UFFCA
upper fraser fisheries conservation alliance

Nechako Fisheries Conservation Program

Chinook and Sockeye Salmon Conservation in the *Netʃa Koh* (Nechako) River in Northern BC

Chinook and Sockeye Salmon Conservation in the *Netʃa Koh*[1] *(*Nechako) River in Northern BC

A report prepared by the Upper Fraser Fisheries Conservation Alliance (UFFCA) and the Nechako Fisheries Conservation Program (NFCP)

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Summary

The productivity of many Fraser Chinook and sockeye salmon populations has been declining over the past several decades. This investigation was undertaken by the UFFCA and the NFCP to evaluate recent productivity changes in Nechako Chinook and the sockeye populations which utilize the Nechako River as a migration corridor.

The analysis considered trends in productivity for the Fraser Sockeye Aggregate population as well as the Early and Late Stuart populations which have been classified in the red-zone under the Wild Salmon Policy and designated as *Endangered* under COSEWIC. Throughout the Fraser River Watershed, sockeye productivity, as estimated by returns per effective female spawner, has dropped steadily over the past seven years and in 2017 Fraser Aggregate productivity was similar to the low level that triggered the Cohen Inquiry. Nechako Chinook status and management procedures were evaluated in relation to the Southern BC Chinook Strategic Planning Initiative (CSPI). The trends in Nechako Chinook spawner escapement have been mainly positive over the period of operation of the NFCP since 1988, however escapement to the river in 2017 fell to only 588 fish, the lowest since Kenney Dam construction in the 1950's. Comparison of the 2017 Nechako escapement with those of three other Upper Fraser Summer Chinook populations (Chilko, Quesnel and Cariboo) indicated that low Chinook productivity occurred regionally in the Upper Fraser and wasn't unique to the Nechako population.

The report considered the causes of the Fraser sockeye and Chinook declines in relation to the scientific results from the Cohen Inquiry into the Decline of Sockeye Salmon in the Fraser River and the analyses carried out by the Independent Advisory Panel convened under the CSPI. The conclusions of the Cohen Inquiry and the Independent Panel were similar. The Independent Panel implicated productivity decreases during early marine life history stages coupled with effects of climate change as being largely responsible for the declines Southern BC Chinook productivity. The Cohen Inquiry concluded that factors in freshwater and marine ecosystems likely contributed to the declines in combination with climate change. Common responses across population productivity patterns suggest that broad regional factors in either freshwater or marine ecosystems could contribute to reduced productivity.

The report has three main recommendations:

1. A recovery planning process for Early and Late Stuart sockeye is required to identify options for stock recovery in an era of changing climate and low marine and freshwater productivity;

2. There needs to be improved marine-based monitoring and assessment of Upper Fraser Chinook; and,

3. A feasibility evaluation is required for a Nechako Chinook Conservation Hatchery that would serve as a coded-wire tagging platform to improve the management of Upper Fraser Chinook.

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Introduction

The Nechako River in Northern BC supports an important Chinook salmon run and provides a migration corridor for sockeye salmon that spawn in tributaries of the Stuart and Nadina/Francois Basins (Figure 1). Since the early 1950's, following construction of the Kenney Dam, flows in the Nechako have been regulated by Rio Tinto Alcan (formerly Alcan) for hydropower production as part of the Kemano Power Development Project. In recognition of the sensitivity of Nechako Chinook and adjacent sockeye populations to flow regulation, flow management practices have been developed and implemented to support the conservation of Nechako salmon. Since 1987, the NFCP has operated an annual monitoring program, focussed on Nechako Chinook and migratory sockeye salmon designed to monitor the effectiveness of conservation measures specified in the *1987 Settlement Agreement* between Canada, BC and Alcan[5].

There have been steady declines in Upper Fraser River sockeye populations for several decades. Early Stuart and Late Stuart sockeye swim up the Nechako River en route to upstream spawning grounds and are highly prized by Upper Fraser First Nations[6]. Biological assessments under the Wild Salmon Policy have classified a number of Upper Fraser sockeye Conservation units as "red-zoned" and a recent COSEWIC[7] assessment classified both Early Stuart and Late Stuart sockeye populations as "*Endangered*". The Government of Canada is required to consider whether or not to list these two populations on Schedule 1 of the *Species at Risk Act* (SARA) within 18 months of COSEWIC's assessment report.

Aboriginal fisheries organizations active in the Nechako River watershed include individual First Nation communities, the Carrier Sekani Tribal Council and the Upper Fraser Fisheries Conservation Alliance (UFFCA). In view of the shared focus of both the NