, the Regional Salmon Recreational Fisheries Coordinator, a representative from the Oceans, Habitat and Enhancement Branch and the Area Chiefs of Stock Assessment.[30]

21. Within DFO, FRIMT is responsible for Fraser sockeye and pink fisheries management in Panel and non-Panel Area waters. This includes responsibility for commercial, FSC, First Nations Economic Opportunity and Treaty, and recreational fisheries. FRIMT meets in November to develop a post-season report and to begin planning for the coming year.[31] It also meets in March or April to work on pre-season fishing plans. In-season, FRIMT meets by conference call as required. These calls generally follow the FRP and FRPTC meetings.

22. The Canadian Chair of the FRP is also the FRIMT Chair.[32] He or she reports to the Regional Director of FAM and the Area Directors of the South Coast, Lower Fraser Area and B.C. Interior.[33] The FRPTC Canadian Co-Chair reports to the Canadian co-chair of the FRP/FRIMT on the work of the FRPTC.[34] The FRP Canadian caucus (or National Section) and FRIMT meet periodically as well.[35]

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[28] Ringtail Document CAN007968 at 2; Ringtail Document CAN005758 at 9; Ringtail Document CAN185429. For further information on the role and responsibility of the Fraser River Panel Technical Committee in Fraser sockeye management, please see the commission's Policy and Practice Report: Overview of the *Pacific Salmon Treaty* and the Pacific Salmon Commission Regarding Management of Fraser River Sockeye Salmon.
[29] Ringtail Document CAN007968 at 2.
[30] *Ibid.* at 2.
[31] *Ibid.* at 3.
[32] As of November 2010, the Canadian Chair of the FRP is Barry Rosenberger, Area Director for the BC Interior. The prior Chair was Paul Ryall (2004-2009).
[33] Ringtail Document CAN007968 at 3.
[34] Ringtail Document CAN030843 at 1.
[35] See e.g. Ringtail Document CAN029983.

Salmon Working Group

23. DFO's Salmon Working Group (the "SWG") is a regional forum for the coordination of salmon planning and review activities and the integration of salmon management activities among areas in the Pacific Region (the "Region").[36] It was created to ensure implementation of national and regional policies on a consistent basis. The SWG also identifies policy needs and provides recommendations for improvements to salmon management programs.[37]

24. Specifically, it:[38]

   a. Reviews, clarifies and provides direction on the implementation and integration of regional and national policies and guidelines related to salmon fisheries management, licensing, regulations, stock assessment, catch monitoring, data management, enhancement, habitat and enforcement;
   b. Reviews and provides recommendations for changes to regional and national policies and guidelines related to salmon fisheries management, licensing, regulations, stock assessment, catch monitoring, data management, enhancement, habitat and enforcement;
   c. Reviews, clarifies and coordinates implementation and integration of agreements under the Treaty;
   d. Co-ordinates the implementation of regional and national strategies related to Oceans management, selective fishing, catch monitoring, new and emerging fisheries, elements of the fishery of the future, allocation and other initiatives as they are developed;
   e. Reviews and implements scientific advice such as that from Centre for Science Advice Pacific ("CSAP") Salmon Sub-Committee;

[36] Ringtail Document CAN006849 at 1.
[37] *Ibid*.
[38] *Ibid.* at 1-2.

f. Recommends salmon research needs to the CSAP Salmon Sub-Committee and other research programs carried out by the Department or other agencies or universities;

g. Reviews and provides recommendations to Panel Chairs regarding improvements to programs designed to implement agreements under the Treaty;

h. Recommends assessment, management, production, enhancement and enforcement needs;

i. Makes recommendations to managers (all levels) about the programs necessary for sound fisheries management for inclusion in the salmon business-planning process; and

j. Co-ordinates the development of IFMPs for salmon, including the establishment of timeframes and consultation processes.

25. The following DFO personnel are members of the SWG: Regional Salmon Resource Manager (Chair)[39], Area Chiefs of Resource Management, Stock Assessment and Conservation and Protection, an Area Director representative, the Regional Salmon Officer, Lead of the Salmon Team[40], Section Head – Salmon & Herring for the North Coast, Head of CSAP, Regional Recreational Fisheries Co-ordinator, Division Manager (or Head) of Salmon and Freshwater Ecosystems, Canadian Chair of the Fraser River Panel, Resource Manager in the Licensing Unit, Chief of the Regulations Unit, Communications Officer and representatives from Resource Management within FAM, Habitat and Enhancement, Treaty and Aboriginal Policy, the Salmon Enhancement Program and National Headquarters.[41]

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[39] As of November 2010, Jeff Grout.

[40] As of November 2010, Brent Hargreaves is the Acting Lead, Salmon Team. The prior Lead was Paul Ryall (2003-2009).

[41] Ringtail Document CAN006849 at 1; and Ringtail Document CAN1885430 at 1.

26. The SWG is intended to enhance communication with stakeholders as to why or why not fisheries may be opened. Depending on meeting agendas, sometimes national DFO representatives are also present. The SWG meets in November to review the season and begin pre-season planning; in March or April to finalise the IFMP; and in June to finalise plans for the upcoming season and discuss outstanding policy issues.[42] The SWG includes a number of sub-committees including the Stock Assessment Coordination Committee.[43]

Stock Assessment Coordination Committee

27. The Stock Assessment and Coordination Committee ("SACC") is the group responsible for the regional coordination of priorities for DFO's stock assessment work throughout the Region including the Fraser River. SACC is a sub-committee of the SWG. SACC is given a budget target and generates a program profile to fit it.

28. SACC is made up of Area Chiefs for Stock Assessment from all DFO Areas, core science members (e.g. Head, Salmon Assessment and Division Head, Salmon and Freshwater Ecosystems[44]), representatives from Oceans, Habitat and Enhancement Branch and the Salmonid Enhancement Program, representatives from FAM and DFO's Pacific Salmon Treaty Coordinator. Area Chiefs of Resource Management are sometimes involved with SACC. The Division Manager of Salmon and Freshwater Ecosystems has the ultimate authority for advising the Regional Management Committee on behalf of SACC.

Regional Management Committee

29. The Regional Management Committee (the "RMC") makes final budget decisions for DFO's Stock Assessment division based on recommendations from SACC. The RMC is a regional body set up to review and make decisions about

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[42] Ringtail Document CAN006849 at 2.
[43] *Ibid.* at 3.
[44] As of November 2010, Arlene Tompkins and Mark Saunders, respectively.

management and well-being of the department's operations and employees.[45] Specifically, the RMC:[46]

a. Is a forum for facilitating forward-planning and the exchange of information, advice and support on regional corporate initiatives, organizational issues of broad corporate significance, priorities and activities such as the annual business plan preparation and allocation of resources;
b. Provides direction on issues related to finance and administration, human resources, technical services, communications, information management technology, capital assets and overall management of the regional and individual cases;
c. Reviews the functioning of its sub-committees, identifies strategic issues within its mandate and initiates action;
d. Sets priorities and develops and approves work plans for the Committee; and
e. Assigns accountability for and monitors progress on RMC decisions.
f. The RMC is made up of the Regional Director General, the Regional Director of Science[47], Regional Director of other branches and Area Directors. Legal counsel also attend, as do individuals invited as required to address the agenda.[48]

<u>Centre for Scientific Advice – Pacific</u>

30. CSAP is the DFO organisation responsible for the review and evaluation of scientific information on the status of living aquatic resources, their ecosystems and the biological aspects of stock management.[49] The CSAP Salmon Sub-Committee is the primary body providing pre-season scientific advice for the

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[45] Ringtail Document CAN005425 at 1.
[46] *Ibid*.
[47] As of November 2010, Laura Richards.
[48] Ringtail Document CAN005425 at 2.
[49] Salmon – Pacific Region, online: DFO Extranet <http://www-ops2.pac.dfo-mpo.gc.ca/xnet/content/salmon/stock.htm> [Stock Assessment Extranet]. Prior to 2010, CSAP was called the Pacific Scientific Advice Review Committee ("PSARC").

development of management plans for Pacific Salmon.[50] CSAP operates via a peer review process and is comprised largely of DFO scientists, with participants from other DFO sectors, academia, First Nations, stakeholders, other government or private institutions and the public.

Resource Management Executive Committee

31. CSAP requests for science advice are passed on to the Resource Management Executive Committee ("RMEC") to determine whether there are overlaps in projects. RMEC decides how resources should be provided to meet science advice requirements according to the priorities determined by RMEC and determines which CSAP requests are approved. RMEC is made up of senior management from Science, FAM and Oceans, Habitat and Enhancement.

DFO Roles and Responsibilities in Harvest Management[51]

Regional Director General, Pacific Region

32. The Regional Director General, Pacific Region:

    a. Provides guidelines for broad policy implementation;
    b. Chairs RMEC which receives science advice from CSAP;
    c. Approves objectives for IFMP development on behalf of the Region;
    d. Approves the IFMP on behalf of the Region, for subsequent submission to the Minister;
    e. Provides final in-season decisions within the Region; and
    f. Approves variation orders for First Nations and recreational salmon fisheries.

Fisheries and Aquaculture Management Branch

33. Fisheries and Aquaculture Management Branch:

[50] *Ibid*.
[51] Ringtail Document CAN075232 at 81-82.

a. Leads process of allocating financial and personnel resources to ensure appropriate approaches to resource management and enforcement throughout the Region;

b. Pre-season:

   i. Identifies options for development of broad objectives for IFMP development;
   ii. Ensures cross-sector input into development of broad objectives for the IFMP;
   iii. Reviews pre-season implementation plans to ensure consistency with the IFMP and between Areas;
   iv. Directs consultation on issues of Regional application (allocation implementation); and
   v. Co-ordinates the annual enforcement priority setting and sets the long-term strategic direction for enforcement;

c. In-season:

   i. Clarifies policy direction and leads process to address cross-Area issues that arise;
   ii. Reviews fishery decisions where issues may arise to ensure consistency with policy, the IFMP and internal DFO processes;
   iii. Provides policy advice related to fishery decisions under consideration;
   iv. Monitors compliance with enforcement and success of implementation of enforcement strategies; and
   v. Approves variation orders for commercial salmon fisheries;

d. Post-season:

   i. Co-ordinates post-season reviews to assess whether objectives of the IFMP have been met;
   ii. Assesses success of overall enforcement program; and
   iii. Provides direction on changes for the coming year.

Science Branch

34. Science Branch:

    a. Leads process of allocating financial and personnel resources to ensure appropriate approaches to stock assessment and research throughout the Region;
    b. Provides pre-season forecasts;
    c. Reviews forecasts and assessment methodologies through CSAP;
    d. Reviews and provides advice on options for exploitation rates and escapement targets;
    e. Implements research projects; and
    f. Establishes guidelines and standards for stock assessment.

Area Offices

35. Allocate resources within the Area to undertake fishery management, enforcement and stock assessment activities according to Regional and Area priorities;

    a. Pre-season:

        i. Participate in identification of objectives for IFMP development;
        ii. Contribute to the draft IFMP and lead consultations with First Nations and stakeholders on IFMP development and pre-season enforcement and management planning;
        iii. Provide pre-season forecasts; and
        iv. Provide input into enforcement priority setting;

    b. In-season:

        i. Implement the IFMP, including review of fishery management decisions to address Area considerations;
        ii. Collect catch information and any other information required to make fishery decisions;
        iii. Collect escapement and biological data;

iv. Implement operational enforcement plans consistent with Regional and Area priorities;
v. Lead in-season consultations with First Nations and stakeholders; and
vi. Make decisions regarding local fisheries and participate in decision-making for fisheries of Regional scope;

c. Post-season:

i. Conduct post-season assessments of the IFMP and enforcement plans;
ii. Lead post-season consultations with First Nations and stakeholders; and
iii. Conduct escapement analyses and fishery assessment reviews.

Canadian Chair, Fraser River Panel

36. The Canadian Chair, Fraser River Panel

a. Pre-season:

i. Co-ordinates the development of Canada's position regarding Fraser sockeye and pink salmon fisheries and negotiates arrangements with the United States; and
ii. Develops fishing plan options consistent with the IFMP and the negotiated arrangements for consideration by the Regional Director, FAM;

b. In-season:

i. Develops fishing plans consistent with the IFMP and the Treaty;
ii. Reviews fishing plans within FAM; and
iii. Co-ordinates the in-season FRP Canadian caucus process and co-ordinates management of Fraser River sockeye and pink fisheries with Regional and international activities (unresolved issues are referred to Director, Resource Management - Program Delivery);

c. Post-Season: Participates in post-season reviews and prepares reports to the PSC and United States.

Run-timing Groups

37. In the Fraser River watershed, 271 individual groupings of spawning sockeye have been identified, each with specific spawning area and migration timing.[52] For management purposes, these spawning populations are aggregated into stocks or populations defined by their run-timing.[53]

38. In the Wild Salmon Policy sockeye are grouped by Conservation Units ("CUs") which are defined as "[a] group of wild salmon sufficiently isolated from other groups that, if extirpated, is very unlikely to recolonise naturally within an acceptable timeframe".[54] Fraser sockeye CUs are not exactly the same as the stocks that historically have been used for management purposes. A stock may include more than one CU, and one CU may include more than one stock.[55] Two hundred and fifty-one of the spawning populations are lake-rearing and make up about 31 CUs, the remaining 20 spawning populations are river-type sockeye which make up about 6 CUs.[56]

39. Most of the steps in the annual Fraser sockeye harvest management process do not operate at the CU level.[57] Rather, management of Fraser sockeye is generally applied at an aggregate (also called stock-group, run-timing group or management group) level (see "Description of the Run-timing Groups" section, below).[58] There are four run-timing groups: Early-Stuart, Early-Summer, Summer and Late-run.[59] Escapement targets and harvest decisions are decided at an aggregate level although there can be exceptions for some stocks (management

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[52] Ringtail Document CAN002907 at 11.
[53] *Ibid* at 12.
[54] Wild Salmon Policy at 38.
[55] Mike Staley, *Fraser River Sockeye Spawning Initiative (FRSSI): A Review for the Cohen Commission* [Staley Report] at 8.
[56] *Ibid*.
[57] Ringtail Document CAN005727 at 37.
[58] Ringtail Document CAN002524 at 63.
[59] Ringtail Document CAN002907 at 20.

of the Cultus and Birkenhead stocks are examples of this).[60] DFO and the FRP manage fisheries openings and closings based on the four stock-groups.

40. For modeling purposes, the PSC splits the four stock-groups into eight stock groupings according to timing-patterns. The Early Stuart stock-group represents one PSC stock grouping; the Early Summer stock-group is broken down into three sub-groups: Early Miscellaneous, Scotch/Seymour and North Thompson; the Summer stock-group consists of two sub-groups: Late Stuart/Stellako and Chilko/Quesnel; and the Late-run also consists of two stock sub-groups: Harrison and Late Shuswap/Weaver. These eight groupings are used in the PSC pre-season fishery planning simulation model (see "Pre-season Planning" section, below) and the PSC in-season run-size assessment models (see "Run-size Assessment" section, below).

Description of the Run-timing Groups

41. The Early-Stuart, Early-Summer, Summer and Late-run stock-groups comprise 7, 74, 12 and 158 spawning populations respectively.[61]

42. The four stock-groups are generally defined by their spawning location and migration timing. The Early-Stuart stock-group spawns in the Takla-Trembleur Lake system and arrives in the lower Fraser River from late June to late July.[62] The Early-Summer stock-group spawns throughout the Fraser system and arrives in the lower Fraser from mid-July to mid-August.[63] The Summer-run spawns in the Chilko, Quesnel, Stellako and Stuart systems and arrives in the lower Fraser from mid-July to early-September. The Late-run arrives in the lower Fraser from late-

[60] See e.g. Ringtail Document CAN002524 at 63-64.
[61] Ringtail Document CAN002907 at 20.
[62] *Ibid*.
[63] *Ibid*.

August to mid-October and spawns in the lower Fraser, Harrison-Lillooet, Thompson and Seton-Anderson systems.[64]

43. Early-Summers include Bowron, Fennell, Gates, Nadina, Pitt, Raft, Scotch, Seymour, and Early-Summer Miscellaneous (Early Shuswap, South Thompson, North Thompson tributaries, North Thompson River, Nahatlach River & Lake, Chilliwack Lake and Dolly Varden Creek) sockeye.[65] The Summer aggregate includes Chilko, Late Stuart, Stellako and Quesnel sockeye. The Late-run group includes Cultus, Harrison, Late Shuswap, Portage, Weaver, Birkenhead, Miscellaneous Shuswap and Late Miscellaneous non-Shuswap sockeye.[66] For stocks labelled “Miscellaneous” only escapement data are available as there is no information on recruits.[67] For the 19 non-Miscellaneous stocks, there is a long-term time series of escapement and recruitment data which are used in the Fraser River Sockeye Spawning Initiative and run-size forecasting models (see “Fraser River Sockeye Spawning Initiative: 2004 to present” and “Run-size” sections, below). These 19 stocks comprise 98.6% of Fraser River sockeye abundance.[68]

44. The make-up of the stock-groups has changed over the years. The Birkenhead stock (Birkenhead, Big Silver, Cogburn, Poole, Samson, Railroad, Green River and Douglas sockeye[69]) was initially considered a Summer stock, but was included within the Late-run in 1990. In recent years, because the Birkenhead stock has not experienced high in-river mortality like the “true” Late-run stocks it has been managed separately.[70]

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[64] *Ibid*.
[65] Staley Report at 8.
[66] Ringtail Document CAN067980 at 30 (draft).
[67] Ringtail Document CAN067965 at 9.
[68] Ringtail Document CAN002907 at 12.
[69] Ringtail Document CAN006693 at 24.
[70] Ringtail Document CAN008320 at 9; and Ringtail Document CAN056602 at 13.

Weak Stock Management in Mixed-Stock Fisheries

45. The run-timing groups are comprised of strong (more abundant and or productive[71]) stocks along with weaker (less abundant and or productive) stocks. Management of Fraser sockeye assumes that exploitation rates on each stock-group are the same for all stocks within the group. However, depending on each stock's production, each stock within an aggregate can theoretically sustain different rates of harvest.[72] And, not all stocks within the aggregate are necessarily exposed to the same harvest rates due to variations in run-timing amongst the stocks in any one run-timing group.

46. An important assumption applied in the current management of Fraser sockeye stocks is that spawning stocks for which there are not sufficient data will benefit from conservation measures for stocks for which there are data (i.e. fisheries managers assume that the 19 stocks are representative of all the spawning stocks). Thus, managers assume that conservation and harvest rules developed for an aggregate also consider the weaker stocks within that aggregate.

Total Allowable Catch

47. Canada provides the Fraser River Panel with run-size forecasts and escapement targets prior to each fishing season.[73] The FRP then develops fisheries plans based on forecasted run-sizes at different run-size probability levels and corresponding spawning escapement targets. The projected total allowable catch ("TAC") is then calculated by the FRP.

[71] "Productivity" of a stock is measured by determining the ratio between the number of spawners in a year and the resulting adult production (catch plus escapement) four years later (Ringtail Document CAN002584 at 13).
[72] Ringtail Document CAN010224 at 2.
[73] See e.g. Ringtail Document CAN002564 at 15; Treaty, Article IV, Para. 3 and Annex IV, Ch. 4, Para 4.

48. The international TAC formula for all Canadian and US Fraser River sockeye fisheries is:[74]

TAC = return - sockeye harvested in test fisheries - total escapement target - MA - AFE

where "MA" means the management adjustment for each Fraser River sockeye run-timing group (see "Management Adjustments" section, below), and "AFE" means the Aboriginal Fisheries Exemption (see "Aboriginal Fisheries Exemption" section, below).

49. The pre-season forecast is used to calculate expected TAC in the pre-season. In-season, run-size as determined in-season by the FRP is used to calculate the TAC allocations.

United States Total Allowable Catch

50. The following equation is used to calculate the United States TAC ("USTAC"):[75]

USTAC = Treaty % * (TAC)

where "Treaty %" is a fixed percentage of the TAC allocated to United States fisheries (now set at 16.5% for each cycle year).[76]

Aboriginal Fisheries Exemption

51. The AFE is a fixed amount of sockeye salmon set aside for Canadian Aboriginal fisheries, as defined in the Treaty. The Treaty identifies a Fraser River AFE amount of up to 400,000 sockeye salmon annually for Canadian in-river and marine aboriginal fisheries, of which up to 20% can be applied to the Early Stuart

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[74] Treaty, Annex IV, Ch. 4, Para 3.
[75] Treaty, Annex IV, Ch. 4, Paras. 2 and 3.
[76] Treaty, Annex IV, Ch. 4, Para. 2.

run-timing group.[77] The portion of the total AFE assigned to the different run-timing groups is initially set using the historical average distribution of the First Nations harvests for the past three cycle years.[78] The values set for each run-timing group may be adjusted where necessary to address conservation concerns, respond to major changes in run-size for a specific run-timing group or where the United States and Canada otherwise agree.[79]

52. The AFE is a Treaty-defined amount. It does not limit Canada's allocation of its TAC to First Nations FSC fisheries.

Canadian Total Allowable Catch

53. The Canadian TAC ("CTAC") is what remains when the USTAC is removed from the TAC:[80]

$$CTAC = TAC – USTAC.$$

Canadian Commercial Total Allowable Catch

54. The Canadian commercial TAC ("CCTAC") is: CTAC –First Nation FSC catch – recreational catch.[81]

Post-season Total Allowable Catch

55. On February 17, 2005, the FRP agreed on a revised Chapter 4, Annex IV of the Treaty that established a new method for calculating post-season TAC.[82] The FRP also decided to apply the new method for calculating post-season TAC retroactively for 2002 through 2004.

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[77] Treaty, Annex IV, Ch. 4, Para. 3(d); see also Policy and Practice Report: Overview of the *Pacific Salmon Treaty* and the Pacific Salmon Commission Regarding Management of Fraser River Sockeye Salmon.
[78] *Ibid*.
[79] *Ibid*.
[80] Treaty, Annex IV, Ch. 4, Para. 3.
[81] Ringtail Document CAN031704 at 26.
[82] Ringtail Document CAN002564 at 43-45.

56. Prior to 2005, post-season TAC was calculated using post-season estimates of run-size, spawning escapement and test-fishing. Since 2005, the calculation has used the estimates of run-size, spawning escapement target, management adjustment and test fishing catch in effect when the FRP relinquishes control of the last US Panel Area (usually late in September).[83] The new method is therefore based on in-season data (i.e. estimated escapement) rather than post-season data (i.e. actual escapement) to calculate total sockeye available for sharing in each fishing season. This affects the TAC and share calculations and specifically the overages and underages relating to yearly TAC.

57. Although TAC is calculated as set out above, certain conservation and management constraints can limit harvesting opportunities and so TAC may not be reached in a given year.

Escapement

58. Under the Treaty, DFO is responsible for establishing annual spawning escapement targets for Fraser River sockeye TAC.[84] For the purposes of pre-season planning, where possible, Canada must provide forecasts of run-size and spawning escapement requirements by stock-group to the FRP.[85] Forecasts of run-timing and diversion rate (see “Run-timing and Diversion Rate” section, below), gross escapement needs (see “Gross Escapement” section, below) and any in-season adjustments in escapement requirements are to be provided to the PSC by Canada as they become available.[86]

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[83] *Ibid*.
[84] Treaty, Article IV, Para. 3 and Annex IV, Ch. 4, Para. 4.
[85] Treaty, Annex IV, Ch. 4, Para. 4.
[86] Treaty, Annex IV, Ch. 4.

Gross Escapement

59. The term "gross escapement" is used in different contexts in relation to harvest management of Fraser River sockeye. The gross escapement in-season target (or gross escapement target) for each stock-group is the sum of:

   a. The spawning escapement requirement (determined by DFO and adjusted in-season based on the estimated run-size);
   b. Canada's total expected or planned First Nations catch in the Fraser River; and
   c. Canada's total expected or planned recreational catch in the Fraser River.

60. The adjusted gross escapement target is the sum of the:

   a. Gross escapement target; and
   b. Management adjustment (see "Management Adjustment" section, below).

61. If the adjusted gross escapement target exceeds the FRP adopted in-season run-size estimate then the gross escapement target is set to equal the run-size estimate.

62. Because spawning ground enumeration estimates are not available until a number of months after the season, the closest measure of progress towards the gross escapement target available to the FRP in-season is the sum of escapement past Mission, based on hydro-acoustics and test fishing data, and First Nations and recreational catch above Mission.

63. The post-season gross escapement estimate (also called gross escapement up-river) is the sum of:

   a. Spawning ground enumeration;
   b. First Nations catches in the Fraser River (above and below Mission); and
   c. Recreational catches in the Fraser River (above and below Mission).

64. Potential spawning escapement is calculated in two ways by the FRP:

a. Mission escapement- to-date minus catch-to-date above Mission; and

b. In-season run-size minus observed catch-to-date.

Pre-1987 Escapement Strategies

65. Until 1986, the International Pacific Salmon Fisheries Commission (the "IPSFC") was responsible for managing Fraser sockeye and pink stocks.[87] In the early 1970s, the IPSFC developed a resource enhancement plan to increase escapements to reach the optimum escapement of major races.[88] A cycle-by-cycle racial approach was implemented every year for sockeye; a summary of the average adult escapements by four-year periods from 1974 to 1985 is shown in Table 1.[89]

Table 1: Summary of average adult escapements by four-year periods for Fraser sockeye.[90]

Years	Sockeye (million)
1974-77	1.172
1978-81	1.553
1982-85	2.018

66. The overall average Fraser sockeye harvest rate in the 1980s was 78%.[91]

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[87] Ringtail Document CAN002485 at 172; see also Policy and Practice Report: Overview of the *Pacific Salmon Treaty* and the Pacific Salmon Commission Regarding Management of Fraser River Sockeye Salmon.

[88] Ringtail Document CAN005102 at 288. The term "race" used by the IPSFC refers to sockeye populations within a stock (e.g. within the Quesnel stock) that return to a specific area (Ringtail Document CAN005102 at 22). An example of an IPSFC race would be the Horsefly race (or population) that returns to the Horsefly River within the Quesnel area.

[89] Ringtail Document CAN005102 at 288.

[90] *Ibid*.

[91] Ringtail Document CAN002907 at 9.

Rebuilding Strategy: 1987 to 2004

67. In 1987, DFO initiated a management and enhancement plan to increase sockeye salmon production in the Fraser River through incremental increases in escapement.[92] The impetus for the plan was the Treaty that provided Canada with benefits from increased production.[93] This rebuilding plan was known as the 1987 Rebuilding Strategy; it was never publicly released by DFO.[94]

68. The purpose of the 1987 Rebuilding Strategy was to forego short-term economic gain to increase long-term value of the catch by increasing run-sizes through increased escapement. This was to be done by decreasing exploitation rates to 60-70% (from approximately 80-90%), providing some protection to smaller stocks and or cycle lines, increasing annual target escapement above brood year levels and setting a maximum exploitation rate of 65-70%.[95]

69. In the development of the 1987 Rebuilding Strategy, the potential for increased production was assessed by DFO using four methods: 1) historical catch review; 2) stock-recruitment analyses; 3) spawning habitat capacity estimates; and 4) lake rearing habitat capacity estimates.[96] Estimates of production potential varied significantly, due in part to the uncertainty of causal factors that created cyclic patterns of sockeye returns. In the result, DFO decided to increase production by increasing spawning escapement.[97]

70. Under the 1987 Rebuilding Strategy, interim escapement goals were established as targets to be reached over a period of 3 to 6 cycles (12 to 24 years).[98] The escapement goals, reviewed by the Pacific Stock Assessment Review Committee (PSARC) in 1990 were derived by stock and cycle and reflected estimated

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[92] Ringtail Document CAN1854388 at 3.
[93] Ringtail Document CAN018984 at 7.
[94] Ringtail Document CAN150681 at 3.
[95] Ringtail Document CAN047016 at 4.
[96] *Ibid*.
[97] *Ibid*.
[98] Ringtail Document CAN185434 at 18.

spawning and juvenile rearing habitat capacities.[99] The goals were different across cycles to reflect the cyclic pattern of abundance. The goals were intended to be modified on the basis of new information acquired during the course of the plan. A basic premise of the plan was to increase annual escapement beyond brood year levels to maintain an increasing rebuilding trajectory.[100]

71. To increase escapement, average exploitation rates were reduced to 65-70% and minimum and maximum escapement targets were set annually.[101] Under this fixed escapement and fixed harvest rate strategy most stocks were expected to reach interim goals within six cycles, assuming average rates of return. The strategy was also expected to result in a progressive trend towards the interim goals. Since returns in any year were highly variable, escapement plans each year were based on a three step approach:

   a. Maintain minimum escapement levels at low stock sizes by reducing harvest rates to zero or slightly above zero;
   b. Increase escapements at moderate to high stock size to the interim goal by implementing fixed harvest rates of 65-70%; and
   c. Maintain maximum escapement levels at the interim goal by increasing harvest rates above 70%.[102]

72. The 1987 Rebuilding Strategy guided escapement management from 1987 to 2004, but stocks and harvests did not respond as predicted.[103] Thus, support for the 1987 Rebuilding Strategy diminished by the early 2000s due to a decline in catch, difficulty in accommodating multiple objectives, lack of flexibility in the

[99] Ringtail Document CAN018984 at 7. PSARC is now called CSAP (see “Centre for Science Advice – Pacific” section, above).
[100] Ringtail Document CAN1854388.
[101] Ringtail Document CAN018984 at 7; and 1987 Rebuilding Strategy at 1.
[102] *Ibid*.
[103] Ringtail Document CAN1854388 at 3; Ringtail Document CAN002569 at 6.

strategy, the considerable time and effort expended on annual review and consultation and the constraints of the strict rebuilding schedule.[104]

Fraser River Sockeye Spawning Initiative: 2004 to present

73. In 2003, in response to the Chamut Report of the External Steering Committee: *Review of the 2002 Fraser River Sockeye Fishery*,[105] DFO reviewed the 1987 Rebuilding Strategy in order to incorporate new information, integrate new policies such as the Wild Salmon Policy and establish a formal framework for setting annual escapement targets.[106] And thus, the Fraser River Sockeye Spawning Initiative ("FRSSI") began and a FRSSI Steering Committee and Technical Working Group were formed.[107]

74. FRSSI was intended to address the perceived shortcomings of the 1987 Rebuilding Strategy through yearly escapement plans based on variable exploitation rates and escapement depending on run-size rather than on a fixed escapement target.[108] Decisions about exploitation rates and escapement are supposed to be made based on performance indicators that account for conservation, cultural, social and economic values.[109]

75. The FRSSI process has four goals:[110]

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[104] Ringtail Document CAN1854388 at 4; Ringtail Document CAN003545 at 2; Ringtail Document CAN047016 at 5; and Ringtail Document CAN002790 at 12.
[105] Ringtail Document CAN002503.
[106] Ringtail Document CAN1854388 at 4; Ringtail Document CAN003545 at 2; Ringtail Document CAN005760; and Ringtail Document CAN008091.
[107] Ringtail Document CAN047016 at 13. In 2003, the Steering Committee Members were: Paul Ryall (Lead, Salmon Team, DFO), Brian Riddell (on secondment from DFO to the Pacific Fisheries Resource Conservation Council), Arnie Narcisse (B.C. Aboriginal Fisheries Commission), Tom Bird (Sports Fishing Advisory Board), Ken Wilson (Sierra Club) and Murray Chatwin (Ocean Fisheries Ltd.). The Technical Working Group members were: Paul Ryall (Lead), Michael Folkes (DFO), Jeff Grout (DFO), Al Cass (DFO), Les Jantz (DFO), Ron Goruk (DFO), Gottfried Pestal (DFO consultant) and Mike Staley (external expert).
[108] Ringtail Document CAN047016 at 8.
[109] *Ibid*.
[110] Ringtail Document CAN003545 at 3; and Ringtail Document CAN021738 at 3.

a. Manage spawning escapement to ensure conservation while respecting social and economic values;

b. Improve the existing consultation processes by focusing on a proactive discussion of targets and operational guidelines, rather than reactive in-season decision-making;

c. Develop management reference points and a long-term strategy for managing Fraser sockeye escapements; and

d. Develop processes for reviewing and modifying escapement strategies.

76. The ultimate purpose of FRSSI is to generate escapement strategies,[111] which are represented as total allowable mortality ("TAM") rules (which include harvest rules as a component), for each run-timing group that protect component stocks and stablise total harvest in a way that achieves a balance between conservation at low abundance and harvest at higher abundance.[112] This balance is intended to be achieved through:[113]

a. No fishing at very low run-sizes (except for test fishing);

b. A fixed TAM rate of 60% at larger run-sizes; and

c. Fixed escapement at low run-sizes (in other words, between the no fishing point and a TAM ceiling of 60%, TAM will increase as run-size increases in order to maintain the same escapement target).

77. In FRSSI, specifying TAM rules is equivalent to setting target escapements from which harvest rules can be derived for each run-timing group.[114] The harvest rules are defined as exploitation rates expressed as a function of run-size and thus

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[111] The term "escapement strategies" has the same meaning as the escapement tables used prior to the FRSSI process (Ringtail Document CAN002907 at 21).
[112] Ringtail Document CAN021738 at 5.
[113] Ringtail Document CAN002907 at 34; Ringtail Document CAN021738 at 5.
[114] Ringtail Document CAN002907 at 34.

target levels of catch and escapement vary accordingly.[115] The harvest rules are bounded by two points: 1) a no fishing point; and 2) a cut-back point.

78. Under FRSSI, the annual escapement target for each run-timing group is estimated using the following equation:[116]

$$\text{Total Escapement Target} = \text{Return} * (1.0 - \text{TAM})$$

where "Return" is the estimated run-size. For pre-season targets, the forecasted Return is used.

Development of FRSSI

79. FRSSI was refined over six years through more than a dozen workshops including an intensive two-year planning exercise. DFO has described the FRSSI process as a pilot implementation of the integrated management processes set out in the Wild Salmon Policy (Strategy 4).[117]

80. For a detailed summary of the development of FRSSI see: Pestal, G., Ryall, P. and Cass, A. Collaborative Development of Escapement Strategies for Fraser River Sockeye: Summary Report 2003-2008 (2008) Can. Man. Rep. Fish. Aquat. Sci. 2855.[118]

The FRSSI Model

81. FRSSI simulates a group of stocks, applies different escapement strategies to each run-timing group over 48 years into the future and tracks the performance of these escapement strategies.[119]

82. At the heart of FRSSI is a computer simulation model (the "FRSSI Model").[120] This model generates a harvest rule for each run-timing group based on: 1)

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[115] Ringtail Document CAN047016 at 16; and Ringtail Document CAN006694 at 9.
[116] Ringtail Document CAN031704 at 25.
[117] Ringtail Document CAN002907 at 7; and Ringtail Document CAN003545 at 4.
[118] Ringtail Document CAN002907.
[119] *Ibid.* at 35 and 42.

assumptions about stock dynamics; 2) the relative preferences for different management objectives (e.g. maximising long-term catch, maximising spawner abundance); and 3) different TAM rules specifying harvest rules at different abundances.[121] The FRSSI Model searches for the harvest rule that best achieves the specified management preferences for the specified stock dynamics.

83. In fact, the FRSSI Model is actually two computer models incorporated into one process. The stock, or population, dynamics[122] component of the FRSSI Model applies stock-recruitment models to the long-term stock-recruitment data set and the second component applies a forward-looking simulation that evaluates the expected outcomes of particular harvest rules (Figure 1; see "Stock (Population) Dynamics" and "Fishery Simulation" sections, below).

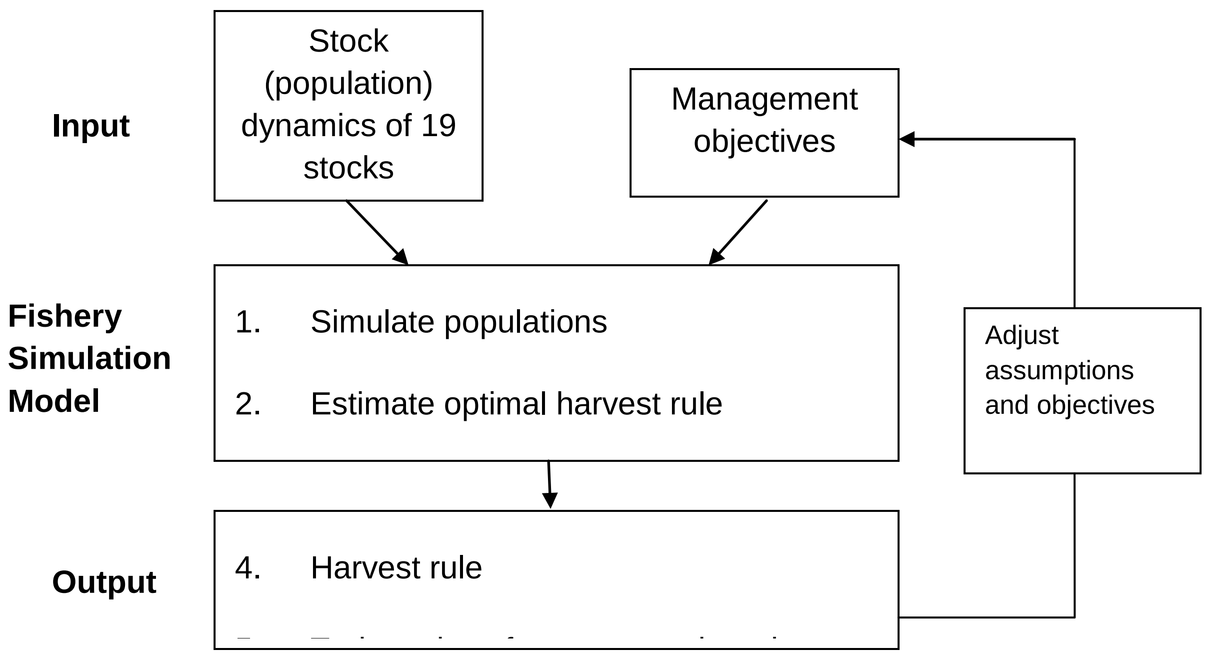

Figure 1: Flow diagram of FRSSI Model.[123]

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[120] Ringtail Document CAN010672.
[121] Ringtail Document CAN047016 at 16; Ringtail Document CAN058447 at 2.
[122] Population dynamics is a general term used to describe the biological characteristics, environmental processes and human factors that determine a population's abundance, growth, reproduction and mortality (Ringtail Document CAN002907 at 10).
[123] Ringtail Document CAN058447 at 3.

84. The FRSSI Model evaluates escapement strategies based on performance of individual stocks, not management groups. There are currently 19 stocks with sufficient escapement and recruitment data that can be used into the simulation model.[124] These 19 stocks comprise 98.6% of the Fraser River sockeye run-size as noted above (see "Description of the Run-timing Groups" section, above).[125]

Performance Measures (Indicators)

85. Expected outcomes are described by performance measures (or indicators) that allow comparison amongst a variety of assumptions and First Nations and stakeholder preferences and can be used to examine whether a harvest rule meets various management objectives.[126] There are three general classes of performance measures:[127]

   a. Yield;
   b. Variability; and
   c. Conservation.

86. Performance indicators make the policy choices faced by managers explicit. In FRSSI, these choices focus on trade-offs between different management objectives such as the trade-off between harvest versus biodiversity, short- versus long-term benefits and catch stability versus maximising opportunity.[128]

87. Conservation performance indicators are supposed to reflect the intent of the Wild Salmon Policy and social performance indicators like Yield and Variability are supposed to focus on the stability of total harvest.[129]

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[124] Ringtail Document CAN1854388 at 4.
[125] Ringtail Document CAN002907 at 12.
[126] Ringtail Document CAN047016 at 21 and 23.
[127] Staley Report at 17.
[128] Ringtail Document CAN002907 at 33.
[129] Ringtail Document CAN003545 at 7.

88. Through forward simulations, the FRSSI Model calculates and accumulates performance measures in one of the three general classes by summarising: 1) averages or totals (e.g. total or average catch over a number of years into the future); or 2) the probability or frequency of an indicator's value being below or above a benchmark (e.g. how many times would spawning abundance or catch fall below some benchmark).[130] Currently, the following performance measures are used to evaluate the performance of a suggested harvest rule:[131]

a. The proportion of simulated years where the four-year running average of spawner abundance falls below a stock-specific benchmark; and
b. The proportion of simulated years where catch for an aggregate would fall below a benchmark.

Total Allowable Mortality

89. Total allowable mortality is the proportion of adult fish from each stock that do not return to the spawning grounds (whether due to catch or other mortality), excluding natural levels of predation.[132] Thus, TAM is not directly equivalent to exploitation rate although the amount of harvested fish is a component of TAM.

90. TAM is capped at a fixed TAM of 60% for all run-sizes. This cap is intended to serve two purposes: ensure robustness against uncertainty (e.g. capacity estimate, changing run-size estimates) and protect weaker stocks that are less abundant, less productive or both.[133] The 60% TAM rate ceiling was not a direct result of the FRSSI Model and analysis; it was set in an attempt to consider small or weak populations of stocks that are not represented in the Model.[134]

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[130] Staley Report at 17.
[131] Staley Report at 18.
[132] Ringtail Document CAN002907 at 79.
[133] Ringtail Document CAN021738 at 5.
[134] Staley Report at 26.

Benchmarks

91. Benchmarks provide a reference point for the FRSSI Model simulation output and are used to measure performance, like the probability that the four year average escapement is less than a benchmark over 48 years. Benchmarks can also be used to monitor long-term performance.[135]

92. In 2006, the FRSSI process explored several approaches for setting biological benchmarks and by 2007 generated three escapement benchmarks (BM1, BM2 and BM3) based on the smallest, largest and twice the largest values of escapement from two different definitions (production benchmarks based on 20% and 40% spawner abundance that maximises recruits or the logarithm of recruits and a conservation benchmark based on the smallest observed four year average).[136] DFO has used BM2 for escapement planning since 2007.[137] Benchmarks used in the FRSSI process are called "interim benchmarks" to distinguish them from the CU benchmarks contemplated by the Wild Salmon Policy. The intention is that the FRSSI benchmarks will be reviewed for consistency once the Wild Salmon Policy benchmarks have been established.

93. The methodology for calculating upper and lower CU benchmarks is set out in: Holt, C.A., Cass, A., Holtby, B. and Riddell, R. Indicators of Status and Benchmarks for Conservation Units in Canada's Wild Salmon Policy (2009) Can. Sci. Adv. Sec. Res. Doc. 2009/058.[138] A CSAP review is scheduled for November 15-16, 2010 to review the development of CU benchmarks based on this methodology.

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[135] Ringtail Document CAN002907 at 14.
[136] Ringtail Document CAN003604 at 11-12; and see also e.g. IFMP Salmon Southern B.C., June 1, 2010 to May 31, 2011 (Draft #2) [2010 Draft IFMP], Appendix 12 at 9 and 25. Document not yet entered into Ringtail at the publication date of this Policy and Practice Report, but the commission has requested production by the Department of Justice through Ringtail.
[137] 2010 Draft IFMP, Appendix 12 at 9 and 25.
[138] Ringtail Document CAN019253.

Stock (Population) Dynamics

94. As noted above, the FRSSI Model first applies a stock-recruitment (S-R) model to estimate a set of S-R parameters in order to capture the population dynamics of Fraser River sockeye. Population dynamics are described as the relationship between spawners and recruits. Typically, S-R models calculate the expected number of four-year old and five-year old recruits (returning adults) produced by the spawners in each brood year (four or five years earlier) and combine these two age classes into a projection of run-size.[139] The models typically have two estimated parameters, productivity (recruits that are produced from spawners four years prior) and capacity (the capacity of the freshwater system to support fry and or juveniles), although some S-R models can incorporate smolt abundance or environmental factors like sea surface temperature.[140]

95. S-R models differ depending on the assumptions they make about:[141]

a. Productivity at low escapements (e.g. are there depensatory effects where production levels do not provide sufficient recruits to recover);
b. Productivity at high escapements (e.g. is there a pronounced decrease in productivity if escapement exceeds capacity); and
c. Cycle line interactions (see “Cyclic Dominance” and “Over-escapement” sections, below).

96. The productive capacity of Fraser River sockeye may be limited in the freshwater spawning or rearing habitat. Attempts have been made to quantify spawning capacity for individual stocks by estimating available spawning area, lake productivity (e.g. photosynthetic rates) and estimates of the capacity parameter

[139] Ringtail Document CAN002907 at 10.
[140] *Ibid*.
[141] *Ibid*.

from stock-recruitment models (see "Stock (Population) Dynamics" section, below).[142] For most stocks, however, these estimates are very uncertain.[143]

97. In the S-R portion of the FRSSI Model, independent capacity estimates (S_{max}) are used as a prior in order to constrain the model's estimates of parameters to a realistic range of possibilities. S_{max} is the estimate of capacity of the freshwater spawning or rearing habitat. For example, it could be a measure of carbon in a nursery lake or it could be the maximum observed spawning abundance for a stock. However, the capacity parameter is highly uncertain.[144] This means that the spawning escapement that maximises sustainable catch is poorly known.[145]

98. There are two S-R models, the Ricker and the Larkin models, that are frequently used to describe Fraser sockeye population dynamics. Initially, the Ricker S-R model was used in the first component of the FRSSI Model, but since 2006 the Larkin S-R model has been applied. The Larkin model incorporates interactions between Fraser sockeye cycle lines (see "Cyclic Dominance" section, below). The Larkin model tends to result in higher estimated harvest or exploitation rates than the Ricker model because the Larkin model has a lower spawning capacity compared to the Ricker model.

Fishery Simulation

99. The second component of the FRSSI Model takes the population dynamics parameters estimated by the first component of the FRSSI Model and tracks the performance of different escapement strategies, which are represented by TAM rules, over a range of stock sizes in a simulated fishery.[146] Simulations are

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[142] Ringtail Document CAN002907 at 14.
[143] *Ibid.*
[144] Ringtail Document CAN002907 at 11.
[145] *Ibid.*
[146] Ringtail Document CAN002907 at 61.

projected 48 years into the future which is a period equal to 12 sockeye generations.[147]

100. More simply, the FRSSI Model tries to capture the population dynamics of, and management objectives for, Fraser sockeye and uses this information to test different harvest rules until it finds one that best achieves management objectives or preferences (which are expressed using performance measures). The management objectives could be to avoid low spawning numbers or to avoid low catches or both. The following process is used:[148]

   a. Set a benchmark for each stock (e.g. spawner level to stay above a certain benchmark or catch to stay above a certain benchmark);
   b. Pick a risk tolerance (e.g. 10% chance of falling below the benchmark); and
   c. Run the simulations and examine the results with a view to maximising the objectives.

101. There are different scenarios depending on management objectives and risk tolerances. For example, if the objective is to avoid low spawners then the model can be instructed to maximise catch from the run-timing group while maintaining a 90% probability that escapement for each stock achieves at least the low escapement benchmark for each year.[149] If, on the other hand, the objective is to avoid low catch, then the model can be told to maximise catch from each run-timing group while maintaining a 70% probability that the run-timing group catch achieves at least the low catch benchmark every year. If the objective is to avoid low spawners and low catch, then the model can be told to maximise catch from the run-timing group and maintain a 70% probability that escapement for each stock achieves at least the low escapement benchmark every year and maintain a

[147] *Ibid.* at 33.
[148] Ringtail Document CAN006694 at 12.
[149] *Ibid.* at 13.

50% probability that aggregate catch achieves at least the low catch benchmark for every year.[150]

102. Each simulated scenario in the FRSSI Model is based on assumptions about the biology and behaviour of Fraser sockeye stocks, including:[151]

a. Characteristics of the S-R model (e.g. spawning capacity, annual variability, cyclic interaction);
b. Level of accuracy in implementing TAM rules; and
c. Amount of non-harvest mortality during up-river migration.

103. FRSSI also assumes that all stocks within a management group are exposed to the same exploitation rate and equally vulnerable to environmental mortality.[152]

How the FRSSI Model Is Used By Managers

104. Using the FRSSI Model, fishery managers determine the TAM rule curve, cut-back point and no fishing point that will be used in a season for a run-timing group (Figure 2).

[150] *Ibid*.
[151] Ringtail Document CAN002907 at 35; Staley Report at 21.
[152] Ringtail Document CAN002907 at 35.

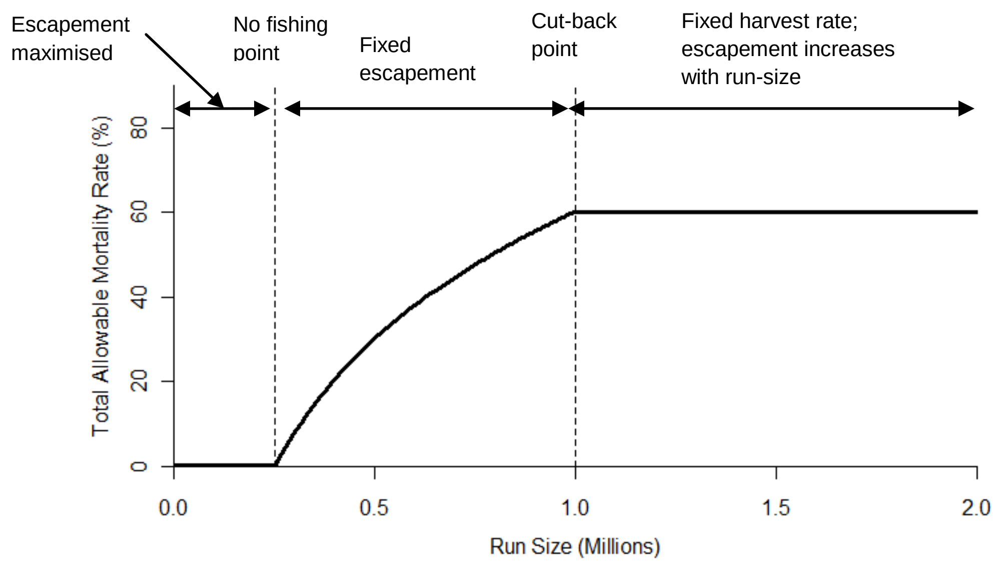

Figure 2: Sample TAM rule curve generated by the FRSSI Model.

105. For the example in Figure 2, the no fishing cut-off is 250,000 fish and the point at which TAM starts decreasing below 60% is 1 million fish.

106. Pre-season or in-season, the run-size is estimated and using the FRSSI Model curve from which, the TAM at any given run-size is determined. For example, if the return or the forecast is 1 million fish, then according to Figure 2, the TAM is 60% which means that the escapement target is 400,000 fish. If the Management Adjustment (see "Management Adjustments" section, below) is calculated to be 25% (of the escapement target), then the MA is 100,000 and the maximum potential catch is 500,000 fish (run-size – (escapement target + MA); 1 million – (400,000 + 100,000)). The exploitation rate after the MA is applied is 50% (maximum potential catch/run-size; 500,000/1 million).

107. In 2008, an exploitation rate floor (minimum) for the Late-run run-timing group was implemented in response to concerns that the TAM would never exceed zero on off-cycle years due to the cyclic nature of the Adams River sockeye.[153]

108. In 2009, the FRSSI Model was updated to run all 19 stocks concurrently rather than one run-timing aggregate at a time.[154]

What FRSSI Does Not Do

109. FRSSI does not:

a. Model where mortalities take place or the relative contribution of non-harvest mortality; work to develop a model that will include a geographic component is currently underway at SFU;[155]
b. Simulate individual fisheries and how catch could be shared amongst those fisheries;[156]
c. Simulate the effect of the TAM rules on the four run-timing groups at once;[157] and
d. Simulate environmental conditions at different stages.[158]

110. Because FRSSI does not simulate the effect of the TAM rules on the four run-timing groups at once, the catch projected in the Model is potential catch and not necessarily realisable catch. To account for this for fishery planning purposes, in 2007 the FRSSI process incorporated a calculation dividing projected potential catch into two parts: 1) realisable catch in fisheries constrained by the overlap in run-timing; and 2) potential catch for fisheries that can harvest each run-timing group separately.[159]

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[153] Ringtail Document CAN021738 at 6; and Ringtail Document CAN002907 at 46.
[154] 2010 Draft IFMP, Appendix 12 at 12.
[155] Ringtail Document CAN021738 at 8.
[156] Ringtail Document CAN002907 at 37.
[157] *Ibid.* at 38.
[158] *Ibid.* at 37.
[159] Ringtail Document CAN002907 at 38.

Scientific Review of the FRSSI Model in 2010

111. In May 2010, the FRSSI Model went through a CSAP review of its methodology. For details of the model changes considered by this review see: Pestal, G., Huang, A.-M. and Cass, A. Updated Methods for Assessment Harvest Rules for Fraser River Sockeye Salmon, Version 9, May 18, 2010, prepared for the CSAP Regional Advisory Meeting, May 27, 2010.[160]

112. The FRSSI Model as it existed prior to the 2010 CSAP review was used to develop the 2010 escapement strategy.

Escapement Target Decision-making

113. Since 2006, the FRSSI Model has been fully integrated into the annual management cycle for Fraser sockeye.[161] Every year, DFO selects a shortlist of three to five FRSSI Model harvest rule options for each run-timing group based on pre-season expectations. These options are presented for public review during the pre-season consultations (e.g. in the draft IFMPs).

114. Only one FRSSI option for each management group is included in the final IFMP and DFO decides which option this will be. Ultimately, it is the Minister of Fisheries and Oceans (the "Minister") who makes this decision, but the decision is made on the basis of recommendations prepared by the Salmon Team, vetted first by the Regional Director of FAM and then by the Regional Director General of the Pacific Region and finally in Ottawa by the Assistant Deputy Minister of FAM and the Director, Fisheries Resource Management Pacific/Central & Arctic at National Headquarters.

[160] Ringtail Document CAN1854388.
[161] Ringtail Document CAN002907 at 35.

115. At the yearly spring FRP meeting, DFO provides the FRSSI-generated Fraser sockeye escapement goals.[162]

Cyclic Dominance

116. Many Fraser sockeye stocks show strong cyclic fluctuations in total abundance. This cyclic pattern is present in a few large stocks in the Summer stock-group (e.g. the Quesnel stock) and some of the Shuswap stocks (e.g. Adams River) in the Late-run group. Eight of the 19 FRSSI stocks show persistent cycles with a predictable peak in abundance every four years (for example, 2010 was a dominant cycle year for the Adams River stock).[163] When this pattern is very pronounced it is called "cyclic dominance". The dominant cycle line is the sequence of years with run-sizes persistently larger than the other cycle lines. The sub-dominant line has moderate abundance and the off-cycle (or off-year) lines tend to have very low abundance. The dominant cycle lines for different stocks do not necessarily coincide.[164]

117. Although cyclic dominance has been studied for many years, there is still no scientific consensus on the cause of this cyclic behaviour in Fraser sockeye. Various mechanisms have been proposed including past harvest patterns, chance events, genetic factors like strongly inheritable age-at-maturity and age-dependent mortality or interactions with predators, diseases or parasites.[165] Negative interactions between cycle lines such as one year class reducing food availability or increasing predators for subsequent year classes have also been suggested as possible causes for cyclic dominance.[166]

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[162] See e.g. Ringtail Document CAN002564 at 15.
[163] Ringtail Document CAN002907 at 13.
[164] *Ibid*.
[165] Ringtail Document CAN005098; Ringtail Document CAN005099; Ringtail Document CAN002835; and Ringtail Document CAN009955.
[166] Ringtail Document CAN012108.

118. Chilko, a large stock within the Summer run-timing group, does not show classic cyclic dominance.[167]

Over-escapement

119. When the term "over-escapement" is applied to a spawning event for a given population, stock, CU or run, it implies that there is a surplus of spawning fish.[168] The most narrow definition of over-escapement is a spawning population size that is larger than the optimal escapement goal.[169] In other words, escapements beyond the optimum spawning population size meant that some harvest may have been foregone and that the returns per spawner may decrease.[170] Some scientists posit that very large escapements could result in decreased future abundance or production of a stock. This idea is based on the theory that there may be negative interactions between cycle-lines for some stocks (also called "delayed density dependence") and is linked to cyclic dominance in so far as delayed density dependence may be a driver for cyclic dominance. The mechanisms posited for delayed density dependence are increased competition for spawning sites, food or nutrients, disease outbreak and or increased predation.

120. A 2004 review by the Pacific Fisheries Resource Conservation Council of the issue of over-escapement found declines in production at higher escapements for some Fraser stocks, but found no evidence of stock collapse or near-collapse following runs with very large numbers of spawners.[171] The authors concluded that productive stocks should not suffer drastic reductions in recruitment because of management actions to protect weak stocks in mixed-stock fisheries that often result in increased escapement for the more productive stocks.[172]

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[167] *Ibid*.
[168] Ringtail Document CAN002587 at 10.
[169] *Ibid*.
[170] *Ibid*.
[171] Ringtail Document CAN002587.
[172] *Ibid*.

121. DFO's current management approach is based on the assumption that occasional large escapements likely reduce the efficiency of sockeye production in that year (i.e. a smaller number of recruits per spawner), but do not cause stock collapse.[173]

122. Potential positive benefits of large escapements to individual systems include increased genetic diversity, recolonisation and transport of marine nutrients into the watershed.[174]

Management Adjustments

123. Management Adjustments ("MAs"), previously called "environmental management adjustments" are designed to increase the likelihood of successfully achieving spawning escapement targets. An MA is a number of fish that is added to escapement targets to correct for expected differences between Mission and upstream abundances estimates. Pre-season, MAs are based on forecasted environmental conditions and historical observed differences between estimates.[175]

124. Management Adjustments are applied to escapement targets pre-season and in-season and are intended to compensate for: [176]

   a. Bias in the relationships between escapement estimates in the lower river (in-season estimates from Mission hydro-acoustic and test fishing programs) and the upper river (post-season estimates from spawning ground enumerations, plus First Nations and recreational catches); and
   b. En-route mortality due to severe conditions (high temperature or flow) in the Fraser River during migration or early river entry of Late-run stocks.

125. Management Adjustments do not identify the possible causes of the difference between abundance estimates at Mission and on the spawning grounds.

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[173] Ringtail Document CAN002907 at 14.
[174] *Ibid.*; and Ringtail Document CAN002587 at 7.
[175] Ringtail Document CAN006694 at 14.
[176] Ringtail Document CAN002564 at 14.

126. In order to predict the number of fish that make it to Mission that will in fact reach their spawning grounds, environmental monitoring of Fraser River temperature and discharge levels is used to evaluate and forecast the influence of fresh water conditions on salmon migratory success.[177] The FRP uses MA models to predict the escapement adjustments necessary at Mission to achieve the target spawning escapement. DFO provides the inputs for the MA models through DFO's Environmental Watch Program.[178]

DFO's Environmental Watch Program

127. The focus of the DFO's Environmental Watch Program, ("EWatch") is providing scientific advice on the impact of different environmental factors on the migration success of Pacific salmon in fresh water.[179] The research conducted is used to provide scientific advice to both fisheries and habitat managers based on a combination of environmental forecasts, ecological modeling and salmon migration research.

128. EWatch currently generates forecasts of Fraser River environmental conditions on three different time-scales:[180]

a. short-term (days);
b. medium-term (months); and
c. long-term (years).

129. Both short- and medium-term environmental models are used to forecast average lower-river temperature and flow conditions experienced by major Fraser River sockeye salmon management groups.[181] This information is then incorporated into the MA models.

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[177] Ringtail Document CAN002659 at 9.
[178] Commission Exhibit 14.
[179] Ringtail Document CAN053407 at 1.
[180] Commission Exhibit 14 at 259-260.
[181] *Ibid*.

130. In early June, EWatch generates long-range forecasts of lower Fraser River summer temperature and flow conditions using relationships between winter snowpack accumulation, summer air temperatures and river environmental conditions.[182] These forecasts are average 31-day temperature and flow conditions for the current year based on forecasted summer air temperature anomalies for the Province (which are provided by Environment Canada) and on the forecasted contribution of snowmelt to summer flows (provided by the BC River Forecast Centre).[183] Fraser River discharges are provided by Environment Canada (Water Survey of Canada) and calculated from water height data collected on a real-time basis from a site in the lower river.[184] Fraser River water temperatures are provided by real-time data-loggers placed at sites throughout the Fraser Basin operated by EWatch and Water Survey of Canada.[185] These forecasts are updated in bi-weekly online reports from July to September to provide information to fisheries managers on the status of fresh water migration conditions for incoming sockeye salmon runs.[186]

Development of Management Adjustments

131. The MA models currently used are a response to recommendations from public reviews in 1992 and 1994.[187] In 1995, gross escapement adjustments were implemented for Early Stuart, Early Summer and Summer-run sockeye.[188] Subsequently, DFO has used models based on historic differences between lower

[182] Ringtail Document CAN019200.
[183] Fraser River Environmental Watch, DFO online: <http://www.pac.dfo-mpo.gc.ca/science/habitat/frw-rfo/intro-eng.htm> [DFO EWatch].
[184] *Ibid*.
[185] *Ibid*.
[186] *Ibid*.
[187] Ringtail Document CAN002564 at 14. See also Pearse P. H., *Managing salmon in the Fraser River: report to the Minister of Fisheries and Oceans on the Fraser River salmon investigation with scientific and technical advice from Peter A. Larkin* (Vancouver: Fisheries and Oceans Canada, 1992); Commission Exhibit 77 [Pearse and Larkin 1992].
[188] Ringtail Document CAN002621 at 14.

river and upriver gross escapement estimates in order to develop pre-season MAs for Early Stuart, Early Summer, Summer and Late-run sockeye.[189]

132. Beginning in the late 1990s, in-season adjustments to compensate for expectations of en-route mortality were implemented by the FRP.[190] For example, the FRP responded to high river temperatures in 1998 by implementing an in-season management adjustment of 665,000 Summer-run sockeye and in 2000, the FRP adopted a Late-run management adjustment of 200,000 fish when in-season data indicated the run had entered the river early.[191] The size of these management adjustments were based on professional judgment, rather than on quantitative models, because at the time, there were not enough data from years with severe mortality events to develop such models.

133. In 2001 and 2002, the FRP adopted models for in-season use that combined the effects of the two sources of escapement estimation error (bias and en-route mortality).[192] These models, developed jointly by the PSC and DFO, predict the difference between lower river and upriver escapement estimates based on the values of environmental or timing variables that relate to large en-route losses.[193] Since 2002, EWatch has provided environmental forecasting and advice on the MA models to the PSC and the FRP. The PSC staff input biological data (run-timing, abundance, stock composition) into the model.

134. For detailed background on temperature and flow monitoring in the Fraser River and the development of the MA models see:

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[189] *Ibid.*
[190] Ringtail Document CAN002564 at 14; see also e.g. 2010 Draft IFMP at 79.
[191] Ringtail Document CAN002564 at 14.
[192] *Ibid*.
[193] *Ibid*.

a. Hague, M.J., Patterson, D.A., and Macdonald, J.S. 2008. Exploratory correlation analysis of multi-site summer temperature and flow data in the Fraser River basin. Can. Tech. Rep. Fish. Aquat. Sci. 2797: 60pp.;[194]

b. Foreman, M.G.G., James, C.B., Quick, M.C., Hollemans, P., and Wiebe, E. 1997. Flow and temperature models for the Fraser and Thompson Rivers. Atmosphere-Ocean 35:109;[195]

c. Hollemans, P., and Foreman, M.G.G. 1997. An improved model for Fraser River temperature predictions. Can. Tech. Rep. Fish. Aquat. Sci. 2172: 27pp.;[196]

d. Macdonald, J. S. 2000. Mortality during the migration of Fraser River sockeye salmon (*Oncorhynchus nerka*): a study of the effect of ocean and river environmental conditions in 1997. Can. Tech. Rep. Fish. and Aquat. Sci. 2315: 20pp.;[197]

e. Macdonald, J. S., Foreman, M. G. G., Farrell, T., Williams, I.V., Grout, J., Cass, A., Woodey, J.C., Enzenhofer, H., Clarke, W.C., Houtman, R., Donaldson, E.M. and Barnes, D. 2000. The influence of extreme water temperatures on migrating Fraser River sockeye salmon *(Oncorhynchus nerka*) during the 1998 spawning season. Can. Tech. Rep. Fish. Aquat. Sci. 2326:117pp.;[198]

f. Patterson, D.A., Skibo, K.M., Barnes, D.P., Hills, J.A. and Macdonald J.S. 2007. The influence of water temperature on time to surface for adult sockeye salmon carcasses and the limitations in estimating salmon carcasses in the Fraser River, British Columbia. N. Amer. J. Fish. Manage. 27(3): 878-884;[199] and

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[194] Ringtail Document CAN002885.
[195] Not available in Ringtail.
[196] Not available in Ringtail.
[197] Ringtail Document CAN018987.
[198] Ringtail Document CAN018990.
[199] Ringtail Document CAN002872.

g. Macdonald, J.S. and Williams, I.V. 1998. Effects of environmental conditions on salmon stocks: the 1997 run of the early Stuart sockeye salmon. In Speaking for salmon. Workshop Proceedings, Simon Fraser University at Harbour Centre, Vancouver, B.C., January 23, 1998 (P. Gallaugher and L. Wood, eds.), pp. 46-51.[200]

Current Management Adjustment Models

135. There are different kinds of MA models. For example, one model uses river temperature data, one uses river temperature and flow (discharge) and another has a quadratic form. There are performance criteria for evaluating which kind of model should be used for any one run-timing group. One example of a commonly considered performance criterion is the statistical R^2 value which is a metric of the ability of the model to explain the data.[201]

136. Management adjustment models other than the Late-run models use environmental inputs (Fraser River temperature and flow) and historical discrepancies between Mission and the spawning grounds. The effect of illegal harvest, incidental mortality and temperature and flow on direct and incidental mortality all are part of the discrepancy data set for Early Stuart, Early Summer and Summer-run sockeye. For Late-run sockeye (excluding the Birkenhead stock), the MA model is based on prior years' run-timing data.[202]

137. For further details about the MA models see: Macdonald, J.S., Patterson, D.A., Hague, M.J. and Guthrie, I.C. 2010. Modeling the influence of environmental

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[200] Not available in Ringtail.
[201] R^2 is also called the "coefficient of determination". It is the proportion of variability in a data set that is accounted for by a statistical model and it provides a measure of how well future outcomes are likely to be predicted by the model.
[202] Ringtail Document CAN002564 at 14.

factors on spawning migration mortality for sockeye salmon fisheries management in the Fraser River, British Columbia. Trans. Amer. Fish. Soc. 139(3): 768-782.[203]

Decision-making by the FRP

138. The FRP chooses a pre-season MA model and calculates an MA for each run-timing group.[204] In-season, the FRP continually reassesses the MA estimates and will revise estimates in order to best reflect in-season environmental conditions. The FRP will also sometimes change the MA model used in-season for a run-timing group. The FRP also chooses a post-season MA. For all of these decisions, the PSC staff provide analysis and recommendations.

Demonstration Fisheries

139. Demonstration fisheries are described by DFO as projects involving new ways to access salmon resources in a manner that improves economic performance in the fishery, increases economic access to fisheries resources by Aboriginal groups and improves cooperation between harvesters while ensuring conservation of salmon stocks.[205] Demonstration fisheries include demonstrations of new gear types, new allocation sharing arrangements within fleets, selective fishing methods, new stock assessment and sampling fisheries, as well as collaborative arrangements between some commercial and First Nation fishers.

140. DFO uses demonstration fisheries to explore ways to access TAC more efficiently, to increase the market value of a product, or to access TAC that may be unavailable due to conservation concerns or that a full fleet fishery is unable to access.[206]

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[203] Final version not available in Ringtail; drafts: Ringtail Document CAN002917 and Ringtail Document CAN060079.
[204] Ringtail Document CAN002564 at 16; 2010 Draft IFMP at 79.
[205] Evaluation of the Aboriginal Aquatic Resource and Oceans Management Program, online: Fisheries and Oceans Canada <http://www.dfo-mpo.gc.ca/ae-ve/evaluations/08-09/6b103-eng.htm>.
[206] See e.g. 2010 Draft IFMP, Appendix 10.

141. As part of its Pacific Fisheries Reform, DFO solicits proposals to develop demonstration fishery projects that support alternative management strategies that:[207]

a. Maintain or improve management control and conservation performance in the fishery;
b. Promote the use of clearly defined shares to improve manageability and industry viability; and
c. Increase the ability of harvesters to work cooperatively to harvest available surpluses and to take on greater responsibility for control and monitoring of their fishery.

142. Each year before the fishing season, interested First Nations and commercial stakeholders (through Area Harvest Committees) submit statements of intent for demonstration fishery projects. For proposals that meet the conditions outlined above, DFO works with First Nations and Area Harvest Committees to develop detailed proposals for implementing the projects and these proposals are included in each year's IFMP. Although the details of how the allocation is handled within each sector's demonstration fishery differ, the allocation counts as a percentage of Fraser sockeye Canadian Commercial TAC.[208]

Integrated Fisheries Management Plans

143. Management and harvest decision rules for the Fraser River sockeye fishery are governed by the South Coast salmon IFMP which is both a management process and a document.

144. Prior to 1999 and the IFMP process, DFO published yearly Fishery Management Plans which provided commercial stakeholders with the rules of a particular

[207] *Ibid*.
[208] *Ibid.*

fishery.[209] These plans were divided up into two types: net fishing plans (seine and gillnetters) and troll fishing plans. The pre-IFMP plans set out the pre-season forecasts, estimated TAC and anticipated fishing opportunities for each DFO fishing area.

IFMP as a Process

145. The IFMP was formally introduced in 1999 as a national co-management initiative when DFO published three documents intended to be comprehensive guidelines for a fisheries co-management approach.[210] These documents are:[211]

   a. Framework and Guidelines for Implementing the Co-Management Approach: Volume 1: Context Concept and Principles;
   b. Framework and Guidelines for Implementing the Co-Management Approach: Volume 2: Integrated Fisheries Management Plans; and
   c. Framework and Guidelines for Implementing the Co-Management Approach: Volume 3: Guidelines for Joint Project Agreements.

146. The focus of these documents is defining a standard framework for fisheries co-management involving two steps. Step one is the IFMP document.

147. The second step in the co-management framework is a legally binding Joint Project Agreement. These voluntary agreements spell out the roles and responsibilities of DFO and resource users with respect to specific co-

[209] See e.g. Ringtail Document CAN000586; Ringtail Document CAN000222; Ringtail Document CAN000711; Ringtail Document CAN001474; Ringtail Document CAN000615; Ringtail Document CAN001491; Ringtail Document CAN000612; and Ringtail Document CAN000563.
[210] Ringtail Document CAN002155 at 2; and Ringtail Document CAN000313 at 29.
[211] Explanatory Note of the Fisheries Policy prepared by DFO, sent to Cohen Commission as part of Feb 1, 2010 correspondence [DFO Explanatory Note] at 7-14. Document not yet entered into Ringtail at the publication date of this Policy and Practice Report, but the commission has requested production by the Department of Justice through Ringtail.

management projects. This two-step framework has been applied most often in the commercial sector to date.[212]

148. The IFMP determines how the salmon fishery will be managed and what will appear in license conditions.[213] DFO's purpose for the IFMP process is to achieve consistency in their management approach and to integrate the complex factors involved in the management of fisheries.[214] The primary goal is to provide a planning framework for the conservation and sustainable use of fisheries resources and the process by which a given fishery will be managed for a period of time.[215]

149. As a process, the IFMP is intended to integrate the expertise and activities of various DFO program activities (e.g. Science, Conservation and Protection, Aboriginal Policy and Governance, Oceans and Habitat, Policy and Economics and Aquaculture) in fisheries management planning under the leadership of FAM's Resource Management staff.[216]

150. According to DFO, the IFMP supports the following objectives for fisheries management to:[217]

    a. Manage fisheries and fish habitat to conserve and protect stock abundance, to restore depleted stocks, and to maintain biological diversity;
    b. Manage fisheries to contribute to an economically and environmentally sustainable, self-reliant industry and provide positive contributions to communities and the Canadian economy;
    c. Achieve shared responsibility and accountability for the management of fisheries;

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[212] *Ibid*.
[213] Ringtail Document CAN000047 at 4.
[214] DFO Explanatory Note.
[215] Ringtail Document CAN000047 at 3; and Ringtail Document CAN002913 at 4.
[216] Ringtail Document CAN002913 at 4.
[217] Ringtail Document CAN000047 at 5.

d. Achieve excellence in fisheries management's programs and people; and
e. Meet responsibilities to aboriginal groups in fisheries matters.

151. The four governing principles of the IFMP process are:[218]

a. Wide and inclusive consultation;
b. Open and transparent decision-making;
c. Enhanced input by stakeholders; and
d. Integration of all relevant interests of DFO and related agencies.

152. Additionally, there are three factors that the IFMPs are supposed to address:[219]

a. The requirement to incorporate the Resource Management Sustainable Fisheries Framework (see "Fisheries and Oceans Canada: Management Context" section, above), in particular the precautionary approach and ecosystem factors and impacts, in fisheries decision-making;
b. The demands of the public for more stability, fairness and transparency in fisheries management systems; and
c. The need to have a rules-based approach to decision-making that is more transparent, rigorous and systematic.

153. The Department's FAM Branch manages the IFMP process.[220] The process is cyclic. More specifically, the process is as follows:[221]

a. The IFMP development process is triggered by the annual post-season review of the fishery. This review helps determine the effectiveness of the previous year's management measures and identify areas for improvement (see the "Post-Season" section, below).
b. Immediately upon completion of the post-season review, the Chair of the salmon IFMP process (this responsibility rotates between different Resource

[218] Ringtail Document CAN002155 at 4.
[219] Ringtail Document CAN002913 at 5.
[220] Ringtail Document CAN002660 at 6.
[221] Ringtail Document CAN002913 at 6-7 and 16.

Management Area Chiefs of the South Coast, Lower Fraser and BC Interior) invites relevant DFO sectors to designate a representative to an IFMP Development Committee ("DC").

c. The DC discusses the results of the post-season review; assigns sectoral tasks required for the development of the IFMP, and puts forward a timeline for the collection and consolidation of information. The Chair tracks progress and consolidates the information into a draft document.

d. The director, Resource Management, invites DC member sectors' directors to meet and discuss the draft IFMP. Feedback is incorporated in a revised draft IFMP including internal agreement in principle on main elements, issues and objectives.

e. Consultations with external groups follow the revised version. Where DFO has determined that there is a legal duty to consult with Aboriginal groups, Resource Management staff are supposed to ensure that the existing process for consultations or any new process designed for this purpose, meets the requirements outlined in the *Interim Guidelines for Federal Officials to Fulfill the Legal Duty to Consult, February 2008*.[222]

f. The Chair presents the draft IFMP at the March IHPC meeting and participants are encouraged to discuss the content of the document, provide additional information and suggest needed changes. A structured agenda and appropriate facilitation techniques are used to guide the meeting, and a record of the discussions and decisions is kept. Feedback is incorporated in a revised draft IFMP in cooperation with participants.

g. The director, Resource Management, invites DC member sectors' directors to meet and discuss the post-consultation draft IFMP. The draft is presented by the Chair. Feedback is incorporated in a revised draft IFMP and this document will become the final draft IFMP.

[222] Ringtail Document CAN056909.

h. The final draft IFMP, and associated briefing note, are delivered to the Minister for approval. To allow time for review of the IFMP, and for the preparation of license conditions prior to the start of fishing activities, the IFMP is supposed to be submitted for approval as far in advance of the opening of the fishery as possible.

i. The final IFMP is released to the public on the DFO national and regional websites; DFO states that, if possible, it should be released a minimum of one month prior to the opening of the fishery.

154. While the Chair of the salmon IFMP process is responsible for making sure that the IFMP is completed every year, the Regional Resource Manager for salmon is tasked with coordinating the staff in all branches across the South Coast, Lower Fraser and BC Interior Areas who contribute to the salmon IFMP.

IFMP Decision-making

155. Ultimately, the Minister must approve the IFMP, but the decision to finalise the IFMP is informed by recommendations prepared by the Salmon Team. These recommendations are in the form of a briefing note to the Minister.[223] This briefing note is vetted first by the Regional Director of FAM and then by the Regional Director General of the Pacific Region. The recommendations are subsequently further vetted in Ottawa by the Assistant Deputy Minister of FAM and the Director, Fisheries Resource Management Pacific/Central & Arctic at National Headquarters.

156. The IFMP may be altered at any time by the Minister under the discretionary powers conferred by the *Fisheries Act*, R.S.C. 1985, c. F-14.[224]

IFMP as a Document

157. The IFMP document aims to serve two key functions:[225]

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[223] Ringtail Document CAN001147; and Ringtail Document CAN001150.
[224] Ringtail Document CAN000047 at 7; and Ringtail Document CAN002913 at 4.

a. Identify the main management and conservation objectives and decision rules for a fishery and the management measures that will be used to achieve these objectives; and

b. Communicate basic information on a fishery and its management within DFO and to outside parties.

158. The IFMP includes all information on the stocks and the fisheries that harvest them. Each IFMP includes an overview of the fishery, stock status and conservation concerns, key management issues, management objectives, stock and harvest expectations, harvest decision guidelines (TAC, harvest levels, allocations), research activities, costs of activities directly linked to the IFMP and financial information related to the management of the species and/or fishery, First Nations FSC fishing plans, commercial and recreational fishing plans, enforcement measures, division of responsibilities between industry, DFO and other parties and a post-season performance review of the prior year's season.[226]

159. The current format of salmon IFMPs was developed over two years from 2000-2002.[227]

IFMP Renewal

160. IFMP Renewal was initiated in 2007/2008 in order to make the IFMP process consistent with the Resource Management Sustainable Fisheries Framework.[228] The DFO states that as part of IFMP Renewal, IFMPs need: 1) to reflect the new DFO framework for sustainable fisheries; 2) better sectoral integration; 3) to

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[225] Ringtail Document CAN000047 at 8.
[226] See e.g. Ringtail Document CAN005186.
[227] Ringtail Document CAN075232 at 64.
[228] Ringtail Document CAN163355 at 32.

include the precautionary approach and ecosystem considerations; and 4) to be integrated with Fishery Sustainability Reports.[229]

161. In April 2008, DFO released a draft (first revision) of a policy document called "*A Framework for Socio-Economic Analysis to Inform Integrated Fisheries Management Planning and Fish Harvest Decisions*".[230] The framework presents guidelines and principles for conducting a socio-economic analysis to inform the IFMP process and annual harvest decisions.[231] The compilation of this framework was done in concert with Resource Management's development of a new template and guidelines for IFMPs.[232] According to this document, IFMPs are supposed to include an economic profile and an assessment of the current economic health/viability of the fishery. An economic analysis of management objectives and measures will be done when the Minister and or senior managers make a request of Resource Management staff to look at particular options.[233]

162. A new salmon IFMP template is intended to be available as of the fall 2010. The new template is supposed to incorporate the following:[234]

a. Foreword;
b. Overview of the fishery;
c. Stock assessment, science and traditional knowledge;
d. Economic, social and cultural importance of the fishery;
e. Management issues;
f. Objectives;
g. Access and allocation;
h. Management measures for the duration of the plan;

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[229] Fishery Sustainability Reports are also called Fishery Sustainability Checklists; they are checklists that are used as a national reporting form for all species and are intended to provide annual (and comparable) status reports for different species.
[230] Ringtail Document CAN002915.
[231] *Ibid.* at 3.
[232] *Ibid*. at 6.
[233] *Ibid*. at 6-7.
[234] Ringtail Document CAN002913.

i. Shared stewardship arrangements;

j. Compliance plan;

k. Performance review; and

l. Glossary and appendices.

163. The intention is to have a standardized format for all IFMPs for all species. The new IFMP templates are a national initiative and the intention is that eventually IFMPs will be multi-year plans.

Advisory Processes

164. The IFMP process is intended to include an opportunity for First Nations and stakeholders to provide their views on the management and conservation measures affecting a fishery.[235] For salmon, input comes to DFO through consultations with the Commercial Salmon Advisory Board, the Sport Fishing Advisory Board, individual First Nations, First Nations organisations and environmental organisations.[236] Consultation is also done inter-sectorally through the salmon IHPC which meets three to four times a year to provide advice to DFO on operational decisions (see "Salmon Integrated Harvest Planning Committee" section, below).

Salmon Integrated Harvest Planning Committee

165. Partly in response to the Institute for Dispute Resolution, *Independent Review of Improved Decision Making in the Pacific Salmon Fishery: Final Recommendations*, 2001,[237] DFO established the IHPC for salmon in 2004.[238] It was created to be the vehicle for consultation by DFO of all stakeholders regarding the Regional salmon management planning process.[239]

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[235] Ringtail Document CAN000047 at 3.
[236] Ringtail Document CAN002659 at 5.
[237] Ringtail Document CAN000447.
[238] Commission Exhibit 14 at 161-199.
[239] *Ibid.* at 177-178.

166. The IHPC is the primary vehicle for inter-sectoral communication and advice between DFO and those with interests in the salmon fishery. Its mandate is to make recommendations to DFO on operational decisions related to salmon harvesting.[240] The goal of the IHPC is to ensure that fishing plans are coordinated and integrated, to identify potential conflicts between sectors and to make recommendations for solutions if there is disagreement among sectors.[241]

167. The IHPC has two regional sub-committees, one for the South Coast and one for the North Coast. Each regional sub-committee is comprised of representatives from commercial and recreational fisheries,[242] First Nations, and environmental organisations grouped into a Marine Conservation Caucus[243] and there is *ex-officio* representation from the Province. The IHPC is chaired by an independent facilitator hired by DFO.[244]

168. The Committee's roles and responsibilities are as follows:[245]

a. Pre-season

i. Provide recommendations that ensure fishing plans are coordinated and integrated, identify potential conflicts, and recommend a means of resolving disputes;

ii. Receive from and provide advice to DFO on pre-season forecasts and stock assessments;

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[240] Ringtail Document CAN002470at 1; specific operational decisions are set out in the Terms of Reference under the "Roles and Responsibilities" section at 4.
[241] *Ibid*.
[242] For the commercial fishery, representatives from the Commercial Salmon Advisory Board sit on the IHPC; for the recreational fishery, representatives from the Sports Fishery Advisory Board sit on the Committee.
[243] The mandate and membership of the Marine Conservation Caucus are described at: http://www.mccpacific.org/.
[244] Ringtail Document CAN002470 at 2 and 5 and Appendix B.
[245] *Ibid*. at 4-5.

iii. Review enforcement plans, identify problems and provide recommendations on the management or enforcement of the fishery, and make recommendations for improvement;
iv. Provide input on stock assessment programs, as required for management purposes;
v. Provide advice on changes to escapement strategies or policies;
vi. Advise on IFMPs (i.e. decision guidelines, fishing plans);
vii. Advise on measures and mechanisms for timely and accurate catch/effort information; and
viii. Advise on selective fishing practices.

b. Post-season

i. Review post-season stock status to determine if conservation goals were met;
ii. Advise on problems encountered regarding management, enforcement and consultation;
iii. Advise on management, enforcement or other actions that will improve the fishery;
iv. Review anomalies not covered in the fishing plan;
v. Review expected stock status for the coming year; and
vi. Review the stock assessment program.

Stock Assessment

169. DFO Stock Assessment staff work under Stock Assessment Area Chiefs at each DFO Area office and within Science Branch (under the Head, Salmon Assessment, Salmon and Freshwater Ecosystems Division). Area Chiefs are responsible for the Area-based Stock Assessment Divisions and they report directly to the Area Director for their Area. There is only one Area Chief for the Fraser Stock Assessment Division (or Program), even though the Division spans

two Areas (Lower Fraser and BC Interior).[246] The Area Chief for Fraser Stock Assessment reports directly to the Area Director of the BC Interior and reports functionally to the Division Head of Salmon and Freshwater Ecosystems of Science Branch.

Pre-season Salmon Outlook Document

170. Annually, DFO produces and continually updates a document called the "Salmon Outlook". The Salmon Outlook is intended to provide an objective and consistent context within which to initiate fisheries planning in BC and the Yukon by stock-group.[247] It provides a preliminary indication of salmon production and associated fishing opportunities by geographic area and species. It is typically updated periodically from December to February as new information becomes available and is made public through DFO's advisory processes.[248] Stock status is provided on a categorical scale of 1 to 4, where scale 1 indicates a conservation concern and scale 4 indicates an abundance of the stock.[249] The categories reflect the current interpretation of available quantitative and qualitative information, including pre-season forecasts if available, and the opinion of DFO Stock Assessment staff.[250]

171. Where possible, quantitative forecasts and status assessments based on CSAP approved methods are included in the Salmon Outlook as they become available.[251] The Outlook is a prelude to CSAP forecasts and formal advice from Science branch.[252]

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[246] As of November 2010, Timber Whitehouse.
[247] Ringtail Document CAN004413 at 1; and Ringtail Document CAN003052 at 1.
[248] See e.g. Ringtail Document CAN007630.
[249] See e.g. Ringtail Document CAN170628.
[250] Ringtail Document CAN004413 at 1; and Ringtail Document CAN003052 at 1.
[251] Ringtail Document CAN004413 at 2.
[252] Ringtail Document CAN007630 at 2.

Test Fishing[253]

172. Test fishing is conducted as a component of harvest management. It is fishing with a specified gear type in order to catch a representative sample of fish in an area. The purpose is to provide in-season run-size abundance and run-timing estimates. Information gathered includes stock abundance, catch effort, run-timing, diversion rate, species and stock composition.

173. The authority of the PSC to conduct test fisheries and the delineation of responsibilities of the PSC and the Parties (Canada and the United States) to the *Pacific Salmon Treaty* with respect to these fisheries is found in:

  a. *Diplomatic Note of August 13, 1985 Pacific Salmon Treaty, Part A* [1985 Diplomatic Note], Para.1c): The Fraser River Panel established pursuant to the Treaty shall assume the following responsibilities consistent with the Treaty: section c) conduct test fishing on Fraser River sockeye and pink salmon;
  b. *Pacific Salmon Treaty*, Article II, Para. 13: the Commission shall authorize the disbursement of funds contributed by the Parties to paragraph 12, and may enter into contracts and acquire property necessary for the performance of its functions; and
  c. *Exchange of Diplomatic Notes (June 30, 1999) Pacific Salmon Treaty*, Para. 7: each Government shall take the necessary steps to implement the obligations under this Agreement consistent with its national laws.

174. FRP authorised test fishing is not included in the yearly calculation of TAC.[254]

175. The PSC drafts test fishing strategies for Fraser River sockeye and pink salmon in Panel[255] and non-Panel Area waters.[256] Functionally, the PSC administers these

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[253] See also Policy and Practice Report: Overview of the *Pacific Salmon Treaty* and the Pacific Salmon Commission Regarding Management of Fraser River Sockeye Salmon.
[254] See e.g. Ringtail Document CAN008585; Treaty, Annex IV, Ch. 4, Para. 3.

test fishing strategies in both Panel and non-Panel Areas, but DFO, working with the Canadian section of the FRP is responsible for test fishing in Canadian non-Panel Area waters. Test fishing is done via contract with commercial vessels and operators.[257] All test fishing in Canadian waters must be licensed by the Minister of Fisheries and Oceans under s. 52 of the *Fishery (General) Regulations*, SOR/93-53.[258]

176. DFO regards catch estimates for test fisheries as accurate for various reasons: 1) there is a known number of participating vessels; 2) participating fishers typically are proficient at species identification and record catch conscientiously; 3) there are often independent observers on board; 4) record keeping is thorough; and 5) data collection and analysis is conducted soon after fishing.[259]

177. Figure 3 shows test fishing locations for Fraser River sockeye (marked with an "X"). The four troll test fishing locations shown on the West Coast of Vancouver Island (Areas 123, 124, 126 and 127) are no longer in operation. Also, there is a test fishery in Juan de Fuca Strait in Area 5 that is not shown on the map.

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[255] The extent of the Panel Area waters is defined in Annex II of the Treaty and is shown in Figure 3. It is effectively Johnstone Strait, off the West Coast of Vancouver Island north of 49^0N and the northern part of Georgia Strait from approximately just south of Texada Island.

[256] Ringtail Document CAN005758 at 10; *Policy for Fraser River Panel Authorized Fraser Sockeye and Pink Salmon Test Fisheries*, online: The Pacific Salmon Commission <http://www.psc.org/info_testfishing.htm> [FRP Test Fishing Policy].

[257] FRP Test Fishing Policy at 2; Salmon Test Fishery – Pacific Region, online: DFO Extranet < http://www-ops2.pac.dfo-mpo.gc.ca/xnet/content/salmon/testfish/default.htm>; and see e.g. Ringtail Document CAN003249.

[258] FRP Test Fishing Policy at 2.

[259] Ringtail Document CAN010365 at 5.

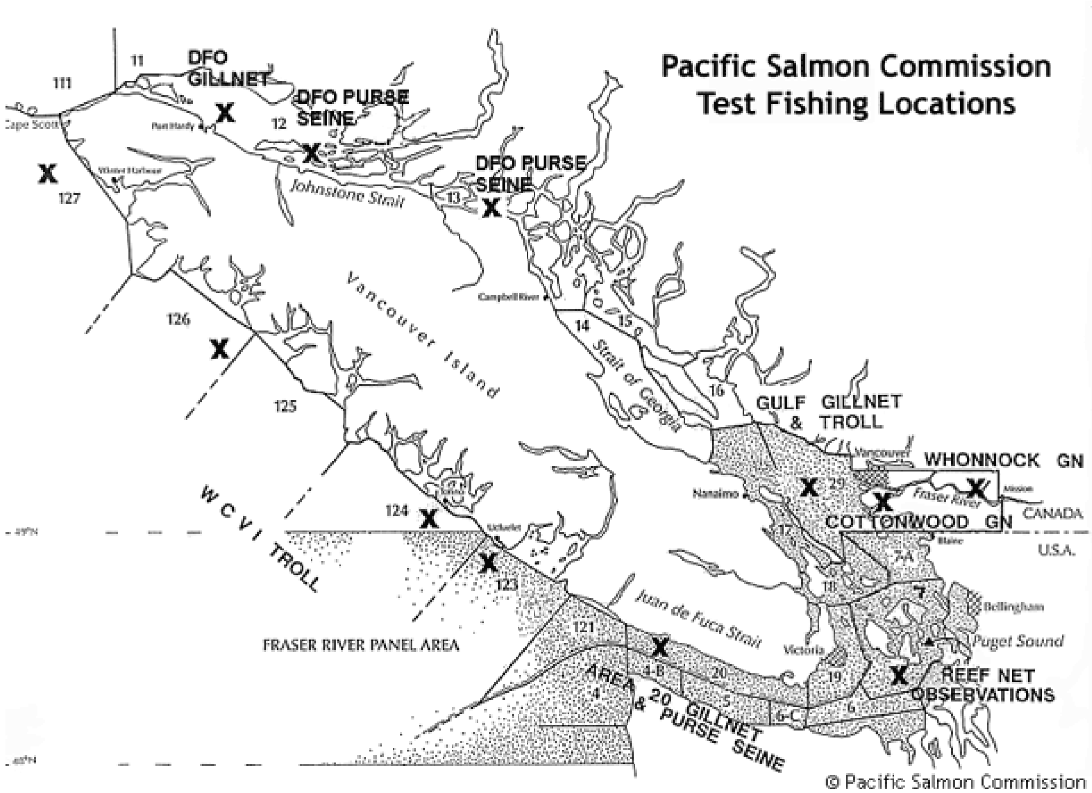

Figure 3: Fraser River Panel Area and the PSC test fishing locations.[260]

The Larocque v. Canada (Minister of Fisheries and Oceans) *decision*

178. Test fisheries are conducted by commercial contractors under licenses issued under s. 52 of the *Fishery (General) Regulations*. Fish caught during test fishing in Canadian waters that are not required for scientific purposes are returned alive to the water if there is a reasonable expectation of their survival. Fish that are killed as a result of the test fishery or that do not have a reasonable expectation of survival and which are not required for scientific purposes may be retained and sold by the s. 52 license holder.[261]

179. Until and including the 2006 fishing season, in addition to allowing the sale of fish that were killed during test fishing and that were not needed for scientific purposes,

[260] Fisheries Maps, online: Pacific Salmon Commission <http://www.psc.org/image_test_fishing_locations.htm>.
[261] FRP Test Fishing Policy at 2.

DFO also used to authorise s. 52 license-holders to catch and sell a certain amount of other fish in order to pay for test fishing. The catch and sale of these fish was counted as part of Canada's commercial TAC.

180. Due to a decision of the Federal Court of Appeal, however, DFO ceased this practice after 2006. In *Larocque v. Canada (Minister of Fisheries and Oceans*), [2006] F.C.J. No. 985 (C.A.) [*Larocque*], a commercial snow crab fisher in the Gulf of St. Lawrence challenged the Minister's decision to use fish sales to finance research activities. Mr. Larocque objected to the Minister's decision to allocate a portion of the fleet's TAC to cover the costs of delivering a scientific data collection survey. The Minister had given the ship contracted to conduct the research permission to sell up to 50 metric tonnes of snow crab. This permission was given as one of the conditions of the s. 52 license.

181. The Federal Court of Appeal overturned the Federal Court and held that the Minister could not finance DFO's scientific research activities by selling public fishery resources. DFO interprets the decision to mean that it cannot finance any test fishing programs through the sale of fish.[262]

Assessment Fisheries

182. Assessment fisheries are commercial fisheries that are used in a structured way to help assess run-size in-season. In an assessment fishery, the commercial fishery is opened at an assessment level and intensively managed to the weekly guidelines developed for the test fishery.[263] Commercial fisheries whose catches have been used for assessment purposes include Areas 12, 13 and 20 seine fisheries.[264]

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[262] See e.g. Ringtail Document CAN006952 at 1; Ringtail Document CAN004860 at 1; and Ringtail Document CAN007950 at 3.
[263] See e.g. Ringtail Document CAN002540 at 13.
[264] Ringtail Document CAN007425 at 35.

183. Catch from assessment fisheries is counted as part of each commercial sector's TAC.[265]

Hydro-acoustics

184. There are two in-river hydro-acoustic programs currently used to assess the abundance of migrating Fraser River sockeye in-season: one at Mission and one at Qualark.

Mission Hydro-acoustics

185. The PSC operates a hydro-acoustics program at Mission that uses vessel- and shore-based acoustic transducers and a DIDSON[266] (sonar) system to detect fish swimming upstream. The program provides an estimated daily upstream migration of sockeye at this point in their migration.[267] The single beam system involves a boat crossing the river 160-180 times a day and began operation in 1977.[268] In 1995, a split beam system was installed in order to examine fish behaviour.[269] Since 2004, a split-beam has been used as the in-season hydro-acoustic management tool in conjunction with a DIDSON system.[270]

186. The single-beam system cannot tell which direction fish are traveling and if fish are on the surface of the River they cannot be detected.[271] Also, at certain times of the season, the single-beam transducer cannot distinguish debris from fish.

187. The split-beam system can measure the speed and direction of fish moving upstream and or downstream.[272] It can also detect fish near the surface.

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[265] See e.g. Ringtail Document CAN007915.
[266] DIDSON stands for Dual-frequency Identification SONAR.
[267] PSC Hydroacoustics Program, online: Pacific Salmon Commission <http://www.psc.org/info_runsizeworkshop.htm> [PSC Hydroacoustics].
[268] Ringtail Document CAN064768 at 20.
[269] *Ibid.*
[270] *Ibid.*; and Ringtail Document CAN002496 at 17.
[271] PSC Hydroacoustics.
[272] PSC Hydroacoustics.

188. The DIDSON is a high-frequency, multi-beam sonar with a unique acoustic lens system designed to focus the beam to create high-resolution images.

189. The data generated by the Mission hydro-acoustic program are daily estimates of sockeye movement past the survey site over a 24-hour period. Most, although not all, potential sources of bias in the salmon estimation model using the Mission split-beam and DIDSON system are negative bias.[273] In other words, if there is error, the error under-estimates the number of fish passing through the area.

190. For further information see:

   a. Xie, Y., Cronkite, G. and Mulligan, T.J. 1997. A Split-Beam Echosounder Perspective on Migratory Salmon in the Fraser River: A Progress Report on the Split-Beam Experiment at Mission, B.C. in 1995. PSC Tech. Rep. No. 8;[274]
   b. Xie, Y., Mulligan, T.J., Cronkite, J.M.W. and Gray, A.P. 2002. Assessment of Potential Bias in Hydroacoustic Estimation of Fraser River Sockeye and Pink Salmon at Mission, B.C. PSC Tech. Rep. No. 11;[275]
   c. Workshop on Hydroacoustics for Salmon Management: March 22-23, 2006;[276] and
   d. Xie, Y., Gray, A.P., Martens, F.J., Boffey, J.L. and Cave, J.D. 2005. Use of Dual-Frequency Identification Sonar to Verify Split-Beam Estimates of Salmon Flux and to Examine Fish Behaviour in the Fraser River. PSC Tech. Rep. No. 16.[277]

Qualark Hydro-acoustics

191. From 1993 to 1998 a secondary hydro-acoustic program operated in the mainstream Fraser at Qualark, approximately 95 km upstream from Mission close

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[273] Ringtail Document CAN064768 at 21.
[274] Document not in Ringtail, but available online at: <http://www.psc.org/publications_tech_psctechreport.htm>.
[275] Ringtail Document CAN009964.
[276] Ringtail Document CAN064768.
[277] Ringtail Document CAN007519.

to the confluence of Qualark Creek and the Fraser River near the town of Yale. This program was implemented in response to the Pearse and Larkin 1992 report. However, operation of the Qualark counter was suspended following the 1998 fishing season due to DFO budget constraints as well as operational difficulties associated with low and changing water levels.[278]

192. In 2007, a DIDSON system was installed by DFO at Qualark and through 2010 this system has provided estimates of in-river returns. For further information on the Qualark program see: Enzenhofer, H.J., Cronkite, G.M.W. and Holmes, J.A. 2010. Application of DIDSON Imaging Sonar at Qualark Creek on the Fraser River for Enumeration of Adult Pacific Salmon: An Operational Manual. Can. Tech. Rep. Fish. Aquat. Sci. 2869: 37pp.[279]

Test Fishing and Hydro-acoustics

193. When there are mixed species at hydro-acoustics sampling sites, hydro-acoustic estimates have to be apportioned to the different species by collecting samples of fish. Therefore, there are test fishing programs for both the Mission and Qualark hydro-acoustic sites. For Mission, there is a gillnet fishery downriver (at Whonnock) that provides information on species composition, test fishing at the Mission site itself and visual counts upstream at Hells Gate.[280] For Qualark, there is a test fishing program at the site which is supervised by DFO.[281]

DFO Catch-monitoring[282]

194. Catch and fishing effort data are collected by DFO in Panel and non-Panel Area waters and are used to inform management decisions.[283] These catch monitoring

[278] Ringtail Document CAN002496 at 16.
[279] Ringtail Document CAN002900.
[280] Ringtail Document CAN064768 at 20.
[281] Ringtail Document CAN002900 at 32-33.
[282] It is anticipated that catch-monitoring will be discussed in greater detail in a subsequent Policy and Practice Report prepared by, or for, the Commission. This section offers an introduction to the topic only.
[283] Ringtail Document CAN002659 at 9.

data are used in-season to assist with run-size abundance estimation and estimates of in-season gross escapement are collected by DFO's Conservation and Protection directorate.

195. There are a variety of catch monitoring programs for First Nations fisheries. Most major First Nations salmon fisheries including those in the Fraser River are monitored and sampled and regular reports are produced.[284] Some First Nations economic fisheries have mandatory landing programs. Other First Nation fisheries are monitored through catch and effort sampling programs and census data. The Department conducts some programs but most fisheries are monitored by First Nations' technical staff.

196. In the recreational sector, most major salmon tidal and non-tidal sport fisheries are monitored though creel surveys (interviews of sport fishermen at landing sites), vessel counts (via aircraft over-flights), or logbook programs (some of the fishing lodges and charter operators in the Pacific Region).[285] Creel surveys generally operate during peak fishing times only.

197. In the commercial sector, harvesters are now required to fill out logbooks of all catches and participate in various hail-in programs.[286] In some cases, independent observers on fishing vessels are mandatory to verify catch data to managers. Mandatory landing slips (official records of salmon landed), also provide catch information.

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[284] Stock Assessment Extranet.
[285] *Ibid*.
[286] *Ibid*.

<u>Stock Identification</u>

DFO Population Structure and Stock Identification Program

198. The DFO Molecular Genetics Laboratory ("MGL") provides genetics advice relating to the conservation and management of fish and shellfish species in Canada.[287] Identification of Fraser River sockeye stocks is now provided through DNA analysis using surveys of microsatellites and single nucleotide polymorphisms (SNPs). Genetic techniques for stock identification were first applied in-season to Fraser River sockeye in 2001. Prior to this, analysis of scale characteristics was the method used to identify Fraser sockeye. Scale pattern analysis limits stock identification to sockeye reared in different nursery lakes and so different stocks or populations that may rear in the same lake cannot be differentiated. Scale analysis still provides an assessment of sockeye age structure, however.

199. The use of microsatellite markers (also called microsatellite loci) in stock identification involves analysing size-specific fragments of DNA. Microsatellite markers are distinguished by different lengths of repeating sequences of DNA base pairs. To identify stocks, MGL amplifies (generates many copies of) 14 different microsatellite markers and separates them into different size fragments using an automated DNA sequencer. The sequencer determines the frequency of each size fragment for each sample and stock composition for individual samples and for stocks or stock-groups is estimated using this information in a statistics program that compares a baseline of the expected frequencies of microsatellite DNA size fragments to the frequencies found in the samples.

200. In addition to the 14 microsatellite loci, from 2001 to 2009 genetic stock identification also involved surveying genetic variation at a major histocompatibility

[287] Molecular Genetics Laboratory (MGL), online: Fisheries and Oceans Canada <http://www.pac.dfo-mpo.gc.ca/science/facilities-installations/pbs-sbp/mgl-lgm/index-eng.htm>.

(“MHC”) locus.[288] In 2009, the MGL began to use five SNPs markers instead of the MHC marker.

201. For more information on past and present methods of genetic stock identification, see:

a. Withler, R.E., Le, K.D., Nelson, R.J., Miller, K.M. and Beacham, T.D. 2000. Intact genetic structure and high levels of genetic diversity in bottlenecked sockeye salmon, *Oncorhynchus nerka*, populations of the Fraser River, British Columbia, Canada. Can. J. Fish. Aquat. Sci. 57: 1985-1998;[289]

b. Miller, K.M., Kaukinen, K.H., Beacham, T.D. and Withler, R.E. 2001. Geographic heterogeneity in natural selection of an MHC locus in sockeye salmon. Genetica: 111: 237-257;[290]

c. Beacham, T.D., Lapointe, M., Candy, J.R., McIntosh, B., MacConnachie, C., Tabata, A., Kaukinen, K., Deng, L., Miller, K.M. and Withler, R.E. 2004. Stock Identification of Fraser River Sockeye Salmon Using Microsatellites and Major Histocompatibility Complex Variation. Trans. Amer. Fish. Soc. 133: 1117-1137;[291]

d. Beacham, T.D., Lapointe, M., Candy, J.R., Miller, K.M. and Withler, R. 2004. DNA in action: Rapid application of DNA variation to sockeye salmon fisheries management. Con. Gen. 5: 411-416;[292]

e. Beacham, T.D., Candy, J.R., McIntosh, B., MacConnachie, C., Tabata, A., Kaukinen, K., Deng, L., Miller, K.M. and Withler, R. 2005. Estimation of Stock Composition and Individual Identification of Sockeye Salmon on a Pacific Rim

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[288] A major histocompatibility complex (“MHC”) is a large genomic region or gene family that is found in most vertebrates that encodes MHC molecules which have a role in the vertebrate immune system.
[289] Ringtail Document CAN070321.
[290] Document not available in Ringtail.
[291] Ringtail Document CAN002851.
[292] Ringtail Document CAN002852.

Basis Using Microsatellite and Major Histocompatibility Complex Variation. Trans. Am. Fish. Soc. 134: 1124-1146;[293] and

f. Beacham, T.D., Candy, J.R., McIntosh, B., MacConnachie, C., Tabata, A., Miller, K.M. and Withler, R. 2005. DNA-Level Variation of Sockeye Salmon in Southeast Alaska and the Nass and Skeena Rivers, British Columbia, with Applications to Stock Identification. N. Amer. J. Of Fish. Mgmt. 25: 763-776.[294]

PSC Stock Identification Program

202. The PSC uses the stock proportions of Fraser River sockeye in commercial, test, assessment and First Nations' catches to provide information on the abundance and timing of sockeye stocks as they migrate to their natal rivers.[295] Racial data are also used to account for Fraser River sockeye salmon wherever they may be caught and to apportion the daily estimates of sockeye escapement past Mission into discrete stock-groups and age classes.[296] This information is required for the development of fishing plans that aid in meeting escapement and catch allocation objectives for Fraser River sockeye.[297]

Escapement Enumeration

203. The enumeration of sockeye spawning escapements in the Fraser River watershed is conducted annually by DFO through spawning ground surveys.[298] Data collected in this program are used to generate estimates of total sockeye production on a stock and run-timing group basis and are used by DFO in the development of subsequent years' forecasts and escapement goals and to track long-term trends in survival and productivity.

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[293] Ringtail Document CAN007471.
[294] Ringtail Document CAN070291.
[295] See e.g. Ringtail Document CAN002564 at 34.
[296] *Ibid*.
[297] *Ibid.* at 30.
[298] *Ibid.* at 39.

204. Fraser sockeye escapement enumeration is the responsibility of DFO's Area Chief of Fraser River Stock Assessment.[299] Work is done with a range of partners, including First Nations and local community organizations.

205. Enumeration methods fall into two categories:

a. High precision methods used for populations of 75,000 or more:

i. Mark-recapture: This method is well-developed in terms of statistical design, implementation and the investigation of bias and is considered very accurate. Calibration is done annually. Until 2004, mark-recapture methods were used to enumerate spawning populations equal or greater than 25,000 sockeye.

ii. Counting (enumeration) fences: All spawning channels have counting fences and fences are also found in the Stellako, Birkenhead and Eagle River systems. The use of fences is limited by geography and biological conditions like the presence of Chinook co-migrating with Fraser sockeye. Cultus Lake has had a counting fence since 1938.

iii. Acoustics: DIDSON is a small portable sonar system. Like with counting fences, the use of DIDSON technology is also limited by geography and biological conditions. From 2005 to 2008, DIDSON was conducted simultaneously with mark-recapture programs in the Chilko and Horsefly systems in order to evaluate this method.[300] DIDSON surveys were done in the Chilko, Mitchell and Quesnel systems in 2009.[301]

b. Low precision method used for populations of less than 75,000

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[299] As of November 2010, Timber Whitehouse.
[300] Ringtail Document CAN069778.
[301] Ringtail Document CAN134396; and Ringtail Document CAN026673.

i. Visual surveys: all populations with less than 75,000 sockeye escapement are surveyed visually.[302] Visual surveys are done on foot, by boat or by air (helicopter or plane) and are calibrated annually. Visual surveys tend to underestimate populations.

206. The number estimated by visual survey is multiplied by an expansion factor of 1.8 to account for negative bias in visual estimation. The IPSFC did extensive calibration research on the visual counting technique for populations of less than 25,000. With respect to populations in the 25,000 to 75,000 range that are now estimated using visual surveys rather than mark-recapture, work is ongoing to calibrate the use of visual surveys and calculate the appropriate expansion factor for these populations.[303]

207. Fraser sockeye spawning escapement estimates are formulated and released in three steps:[304]

a. Preliminary estimates: Based on data that have been entered into the computer database at the completion of the field project. Data accuracy has not been verified and bias tests have not been performed (mark-recapture projects). Significant changes in preliminary estimates are possible. Preliminary estimates are usually available in the fall.

b. Near final estimates: Based on data that have been verified for accuracy and tested for bias. Minor changes in near final estimates are typical. Near final estimates are usually available for all run-timing groups around February of the following year.

c. Final estimates are released after all data have been incorporated into the analyses and all verification steps have been completed. Final estimates are

[302] Until (and including) 2003, only populations of less than 25,000 sockeye were surveyed visually. All other populations were enumerated using either mark-recapture or counting fences.
[303] See e.g. Ringtail Document CAN070636.
[304] Ringtail Document CAN075232 at 52.

usually not available for all run-timing groups until late in the following year (e.g. for 2009, these data would be available in late 2010).

208. For a description of the mark-recapture method see: Schubert, N.D. 2000. The 1994 Stellako River sockeye salmon (*Oncorhynchus nerka*) escapement: evaluation of pooled Peterson and stratified mark-recapture estimates of a known population. Can. Tech. Rep. Fish. Aquat. Sci. 2303: 56pp.

209. For a brief description of different enumeration methods see: Ringtail Document CAN002584 at 9-10.

Pre-season Planning

DFO

210. Prior to each fishing season, decisions are made within DFO regarding spawning escapements targets, exploitation rates, management priorities and conservation constraints. Harvest decision guidelines are set out in each year's IFMP for South Coast salmon.

211. Pre-season run-size forecasts for Fraser River sockeye are provided annually to stakeholders, the public and the FRP. DFO estimates run-size for only 19 stocks of Fraser sockeye because these are the stocks for which stock-specific catch data are available.[305]

212. Key to pre-season planning are:

a. Pre-season forecasts for each run-timing aggregate;
b. The total allowable mortality rate; and
c. Management adjustments.

[305] Ringtail Document CAN007891 at 23.

213. These inputs are used by DFO to calculate the pre-season total escapement targets, adjusted escapement targets and TAC for each management group for Fraser River sockeye.

214. DFO pre-season planning is complete when DFO releases the final IFMP around the end of June.

The FRP

215. Prior to the fishing season, the FRP recommends a commercial fishery regime and a management plan for Panel Area fisheries, which must be approved by the PSC Commissioners.[306] Sometime between May and July, the PSC commissioners approve the pre-season management plan in Panel Area waters.

216. The pre-season management plan identifies the approximate pattern of fishery openings required to achieve the FRP objectives given pre-season expectations. It represents a template that can be used if the forecasted numbers of fish return to spawn. To generate the pre-season management (harvest) plan, the FRP uses a pre-season fishery planning simulation model.[307] This plan is based on abundance and timing forecasts (usually at the 50% probability level), escapement targets provided by DFO, international catch allocation goals set by the Treaty, domestic catch allocation goals for each country, management concerns for non-Fraser sockeye stocks and other species identified by each country and historic patterns in migration and fisheries dynamics.[308] Each year, the FRP must decide which specific model inputs and assumptions to use. The pre-season fishery plan and run-size assessments are revised by the FRP in-season on a weekly basis as information about catch, abundance and stock composition of the migrating stocks

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[306] See e.g. Fraser River Panel Annual Reports available online at: http://www.psc.org/publications_annual_fraserreport.htm. See also Policy and Practice Report: Overview of the *Pacific Salmon Treaty* and the Pacific Salmon Commission Regarding Management of Fraser River Sockeye Salmon.
[307] Ringtail Document CAN007891 at 10.
[308] Treaty, Annex IV, Ch. 4; and Ringtail Document CAN002564 at 10.

become available from test, assessment and commercial fisheries and in-river hydro-acoustic counting stations.[309]

217. The pre-season fishery planning model is restricted to data from ocean areas and involves modelling the abundance and movement of eight stock groupings.[310] There is a high degree of uncertainty associated with the use of the model as it uses predictive information about diversion rate, run-size abundance (at different probability levels), return timing and en-route mortality that is itself, uncertain.[311]

218. For further details on the model see: Cave, J.D. and Gazey, W.J. 1994. A preseason simulation model for fisheries on Fraser River sockeye salmon (*Oncorhynchus nerka*). (1994) Can. J. Fish. Aquat. Sci. 51: 1535-1549.

Pre-season Forecasting: Run-size, Run-timing and Diversion Rates

Run-size

219. The pre-season forecast is the number of sockeye predicted to return each year based on data from 19 stocks.[312] Probability distributions are used to show uncertainty in the forecasts.[313] The forecast run-size used to be reported as the probability that the actual run-size would exceed the projection at different probability levels. Under this system, the 10% probability level was the highest forecasted run-size and then for the 25%, 50% 75% and 90% probability levels the forecast size decreased, with the 90% probability level indicating the lowest expected run-size.[314]

220. However, since the 2010 forecast, presentation of the different probabilities that convey forecast uncertainty has changed.[315] Forecast probabilities are now

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[309] Ringtail Document CAN007891 at 2; and Ringtail Document CAN002564 at 10.
[310] Ringtail Document CAN007891 at 10.
[311] See e.g. Ringtail Document CAN007259 at 8-9.
[312] Ringtail Document CAN021602 at 4.
[313] *Ibid.* at 6.
[314] See e.g. Ringtail Document CAN019183 at 10.
[315] 2010 Draft IFMP at 70.

described as the probability of returning at or below the specified forecast. In this arrangement, the lowest probability levels (e.g. 10% and 25%) are now associated with the lowest forecast. In other words, the "old" 75% forecast is equivalent to the "new" 25% forecast. DFO considers this new format to be appropriate from a conservation perspective.[316]

221. Pre-season forecasts are based on biological and or statistically-based models. Many different kinds of models exist to forecast Fraser River sockeye returns.[317] According to DFO, the most appropriate models vary between different stocks depending on the life history and production patterns of the stocks and the data available.[318] There is no one model that works best for all of the 19 stocks modelled in the forecast. The variables typically used in forecasts are historic trends in escapements and total returns, returns of sibling age classes and returns and escapement of the brood (parental) year.[319] There are models that also include some environmental variables, including Fraser River discharge, seas surface temperature and the Pacific Decadal Oscillation index.

222. Model selection involves a ranking of the models based on the following:

a. Choosing candidate models depending on data availability;
b. Performing a retrospective analysis for each stock by sequentially forecasting abundance for years where there are observations of abundance;
c. Evaluating the model performance by comparing the retrospective forecasts with observations using standard statistical performance criteria (mean raw error, mean absolute error and root mean square error); and
d. Identifying the "best" forecast model from step #3 (e.g. if a model is applied to a stock and all three performance criteria are close to zero, this suggests that the model is the best choice).

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[316] *Ibid*.
[317] See e.g. Ringtail Document CAN002926; Ringtail Document CAN185610.
[318] Stock Assessment Extranet; Ringtail Document CAN021602 at 4.
[319] Stock Assessment Extranet.

223. Implicit in the use of abundance information and historic stock-recruitment relationships to estimate future abundances is the assumption that future production will be similar to levels experienced in the past.[320]

224. The CSAP Salmon Sub-committee meets annually to review the forecasts. Conclusions and recommendations accepted by CSAP are then presented in annual Canadian Science Advisory Secretariat ("CSAS") Science Advisory Reports ("SARs") that are summaries of each season's run forecast.[321] This document is then presented to RMEC and becomes DFO's official record of scientific advice. CSAS also produces Research Documents that set out the scientific basis for the forecast.

225. In 2010, formal changes to the forecasting methodology were reviewed through the CSAP process and published in a CSAS Research Document along with the annual forecast published in SAR format.[322] Significant changes to the methodology include: 1) retrospective analyses to determine what models have performed best over the last eight years for each of the 19 stocks; 2) presentation of the forecast as three different productivity-based results in three different tables; 3) use of models like the Kalman Filter; and 4) use of different productivity estimates for age-four and age-five returning adults.

226. DFO generally provides the FRP with run-size forecasts at the FRP meeting in February and with final pre-season run-size forecasts in April.[323]

Run-timing and Diversion Rates

227. DFO also provides the FRP with forecasts of run-timing group peak arrival timing and diversion rate.[324] These forecasts are provided as two run-timing forecasts

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[320] Ringtail Document CAN021602 at 8.
[321] SARs have replaced the Stock Status Reports (Ringtail Document CAN003691 at 3).
[322] Ringtail Document CAN185610.
[323] See e.g. Ringtail Document CAN002564 at 9; Ringtail Document CAN002565 at 15; Ringtail Document CAN002567 at 11; and Ringtail Document CAN002566 at 16.

and two diversion rate forecasts in four separate memoranda to the Canadian Co-Chair of the FRP.

Run-timing

228. The run-timing forecast is a prediction of the median (i.e. 50%) Fraser sockeye return timing date, which is the most probable calendar date when half of the run of a particular stock is expected to have passed a specific location on its return migration. Two run-timing forecasts are produced prior to each fishing season. Each forecast is used in pre-season fishery planning by the FRP and the FRPTC. The first forecast, for the Chilko stock is based on data collected in March and is typically released in mid-April. The second forecast, for the Early Stuart stock, is based on data collected in May and is typically released in mid-June.

229. For the past decade DFO has produced run-timing forecasts for Chilko and Early Stuart stocks using a statistical method known as linear regression, which mathematically relates an independent variable (i.e. “cause”) to a dependent variable (i.e. “effect”). In the current approach two independent variables (ocean currents and sea surface temperature) are relied on to predict the dependent variable, median return timing date. The statistical “fit” between cause and effect variables depends on historical data (typically from 1982 to present) and is updated each year. PSC staff provide post-season estimates of median timing dates for both Chilko and Early Stuart stocks to DFO.

230. The ocean current index is estimated using the OSCURS computer model, a simulation model that predicts the likely direction and magnitude of oceanographic currents for a given date and location in the North Pacific. Predictions of average eastward sea current velocity during March at latitude 57.5ºN, longitude 145ºW are applied to the Chilko timing model, while predictions during May at latitude 45ºN, longitude 140ºW are applied to the Early Stuart timing model. The sea surface

[324] See e.g. Ringtail Document CAN002564 at 15; Ringtail Document CAN002565 at 16; and Ringtail Document CAN002566 at 17.

temperature data are the mean temperatures within an area of the North Pacific during November and December of the year preceding the forecast.

231. Uncertainty in the forecasted run-timing date is expressed in the form of a prediction interval at different probability levels. The median timing date is predicted to occur within the range of dates in the prediction interval with a specified probability. Inclusion of a prediction interval with the timing forecast serves to inform decision makers of the uncertainty around the forecast. In addition to the forecast date, the memoranda to the FRP include the historical time series median date. This allows the FRP to compare the forecasted date with the historical median. Large deviations from the historical median may be driven by abnormal environmental conditions. Uncertainty (i.e. the prediction interval) increases as the forecast value deviates from the time series median. In other words, if a forecast is close to the outer limits of historical median observations (high or low), then there is less certainty in that forecast.

232. Run-timing forecasts are provided by DFO to the FRP for Early Stuart and Chilko stocks only. The Early Stuart stock is the earliest of the four run-timing groups so its timing is monitored as the first indicator for overall Fraser Sockeye return timing. There is a good historical record of Early Stuart run-timing which allows for a more robust statistical relationship between timing and oceanographic indicators. The Chilko stock, part of the Summer run-timing group, has historically been numerically strong during each year of the four year sockeye cycles thus allowing for the inclusion of more data in the timing forecast model and as a result Chilko has become the stock of choice for Fraser sockeye return timing estimates. Quesnel stocks and stocks in the Late-run aggregate have shown cyclic dominance, resulting in small returns in two years out of the four year cycle. Consequently, for these stocks run-timing estimates can only be prepared for half of the historical data, leading to less certainty in forecasting.

233. For further information on the development of run-timing forecasts see: Blackbourn, D. 1987. Sea surface temperature and the pre-season prediction of return timing in Fraser river Sockeye salmon (*Oncorhynchus nerka*). Can. Spec.

Pub. Fish. Aquat. Sci. 96: 296-306 (in Smith, H., Margolis, L. and Wood, C.C., Eds., Sockeye salmon (*Oncorhynchus nerka*) population biology and future management).

Diversion Rate

234. Fraser River sockeye travel south along the British Columbia coast as they migrate towards their spawning grounds in the Fraser River watershed. The diversion rate is the percentage of these sockeye that return from the Pacific Ocean through Johnstone Strait as opposed to Juan de Fuca Strait. Annually, DFO submits two forecasts of Fraser sockeye diversion rate to the Canadian Co-Chair of the FRP. The first is released in early June, the second in early July as additional environmental data become available. In-season updates to the diversion rate estimate are prepared by the FRPTC.

235. Historically the majority of returning adult Fraser sockeye stocks migrated via the Juan de Fuca Strait, but diversion rate varies by year as well as by stock. Intermittent years would see larger returns via Johnstone Strait.[325] During the last two decades the majority of returns, by year, have varied equally between the northern and southern routes. Unlike run-timing, the diversion rate forecast is not stock-specific, but a total estimate, accounting for all Fraser Sockeye returns.

236. Data to calculate diversion rates have been collected annually since 1976.[326] Since about 2000, forecasts of diversion have been based on the historical relationship between the average May/June sea surface temperatures measured at Kains Island lighthouse (at the northern end of Vancouver Island) and the estimated post-season diversion rates for 1977 to the year prior (for example, if the forecast is for 2010, then the data set covers 1977-2009).[327] The models minimise

[325] Which is why diversion rate is also called “northern diversion rate”.
[326] Ringtail Document CAN030059.
[327] Ringtail Document CAN031995; McKinnell, S., Freeland, H.J. and Groulx, S.D. 1999. Assessing the northern diversion of sockeye salmon returning to the Fraser River, BC. Fish. Oceanogr. 8(2): 104-114 (not available in Ringtail).

the amount of error between a fitted (predictive) line and the true historical data. Once a relationship between cause (sea surface temperature) and effect (diversion rate) is estimated (e.g. by fitting the regression line), the fit is used to predict upcoming diversion given known ocean temperatures.

237. Beginning in 2009, the diversion forecast memoranda include estimates of uncertainty around the forecast. These estimates of uncertainty are calculated using published deterministic methods associated with the statistical model, not through probabilistic methods (e.g. Monte Carlo simulations). Uncertainty is presented as a prediction interval around the forecast (e.g. the median or 50% probability level). Prediction intervals are stated with a probability level, for example "diversion forecast of 32%, with 50% probability the range is within 27%-42% and 95% probability the range is within 16%-59%".

238. For a review of the history and development of diversion forecasting, see: McKinnell, S., Freeland, H.J. and Groulx, S.D. 1999. Assessing the northern diversion of sockeye salmon returning to the Fraser River, BC. Fisheries Oceanography 8(2): 104-114.

How Pre-season Forecasts Are Used in Fraser Sockeye Management

239. The FRP uses forecasts in its pre-season planning process. Pre-season abundance, diversion rate and run-timing assumptions are put into the pre-season fishery planning model to develop a schedule of potential fisheries under different scenarios.

240. In-season, the FRP makes decisions about returning run-sizes by stock-group. At the beginning of the fishing season, the official run-size is the 50% probability forecast level of abundance as stipulated by Annex IV, Chapter 4 of the Treaty.[328] However, few Panel Area fisheries are opened solely based on pre-season

[328] Unless otherwise adopted by the FRP based on recommendations from the FRPTC and the PSC staff (Annex IV, Ch. 4, Para. 13(a)).

forecasts.[329] In-season, forecasts of abundance are compared with in-season data to see how the run is tracking relative to the forecast. Pre-season forecasts are also used as inputs to the run-size assessment model (see "Run-size Assessment" section, below).

In-season Decision-making

Run-size Assessments: the FRP

241. PSC staff generate in-season run-size estimates of Fraser River sockeye by stock-group and provide these to the FRP which adopts in-season run-sizes throughout the season.

Methods for Estimating Run-size

242. Estimates are primarily based on catch, effort, escapement, stock composition, run-timing and diversion rate data.[330] Commercial catches and test fisheries provide important data before and after the commercial fishing season and between fishing periods. Information about upstream migration in the Fraser River is primarily obtained by the hydro-acoustic program at Mission, visual observations at Hell's Gate and analysis of catches in Fraser River First Nations' fisheries.

243. Until about 2009, these data were analysed using purse seine catch, catch per unit effort ("CPUE") and cumulative-normal and cumulative-passage to date models, which are described in the PSC's Technical Report No. 63[331] and in the FRP's 1995 Annual Report.[332] CPUE is defined as catch divided by unit effort. The unit of effort for gillnet catches is a standardised measure of the length of the net (in

[329] Ringtail Document PSC000006 at 19.
[330] Ringtail Document CAN002564 at 25.
[331] 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. 6 (available online at: http://www.psc.org/publications_tech_psctechreport.htm).
[332] Ringtail Document CAN002621.

one thousand fathom meters) multiplied by the number of minutes the net was in the water.

244. Run-size estimates are now predicted in-season using a Bayesian cumulative-normal model. The cumulative-normal model compares the reconstructed daily migration pattern (fish past Mission) to ideal run-timing curves, assuming that the run follows a normal distribution curve. By assuming the run follows this idealized pattern, the run-size can be estimated once the 50% migration date (i.e., the date 50% of the run has migrated past the reference location, which corresponds to the peak of the normal distribution) has been identified, by doubling the abundance up to that date.

245. Prior to observing the peak of a Fraser sockeye run, there is considerable uncertainty about the run-size. The uncertainty about the actual size of the run is estimated using Bayesian methodology. The Bayesian version of the cumulative-normal model relies on additional information (pre-season forecasts of run-size and timing, expected duration of the run, average historical expansion line[333] estimates and pre-season forecasts of diversion rate) to reduce the uncertainty and keep the run-size estimates within realistic bounds. This prior information (also called priors) is incorporated within the Bayesian model through the use of prior probability distributions. These priors indicate which parameter values are assumed to be plausible. Theoretically, the Bayesian version of the cumulative-normal model should provide more stable estimates than the original cumulative-normal model since the Bayesian version relies on historical data (through the use of priors) as well as in-season data.

246. The data used to predict the in-season run-size estimate using the cumulative-normal model are:

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[333] See “Expansion Lines” section, below.

a. CPUE data from test fishing vessels using gillnets during the early part of the fishing season and purse seines for the latter part of the season: Test fishing vessels in Johnstone Strait (Area 12) and Juan de Fuca Strait (Area 20) collect CPUE data during the migration of salmon to the Fraser River. These data provide an early indicator of relative day-to-day changes in abundance. Daily abundance past the test fishery assessment sites is estimated from CPUE data and estimates of historic catchability.[334] For Early Stuart, Early Summer and Summer-run stock-groups and the Birkenhead stock, these estimates of daily abundance are used by default, until six days later more accurate estimates are reconstructed from the sum of catch and the daily abundance of sockeye migrating past Mission. However, because Late-run stocks tend to delay their upstream migration for variable periods, daily abundance estimates cannot be updated with Mission data and thus the run-size assessments for these stocks rely almost entirely on test fishery CPUE data.

b. Hydro-acoustic data collected at Mission: Daily abundance or "escapement" at Mission is estimated using hydro-acoustics. These daily abundance estimates are more accurate than the daily abundance estimates derived from the test fishing CPUE data.

c. Stock identification data based on DNA and scale pattern analyses.

d. Catch data: Historically, in-season run-size models were based on commercial catch data due to the large proportion of the run caught by the fishery. However, because of the present irregularity of commercial catches and associated inconsistencies in harvest rates, catches are now only used in combination with estimates of daily abundance at Mission to reconstruct the run.

247. Additional information used as priors for in-season run-size estimation are:

[334] Catchability is defined as the portion of the fish that are removed from a population by a defined effort and expansion lines are defined as the inverse of the catchability metric.

a. Pre-season run-size forecasts based on historic stock-recruit data (provided by DFO to the PSC staff);
b. Pre-season run-timing forecasts (provided by DFO to the PSC staff);
c. In-season run-timing estimates based on timing estimates of earlier run-timing groups and the correlation between timing estimates for different run-timing groups (generated by the PSC staff);
d. Pre-season diversion rate forecasts (provided by DFO to the PSC staff); and
e. In-season catchability estimates based on historic CPUE and post-season run-size data (generated by the PSC staff; see “Expansion Lines” section, below).

248. Major assumptions of the current run-size assessment method are that: 1) the returning fish are normally distributed; and 2) stock identification, daily abundance estimates from hydro-acoustics and commercial catches are representative of the true pattern changes in the daily abundance of each stock-group for which run-size estimates are generated.

249. The following uncertainties are accounted for by the Bayesian cumulative normal model used to estimate the total run-size:

a. Run-size uncertainty: The probability distribution for run-size accounts for uncertainty by describing the range of possible values of the run-size and the probability of each value within that range;
b. Uncertainty about the 50% migration timing of the run;
c. Uncertainty about the spread of the run;
d. Uncertainty about the catchability which in combination with the CPUE data provide an indication of the uncertainty in the daily abundance estimates; and
e. Observation/process uncertainty/error: These errors explain why the observations deviate from the bell-shaped distribution.

250. Since 2007, there has been a hydro-acoustic program at Qualark as well (see “Hydro-acoustics” section, above), but for 2007 through 2009, no data from this program was used in the run-size assessment models. In 2010, the data from this program were indirectly used in run-size assessments as the Qualark information

was used to adjust the Mission hydro-acoustic numbers which are included in the models.

Pre-season Run-size Forecasts and In-season Run-size Assessments

251. Pre-season run-size probability levels do not directly affect in-season run-size estimates, but the full probability distribution of the pre-season run-size is used as a prior probability distribution within the in-season run-size model and as such has an impact on in-season run-size estimates. Prior probability distributions (priors) on run-size indicate the possible range of the run-size at the start of the season. The priors on run-size are pre-season forecasts derived through stock-recruit analysis using historic stock-recruit data. These data are independent of the data used to estimate the run-size in-season. At the start of the season, in-season data are limited so the prior (or pre-season forecast) will largely determine the posterior probability distribution (posterior) of the run-size, i.e., the in-season run-size estimate. Once the peak of the run is observed, however, the influence of the pre-season forecast on the run-size estimate is reduced substantially. As more in-season data accumulate towards the end of the season, the Bayesian cumulative normal model will ignore the pre-season forecast in favour of the in-season data.

Data for Run-size Assessments

252. Pre-season run-size estimates are provided for each of the four run-timing groups as well as for the 19 individual stocks for which historic stock-recruit data are available. The remaining stocks are grouped under the heading “Miscellaneous stocks”.

253. In-season, run-size estimates are provided for each of the four run-timing groups. In addition, run-size estimates are also provided for some subgroups or individual stocks where there are sufficient amounts of stock identification data to derive stock or sub-group CPUE, catch and daily abundance estimates. Because run-size estimates for individual stocks may vary substantially from year-to-year, the groups of stocks for which individual or sub-group run-size estimates are available may differ each year. In 2009, in-season run-size estimates were provided for the

following stocks or stock-groups: Early Stuart, Early Miscellaneous, Scotch/Seymour/North Thompson, Chilko/Quesnel, Late Stuart/Stellako, Harrison, Birkenhead and Late-run without Harrison.

Expansion Lines

254. Expansion lines are factors used to extrapolate the relative index of abundance in marine test fisheries (CPUE data) to absolute abundance. The inverse of the expansion line is "catchability". The uncertainty in catchability is high because the removal of fish used to generate the estimate of catchability is small relative to the total population. Thus a small change in catchability can have a large impact on run-size estimates that rely on expansion lines. As well, the inter-annual variability of catchability is high and that is why the PSC staff report the probability intervals associated with any estimate of catchability to the FRP.

255. Historic annual expansion lines are generated based on historic CPUE data and historic run-size estimates for individual years. Expansion lines differ from year-to-year and expansion line estimates used for in-season assessment need to take this uncertainty into account. To account for uncertainty in expansion lines used in run-size assessment models, a prior probability distribution for the expansion line is derived using historic data within a hierarchical model structure. Using hierarchical models, one can predict the expansion line for a year for which no data has been observed based on the average expansion line across the years and the variation in expansion lines among years.

256. Assumptions involved in using expansion lines relate to the major assumptions involved in estimating run-size as set out above, but specifically include that:

a. Abundance is reconstructed without bias;
b. The proportion of abundance passing an area is known;
c. Fish are equally vulnerable to gear among and within areas;
d. Effort to catch fish is consistent throughout the time-series (i.e. fishing is done in the same way every year and samples are random); and
e. Any non-random sampling effects of fishing gear is accounted for.

257. In addition to their use in run-size assessment, expansion lines are also used in-season to generate a projection of run-size six days into the future from the Mission data and these projections can be used by Canada and United States to plan fisheries.

Decision-making

258. During the fishing season, the FRP confers (by phone or in person) on at least a weekly basis to assess the run-size of Fraser sockeye run-timing groups and to enact in-season orders for the regulation of the commercial sockeye and pink fisheries in Panel Area waters.[335] Orders for the adjustment of commercial fishing times and areas in Panel Area waters are made in response to updates of stock-group run-sizes and MAs.[336]

259. The PSC staff provide analysis and recommendations about run-size and MAs to the FRP which then determines in-season run-sizes and MAs.[337] Generally, the FRP picks the model that has the highest statistical correlation expressed by the model's R^2 value. However, FRP decisions are not always based purely on quantitative data from stock assessment models as there is a qualitative aspect to in-season decision-making based on past management experience. In other words, there are no strict in-season decision rules for the FRP although through the Canadian caucus, Canadian fisheries are supposed to adhere to the IFMP harvest decision guidelines.

260. The FRP may use a different MA model in-season than what was decided pre-season or it may decide that none of the models are reflective of the in-season environmental conditions in which case a value like the historical average MA for a run-timing group could be used.

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[335] See e.g. Ringtail Document CAN002564 at 20; Ringtail Document CAN002565 at 20; Ringtail Document CAN002566 at 19; and Ringtail Document CAN002567 at 15.
[336] Treaty, Article VI, Para. 6.
[337] See e.g. Ringtail Document CAN002564 at 16.

Managing for Escapement Targets

261. Under the terms of the Treaty, the FRP's highest priority is to "obtain spawning escapement by stock or stock grouping".[338] However, spawning escapement estimates are not available for several months after the season so estimates from the spawning grounds are not useful for tracking in-season progress toward this objective. Spawning escapement is therefore not used for in-season management except as a component in the calculated targets for gross escapement and potential spawning escapement (see "Gross Escapement" section, above).

262. Because spawning escapement estimates are not available in-season, Canada, the United States and the FRP must use proxies to inform management decisions regarding the fishery. The closest in-season proxy for monitoring escapement is how many fish migrate past Mission hydro-acoustics. In addition, more fish in the form of MAs must be added to the escapement estimated at Mission to account for historical differences between in-season and spawning ground escapement estimates and any additional increments that may be needed as a result of adverse river migration conditions.

263. To relate Mission escapement to the spawning escapement target for each run-timing group, two in-season proxies are generally used:

    a. Potential spawning escapement measured by the fish counted at Mission (the "Mission Escapement"); and
    b. Gross escapement measured by the Mission Escapement plus the in-river First Nations and recreational catch.

264. If the proxy is potential spawning escapement, then in order to track the achievement of management objectives in-season, the Mission Escapement is

[338] Treaty, Annex IV, Ch. 4, Para. 10(a).

compared to the spawning escapement target[339] plus the MA plus the expected catch above Mission. If the proxy is gross escapement, then in order to track the achievement of management objectives in-season, Mission Escapement plus the in-river First Nations and recreational catch is compared to the spawning escapement target plus the MA plus the expected in-river First Nations and recreational catch. Whichever of these proxies is used by Canada, the United States and the FRP, the in-season targets include the spawning escapement target, MAs and some portion of in-river First Nations and recreational catch. Both of these values are proxies to help the FRP and DFO gauge in-season progress toward escapement targets (as defined by Canada using the FRSSI model; see “Escapement” section, above).

265. Under the Treaty, Canada and the United States bring fishery proposals for commercial fisheries in Panel Area waters to the PSC staff who must provide advice to each country as to whether its proposed fishery regulations are consistent with the recommendations and projections described in Paragraph 13(a) of the Treaty (run-sizes) and Paragraph 13(b) of the Treaty (projected harvestable surplus).[340] Because harvestable surplus is defined as the total run minus spawning escapement and MA and because TAC has the additional deductions of test fishing catches and the AFE, the magnitude of the TAC relative to the expected catches in proposed fisheries becomes the gauge of “consistency” for the PSC staff. In other words, if the expected catches in proposed fisheries are less than the available TAC, the PSC staff would judge those proposed fisheries consistent with the Treaty. With respect to the spawning escapement target, implicit in this positive judgment is that the MA will be sufficient to compensate for any expected en-route losses or systematic differences to ensure that the spawning targets are reached.

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[339] Provided to the FRP by Canada and calculated based on in-season run-size assessments using the TAM rule from the FRSSI Model.
[340] Treaty, Annex IV, Ch. 4, Para. 13(d).

Fishery Openings and Closings: DFO and the FRP

266. Information on in-season run-size estimates and management actions, such as openings and closings, as well as other important information for commercial, recreational and First Nations fisheries are posted on the internet regularly throughout the fishing season by DFO and the PSC.

267. DFO regulates First Nations and recreational fisheries in all BC waters and commercial fisheries in non-Panel Area waters and commercial fisheries in non-Panel Area waters.[341] The FRP is responsible for in-season decision rules and harvest regulation for the commercial Fraser River sockeye fishery in Panel Area waters.[342]

268. DFO is responsible for in-season enforcement of Fraser River sockeye fishery openings and closings in Panel and non-Panel Area waters.

Commercial and Recreational Fishery Openings

269. The FRP's Canadian caucus and FRIMT put commercial and recreational fishing plans together for all Canadian commercial and recreational fisheries.

270. For Panel Area waters, the Canadian Chair of the FRP, on behalf of DFO, has the decision-making authority regarding commercial fishery proposals and he presents these fishery proposals to the FRP and the PSC staff at the in-season FRP meetings. Proposals are evaluated by the PSC staff and if they are consistent with available harvestable surpluses, then the proposed commercial fisheries can go ahead as stipulated in paragraph 13 of the Treaty, Annex IV, Chapter 4. Alternately, if the fishery proposals are judged inconsistent by the PSC staff, if both the Canadian and United States National Sections (caucuses) agree, the fisheries can proceed.

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[341] Ringtail Document CAN002564 at 46; see Figure 3, above, for map of Fraser River Panel Area waters.
[342] Treaty, Article VI, Para. 6 and Annex IV, Ch. 4, Paras. 5 and 12; see also Policy and Practice Report: Overview of the *Pacific Salmon Treaty* and the Pacific Salmon Commission Regarding Management of Fraser River Sockeye Salmon.

271. Once FRIMT and the FRP Canadian caucus decide to open a recreational or commercial fishery (and if the latter is in Panel Area waters, once the fishery is approved by the PSC or the FRP), then variation orders are drafted in the DFO Area offices by fishery managers.[343] For recreational fisheries, the variation orders are sent to the Salmon Team at DFO's Pacific Region Headquarters for review. The Salmon Team will draft the appropriate recreational fishery notices and these along with the variation orders are then sent to the Regional Director General for approval. For commercial fisheries, the Area Resource Managers generate the fishery notices as well as the variation orders and the notices are approved by the Area Chief or Area Head of the office that produces them. Following this process, the fishery notices go to the Salmon Team for review and posting on the DFO website.

First Nations FSC and Economic Opportunity Fisheries

272. Fishing plans for First Nations' FSC and Economic Opportunity fisheries are the product of bilateral planning meetings with each First Nation that are held with DFO Area Resource Managers.[344] These fishery plans are subsequently reviewed and must be approved by FRIMT and by the Regional Director General.[345] The FRP Canadian caucus is informed about these fishery openings.

273. First Nations' access to salmon for FSC and economic purposes is managed through communal licenses.[346] Communal licenses describe fishing dates, times, locations, gear, harvest targets and other conditions.[347]

274. There are no formal fishery notices for FSC fisheries so there is no review process through the Salmon Team like for recreational and commercial fishery decisions. Fishery notices for First Nations' Economic Opportunity fisheries are posted on the

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[343] A variation order is a variation from the regulatory regime which says the fishery is "closed until open".
[344] Ringtail Document CAN004038 at 8.
[345] Ringtail Document CAN075232 at 81.
[346] Ringtail Document CAN004038 at 8.
[347] *Ibid*.

DFO website. The fishery notice is drafted by the appropriate Area Resource Manager, approved by the Area Chief and then sent to the Salmon Team for review. Economic Opportunity fishery notices do not have variation orders because these fisheries are implemented with a communal license unlike for other commercial and for recreational fisheries.

Treaty FSC and Commercial Fisheries

275. For the Tsawwassen First Nation ("TFN") the amount of fish available for FSC is set out in the *Tsawwassen First Nation Agreement* (the "TFN Treaty").[348] Fishing for FSC or commercial purposes is by way of a communal license as per FSC and Economic Opportunity fisheries for non-treaty First Nations.[349]

276. Annual fishing plans are developed by the TFN and brought to the Joint Fisheries Committee ("JFC") in which the Province, TFN members and DFO participate.[350] The fishing plan agreed on by the JFC is provided to the Minister in the form of recommendations regarding the conditions of the TFN communal license.[351] The communal license must be approved by the Minister. If in issuing the communal license, the Minister varies significantly from the provisions recommended by the JFC, the Minister must provide written reasons to the TFN and the JFC.[352]

277. The TFN also have a harvest agreement which is not part of the TFN Treaty although it was negotiated and ratified concurrently with the TFN Treaty.[353] All commercial access for the TFN is set out in the harvest agreement.

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[348] *Tsawwassen First Nation Final Agreement*, Canada, British Columbia and Tsawwassen First Nation, 6 December 2007 [TFN Treaty], Fisheries, Chapter, 9, s. 23 and Appendix J-2. Available online at: online: Province of British Columbia <http://www.gov.bc.ca/premier/media_gallery/downloads/2007/oct/tsawwassen_first_nation_final_agreement.pdf>.
[349] TFN Treaty, Fisheries, Chapter 9, ss. 5 and 59-64. In the TFN Treaty, the communal licenses are called "Tsawwassen Harvest Documents" (TFN Treaty, Fisheries, Chapter 9, ss. 59, 61-64).
[350] TFN Treaty, Fisheries, Chapter 9, ss. 65-73.
[351] TFN Treaty, Fisheries, Chapter 9, s. 62.
[352] TFN Treaty, Fisheries, Chapter 9, s. 62 .
[353] TFN Treaty, Fisheries, Chapter 9, ss. 102-105.

Post-season

<u>Review Process</u>

278. At the end of the season, DFO and the FRP compare actual escapement to pre-season targets to evaluate the effectiveness of management measures.[354]

DFO

279. DFO does a post-season review internally and also externally through the IFMP process (see "Salmon Integrated Fisheries Management Plans" section, above). The post-season review is part of the Auditor-General's government-wide requirements to establish performance measures for the effectiveness of government programs.[355] DFO is supposed to consider four main elements in its review:[356]

   a. Assessment of the IFMP development process;
   b. Assessment of the IFMP document itself;
   c. Assessment of the effectiveness of the measures implemented (outputs and outcomes); and
   d. Recommendations and suggestions for improvements.

280. The performance review also provides an opportunity to examine harvest decision rules and test whether the rules are working and are compliant with the precautionary approach.[357] It is supposed to involve all members of the IHPC and relevant DFO sectors.

281. As part of its review, DFO prepares an annual post-season report for Canadian Treaty Limit Fisheries for the PSC.[358] This review has an objectives and overview

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[354] Ringtail Document CAN006718 at 24; and Ringtail Document CAN002564 at 39.
[355] Ringtail Document CAN002913 at 16.
[356] *Ibid*.
[357] *Ibid*.
[358] See e.g. Ringtail Document CAN017993.

section with a description of the Canadian pre-season plan including escapement targets, the in-season run-size assessments including a comparison to forecasted returns, the harvest opportunities and preliminary spawning ground escapement estimates.[359]

282. For the past several years, DFO has also published a Record of Management Strategy for Fraser River sockeye and pink salmon ("RMS") which provides a comprehensive record of decisions taken every year and the data relied on for that decision-making.[360] The RMS is a historical record of management actions for the sockeye and pink fishery. The Salmon Team coordinates its production and content is drafted by members of FRIMT. DFO enforcement staff sometimes use the RMS to support fishery-related prosecutions.

The FRP

283. The mandate of the FRP is to manage commercial fisheries in the Panel Area to achieve a hierarchy of annual goals (in order of priority):[361]

a. Spawning escapement targets for Fraser River sockeye and pink salmon that are set by Canada or modified by Panel agreement;
b. Targets for international sharing of the TAC as defined in the Treaty or by agreement of the Parties; and
c. Domestic catch allocation goals within each country.

284. In the process of achieving these objectives, the Panel must also consider conservation concerns for other stocks and species of salmon when planning and conducting the fisheries.[362]

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[359] *Ibid*. at 16-20. DFO also produces a yearly post-season report for Southern BC fisheries. The section of this report relating to Fraser sockeye is the same as for the Canadian Treaty Limit Fisheries report to the PSC. Compare e.g. Ringtail Document CAN017996 at 6-12 to Ringtail Document CAN003231 at 20-27.
[360] Ringtail Document CAN005748 at 1; and see e.g. Ringtail Document CAN007896.
[361] Ringtail Document CAN002564 at 43; Treaty, Annex IV, Ch. 4, Para. 10; and see also Policy and Practice Report: Overview of the *Pacific Salmon Treaty* and the Pacific Salmon Commission Regarding Management of Fraser River Sockeye Salmon.

285. In evaluating whether it achieved spawning escapement targets, the FRP uses two performance measures: 1) whether in-season estimates of gross escapement met the adjusted (by inclusion of a MA amount) gross escapement targets; and 2) whether up-river gross escapement estimates met the unadjusted targets.[363]

286. In order to measure its achievement of targets for international sharing and each country's domestic catch allocation, the final TAC, USTAC and CTAC are compared to the actual catch of sockeye by each country.[364]

287. The escapement estimates and data collected on the spawning grounds by DFO also enable the PSC to do a post-season evaluation of its in-season stock identification and stock monitoring programs.

288. The FRP publishes an annual report to the PSC.[365] This report provides an annual summary of the management of the Fraser River sockeye and pink salmon fisheries, including a summary of pre-season planning, in-season management actions and a post-season review of how well the FRP did in meeting the objectives established under the Treaty.

289. The PSC publishes annual reports that summarise the yearly activities of the Commission.[366] These reports include the results of the fishing season as presented by the Parties, records of meetings of the PSC and annual reports from some of the PSC's committees.

Post-season Estimates of Total Run-size

290. Post-season, the FRP determines the final post-season run-size estimate. This run-size estimate also changes the in-season exploitation rate and escapement

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[362] Ringtail Document CAN002564 at 43.
[363] *Ibid*.
[364] See e.g. Ringtail Document CAN002564 at 46-47.
[365] Ringtail Document CAN005748 at 1; see e.g. Ringtail Document CAN002564, Ringtail Document CAN002565, Ringtail Document CAN002666 and Ringtail Document CAN002567.
[366] Ringtail Document CAN005748 at 1; see e.g. Ringtail Document CAN002680.

estimates.[367] A final post-season estimate of run-size is not available until all the spawning escapement information has been collected and analysed and this process often continues into the following year.[368]

Summary of DFO, the PSC Staff and FRP Harvest Management Roles and Responsibilities

DFO

291. DFO is responsible for: [369]

a. Management of Canadian commercial fisheries in non-Panel Area waters in a manner consistent with the terms of the Treaty;
b. Management of Aboriginal fisheries in Panel and non-Panel Area waters;
c. Management of recreational fisheries in Panel and non-Panel Area waters; and
d. Research and monitoring of Fraser sockeye stocks.

292. More specifically, pre-season, DFO is responsible for:[370]

a. Pre-season forecasting of abundance, timing and diversion rate of Fraser River sockeye and pink salmon;
b. Addressing issues from the previous season's post-season review;
c. Considering new initiatives;
d. Defining management objectives;
e. Setting spawning ground targets and harvest guidelines;
f. Setting allocation and sharing objectives;
g. Obtaining Ministerial direction and approval;
h. Reviewing and developing in-season decision rules;
i. License conditions;

[367] Ringtail Document CAN013786 at 6.
[368] Ringtail Document CAN002496 at 19.
[369] Ringtail Document CAN005758 at 18-19.
[370] Ringtail Document CAN006718 at 20-21; and Ringtail CAN005758 at 18-19.

j. Consulting with stakeholders; and

k. Test fishing in non-Panel Area waters.

293. During the fishing season, DFO is specifically responsible for:[371]

a. Test fishing in non-Panel Area waters;

b. Issuing licenses;

c. Reviewing in-season information (catch information and test fishing);

d. Fishery openings and closings based on in-season information (directly if non-Panel Area waters and through the Canadian caucus of the FRP for commercial fisheries in Panel Area waters);

e. Issuing fishery notices and updates; and

f. Enforcement.

294. Post-season, DFO reviews the fishing season by compiling catch and escapement data, comparing these data to the pre-season objectives and identifying issues for the following year.[372]

The PSC Staff and the FRP

295. The PSC staff:[373]

a. Develop pre-season management (harvest) plans based on pre-season forecasts of run-size abundance, run-timing and diversion rates (one of which will be adopted by the FRP at its May pre-season planning meeting);

b. Compile catch by stock or stock-group (and age) data for Fraser River sockeye and pink salmon;

c. Design and conduct test fishing on Fraser River sockeye and pink salmon;

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[371] Ringtail Document CAN006718 at 23.
[372] *Ibid* at 24.
[373] Ringtail Document CAN005758 at 16-17 and 20-23; Ringtail Document CAN007891; Ringtail Document CAN032176 at 6-8 (as part of the renegotiation of Annex IV, Ch. 4, the FRP agreed on a draft paragraph 14 that sets out the PSC staff, FRP and Party duties and responsibilities).

d. Design and conduct studies to identify and discriminate between races of Fraser sockeye and pink salmon harvested in Panel Area waters;
e. Design and conduct studies relevant to improving assessment methods;
f. Collect data on upriver escapements by observation at Hells Gate and the hydro-acoustic program at Mission;
g. Recommend data collections for areas outside the Panel Area;
h. Maintain databases of total production by year for Fraser pink salmon and by stock and age for Fraser sockeye including associated biological data such as fish length and scale measurements;
i. Interpret statistical and biological data and other information the PSC has collected and or that are provided by the Parties and provide the Panel with in-season estimates of Fraser sockeye abundance by stock;
j. Design and maintain a website for posting regulatory announcements, meeting schedules, new releases and to provide access to scientific information including test fishing results and technical reports; and
k. Calculate sockeye TAC.

296. The FRP: [374]

a. Identifies and reviews special management problems for Fraser River sockeye and pink stocks;
b. Reviews and evaluates information provided by the Parties pursuant to Treaty, Article IV, Para. 3;
c. Makes proposals to the PSC regarding regulations for the harvest of Fraser River sockeye and pink salmon in Panel Area waters;
d. Collects in-season information on catches in Panel Area waters;
e. Reviews information on escapement in Panel Area waters;
f. Collates information provided by the Parties pursuant to the Treaty for fisheries outside of Panel Area waters;

[374] Ringtail Document CAN005758 at 21-22; Ringtail Document CAN032176 at 6-8; Treaty, Article IV, Para. 6 and Annex IV, Ch. 4 and 1985 Diplomatic Note, Para. A.

g. Based on the pre-season and in-season calculations of TAC and harvestable fish, sets fishing times (openings) for Panel Area commercial fisheries; and

h. At the end of each fishing season, provides the PSC with an accounting of catches of Fraser River sockeye and pink salmon and with an appraisal of the extent to which the FRP achieved the objectives set by the Parties.

297. The above description of DFO, the PSC and the FRP roles and responsibilities are further summarised in Table 2.

Table 2: Summary of DFO, the PSC, FRP Canadian caucus and United States caucus's harvest management responsibilities.[375]

	DFO	PSC	FRP Canadian caucus (section)	FRP US caucus (section)
Pre-season	1. Pre-season forecasts of run-size, run-timing and diversion rate 2. Catch monitoring 3. Pre-season assessment and forecasting of the in-river migration environment 4. Escapement targets (using FRSSI) 5. Consultations with affected harvest interests 6. Development of pre-season fishing plans in Non-Panel Area waters for the commercial fishery and in all areas for First Nations and recreational fisheries (IFMP)	1. Test fishing strategy 2. Biological sampling plan for Panel Area waters 3. Catch monitoring plan in Panel Area waters 4. Recommendations to the FRP regarding adoption of pre-season MAs and run-size by stock-group 5. Recommendations to the FRP for pre-season TAC and TAC shares to each country for planning purposes 6. News releases	1. Agree on pre-season fishing plan for Panel Area waters	1. Catch monitoring 2. Consultations with affected harvest interests 3. Agree on pre-season fishing plan for Panel Area waters

[375] Ringtail Document CAN005758; Ringtail Document CAN032176; Ringtail Document CAN075232 at 80; and 1985 Exchange of Notes at Para. A1.

	DFO	PSC	FRP Canadian caucus (section)	FRP US caucus (section)
In-season	1. Test fishing 2. Catch monitoring 3. Monitoring the in-river migration environment 4. Monitoring the progress of escapement into the spawning grounds 5. Consultations with affected harvest interests 6. Decisions to open and close all fisheries in Non-Panel Area waters and First Nations and recreational fisheries in Panel Area waters 7. Submit commercial fishery recommendations to the FRP for Panel Area waters	1. Test fishing 2. Biological sampling in Panel Area waters 3. Catch monitoring in Panel Area waters 4. Recommendations to the FRP regarding adoption of MAs and run-size by stock-group 5. Report on the progress of escapement into the Fraser River at Mission and Hell's Gate 6. Recommendations to the FRP for TAC and TAC shares to each country 7. Evaluation of each country's fishery recommendations for commercial fisheries in Panel Area waters 8. News releases	1. Decisions to open or close commercial fisheries in Panel Area waters (joint decision with the United States Section) 2. Decisions to open or close all fisheries in non-Panel Area waters (with FRIMT) 3. Decisions to open or close First Nations and recreational fisheries in Panel Area waters (with FRIMT)	1. Catch monitoring in US waters 2. Consultations with affected harvest interests 3. Decisions to open or close fisheries in Panel Area waters fisheries (joint decision with Canada)
Post-season	1. Final spawner escapement estimates 2. Final catch data 3. Reports on sockeye and pink salmon research 4. Review of the season with interested parties	1. Recommendations to the FRP regarding adoption of final MAs and run-sizes by stock-group 2. Report on the FRP activities and the achievement of objectives 3. Recommendations to the FRP for future management and monitoring improvements		1. Final catch data

Fishery Summary

298. In the 1980s, the overall Fraser sockeye exploitation rate was an average of 78%.[376] This was reduced to an average of 37% between 2000 and 2008.[377] Between 1987 and 2008, despite declining abundance and production observed since the mid-1990s, total spawning escapement also increased.[378] According to DFO, this shift towards increased escapement and reduced exploitation rates was in part driven by harvest constraints imposed by managers to protect weak stocks such as the Early Stuart run-timing group and the Cultus Lake sockeye within mixed-stock fisheries.[379]

299. Tables 3 to 5 summarise pre-season forecasts, post-season run-sizes, exploitation rates and escapement from 1985 to 2009. Unless otherwise noted, the numbers in Table 3 are from the "Report of the Fraser River Panel to the Pacific Salmon Commission for the YEAR Fraser River Sockeye Salmon Fishing Season" for the corresponding YEAR. Where no value is indicated, none has been reported in the sources referred to in this document.

Table 3: Fraser River sockeye pre-season forecasts and post-season run-sizes for 1985-2009.

Year	Pre-Season Forecast (50p)	Range (75p-25p)	Post-Season Run-size[380]
2009	10,488,000[381]	6,037,000 - 19,424,000[382]	1,443,120

[376] Ringtail Document CAN002907 at 9.
[377] *Ibid*.
[378] *Ibid*.
[379] *Ibid*.
[380] All values from this column are from the Excel spreadsheet Sockeye_ExploitationRate_by_stock.xls provided by the PSC to the Cohen Commission [Sockeye Spreadsheet]. Document is not yet available on Ringtail at the publication date of this Policy and Practice Report.
[381] Meeting Binder, Pacific Salmon Commission, Fraser River Panel, January 11-15, 2010 at 50. Document not yet available in Ringtail at the publication of this Policy and Practice Report.
[382] Note: these numbers are from an early pre-season forecast, at the time the p50 estimate was 10,577,000 Table 1, Pre-Season Sockeye and Pink Forecasts for 2009 by Stock/Timing Group and Probability. Science Advisory Report 2008/xxx (draft) at 1. Document not yet available in Ringtail at the publication of this Policy and Practice Report.

2008	2,897,000[381]	1,854,000 - 4,480,000[383]	1,753,866
2007	6,274,000[381]	3,602,000 - 11,257,000	1,507,757
2006	17,357,000	9,530,000 - 31,902,000	12,967,272
2005	12,548,000	8,679,000 - 18,316,000	7,024,549
2004	4,920,000[384]	2,872,000 - 8,663,000	4,184,020
2003	5,467,000[385]	3,141,000 - 9,744,000	4,889,373
2002	13,366,000[385]	7,911,000 - 22,309,000	15,131,528
2001	12,865,000[385]	6,798,000 - 24,662,000	7,191,488
2000	4,083,000[381]	2,296,000 - 7,437,000	5,198,916†
1999	8,248,000		3,639,922
1998	11,218,000		10,865,461†
1997	18,230,000	7,668,000 (p75)	16,377,339†
1996	1,560,000 (p75)	2,662,000 (p50)	4,482,908
1995	10,252,000		3,880,668†
1994	18,965,000		17,271,232†
1993	17,113,000		23,576,662†
1992	5,830,000		6,351,240†
1991	14,500,000		12,359,751†
1990	16,400,000		21,954,455†
1989	12,800,000		18,467,796†
1988	2,840,000		3,708,629†
1987	6,228,000		7,644,688†
1986	14,092,000		15,837,641†
1985			13,674,911

†Indicates that there are inconsistencies (usually minor, but more than just rounding) between the data used (see Footnote 383) and other sources.

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[383] Table 2, Pre-Season Forecasts for 2008 by Stock/Timing Group and Probability. Science Advisory Report 2007/xxx (draft) at 1. Document not yet available in Ringtail at the publication of this Policy and Practice Report.

[384] Forecast run-sizes were developed at the 50%, 60%, and 75% probability level. The forecast presented here is for the 50% probability level.

[385] Forecast run-sizes were developed at the 50% and 75% probability level. The forecast presented here is for the 50% probability level.

Table 4: Exploitation rates for Early Stuart, Early Summer, Summer and Late run-timing groups, Cultus for 1985-2009.[386]

Year	Average (%)	Early-Stuart (%)	Early-Summer (%)	Summer (%)	Late (%)	Cultus (%)
2009	8.6	11.3	9.9	11.3	4.5	7.1
2008	32.7	12.2	28.7	39.1	16.5	71.2
2007	24.8	7.6	27.1	32.1	17.4†	16.2†
2006	41.9	16.9	44.6	54.3	37.8	24.3†
2005	25.0	9.8	23.2	27.8	11.8	12.2†
2004	56.1	29.7	54.8	62.3	34.1	25.8
2003	48.0	3.8	50.6	54.7	35.2	24.3
2002	27.9	9.1†	43.0	37.7	18.7	13.7
2001	22.3	20.2	23.2	22.5	20.3	26.3
2000	47.1	59.8†	45.5	46.1	47.3	39.6
1999	15.4	15.6†	21.8	15.9†	12.9	12.4
1998	28.8	11.1	34.4†	34.7	19.5	14.8
1997	69.8	46.2†	69.6†	71.5	86.6†	90.6
1996	48.9	8.4†	32.5†	53.3	48.0	17.5
1995	55.4†	11.2†	46.0†	59.3	55.5†	46.7
1994	77.3	22.7	61.5†	74.2†	83.0†	81.1
1993	75.6†	40.3†	61.2†	76.2†	87.3†	90.2†
1992	76.9†	48.9†	76.6†	80.2†	72.2†	84.0
1991	73.3	72.5	67.3†	77.3†	70.2†	69.0
1990	72.4	37.3	67.6†	81.6	66.6	82.1
1989	83.4	68.3	85.0†	84.5	85.7	80.1
1988	63.1	18.9†	55.5†	58.4	81.2†	91.2
1987	75.1	16.6	68.8	79.2	75.5	68.0
1986	76.8	37.3	71.0	77.3	77.2	73.8
1985	84.8	34.3	79.0	86.3	85.8	56.1

†Indicates that there are inconsistencies (usually minor, but more than just rounding) between the data used (see Footnote 389) and other sources.

386 All values from this table are from the Sockeye Spreadsheet.

Table 5: Fraser River sockeye escapement, run-size and escapement as a proportion of run-size for 1985-2009.[387]

Year	Escapement	Run-size	Proportion
2009	1,050,126	1,443,120	72.8%
2008	815,472	1,753,866	46.5%
2007	889,286†	1,507,757	59.0%
2006	4,661,459	12,967,272	35.9%
2005	3,307,950	7,024,549	47.1%
2004	524,446	4,184,020	12.5%
2003	1,979,385	4,889,373	40.5%
2002	10,201,057	15,131,528	67.4%
2001	5,256,702	7,191,488	73.1%
2000	2,352,930	5,198,916†	45.3%
1999	1,832,759	3,639,922	50.4%
1998	4,418,998	10,865,461†	40.7%
1997	4,251,921	16,377,339†	26.0%
1996	2,027,534†	4,482,908	45.2%
1995	1,731,233	3,880,668†	44.6%
1994	3,128,543	17,271,232†	18.1%
1993	5,754,095†	23,576,662†	24.4%
1992	1,068,805	6,351,240†	16.8%
1991	3,306,272	12,359,751†	26.8%
1990	6,064,285†	21,954,455†	27.6%
1989	3,060,183	18,467,796†	16.6%
1988	1,370,339	3,708,629†	37.0%
1987	1,905,471†	7,644,688†	24.9%
1986	3,657,738	15,837,641†	23.1%
1985	2,077,686	13,674,911	15.2%

†Indicates that there are inconsistencies (usually minor, but more than just rounding) between the data used (see Footnote 387) and other sources.

[387] All values from this table are from the Sockeye Spreadsheet.

Other Commercial Fishery Models

Individual Transferrable Quotas (Shares)

300. In a competitive derby fishery, fishermen compete with one another for greater portions of TAC and fisheries managers attempt to control the “inputs” to fishing such as restricting fishing effort by number of vessels, fishing time, fishing area and gear-type. In contrast, with individual transferrable quotas or shares (“ITQ”), commercial fisheries are managed through the output of fishing, i.e. catch.[388] In ITQ fisheries, license holders do not compete for catch. Rather, each license holder is granted a defined share of the target catch before fishing begins. Each individual fisher is held accountable to keep his or her catch within his or her defined share.[389]

301. A competitive derby-style fishery has traditionally been the way the Fraser River sockeye commercial harvest has been managed and this type of fishery currently remains the primary commercial fishery model. However, in recent years ITQ fisheries have been introduced on a limited basis as demonstration fisheries (for example in 2010, the Area B Seine and Area H Troll fisheries were managed as ITQ demonstration fisheries).

Small Bite Fisheries

302. Small bite fisheries are smaller, but more frequent commercial fisheries intended to distribute the total allowable harvest across the entire run where possible.[390] Instead of one or two large openings like in the traditional purse seine model, a small bite fishery would have more openings that are time-restricted and conducted in a smaller area with a limited number of boats. One advantage of small bite fisheries is that fisheries could be opened to catch a portion of the TAC. The current management regime does not allow managers to control how many

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[388] Ringtail Document CAN003213 at 9.
[389] *Ibid*.
[390] Ringtail Document CAN036983 at 17.

vessels can fish during an opening and thus fisheries are often not opened if there is a risk of over-harvesting. Another potential benefit of a small bite fishery is the collection of continuous in-season information with respect to run-size and timing that could help improve stock assessment and decrease uncertainty around run-size assessments. Small bite fisheries could be implemented as either competitive derby or share-based (ITQ) fisheries.

Terminal Fisheries

303. Most Fraser sockeye are harvested in mixed-stock fisheries that are directed towards the most abundant stocks, but the return timing of larger stocks usually overlaps with less productive stocks and so there are only limited opportunities to protect small stocks through the use of spatial or temporal fishery closures. Given the co-migration of many Fraser stocks, some people view large, mixed-stock marine fisheries as incompatible with the conservation of stock biodiversity and or First Nations priority of access for FSC fish, particularly in middle to upper areas of the Fraser watershed where First Nations rely on small sockeye stocks for their FSC needs. One model that has been proposed to address these issues is a terminal fishery. In a terminal fishery (whether FSC and or commercial), stocks would be entirely or primarily harvested near the area in the watershed where they spawn. However, in the Fraser watershed even a terminal fishery would to some extent be a mixed-stock fishery given the geography of the river and the migratory behaviour of Fraser sockeye.

Appendix 1: List of Abbreviations

AFE – Aboriginal Fisheries Exemption

BC – British Columbia

BM1 – Benchmark 1

BM2 – Benchmark 2

BM3 – Benchmark 3

CCTAC – Canadian Commercial Total Allowable Catch

CPUE – Catch Per Unit Effort

CSAP – Centre for Science Advice – Pacific

CSAS – Canadian Science Advisory Secretariat

CTAC – Canadian Total Allowable Catch

DC – IFMP Development Committee

DFO – Fisheries and Oceans Canada

DIDSON – Dual-frequency Identification SONAR

DNA – Deoxyribonucleic Acid

EWatch – DFO’s Environmental Watch Program

FAM – Fisheries and Aquaculture Management

FRIMT – Fraser River Sockeye and Pink Salmon Integrated Management Team

FRP – Fraser River Panel

FRPTC – Fraser River Panel Technical Committee

FRSSI – Fraser River Sockeye Spawning Initiative

FSC – Food, Social and Ceremonial

IFMP – Integrated Fisheries Management Plan

IHPC – Integrated Harvest Planning Committee

IPSFC – International Pacific Salmon Fisheries Commission

ITQ – Individual Transferrable Quotas

JFC – Joint Fisheries Committee

MA – Management Adjustment

MGL – DFO's Molecular Genetics Laboratory

MHC – Major Histocompatibility Complex

PSARC – Pacific Scientific Advice Review Committee

PSC – Pacific Salmon Commission

R^2 – Coefficient of determination, R-squared

RMC – Regional Management Committee

RMEC – Resource Management Executive Committee

RMS – Record of Management Strategy

S-R – stock-recruitment

SACC – Stock Assessment Coordination Committee

SAR – Science Advisory Report

SFF – Sustainable Fisheries Framework

S_{max} – Capacity estimate of Fraser sockeye freshwater spawning or rearing habitat

SNPs – Single Nucleotide Polymorphisms

SWG – Salmon Working Group

TAC – Total Allowable Catch

TAM – Total Allowable Mortality

TFN – Tsawwassen First Nation

US – United States

USTAC – United States Total Allowable Catch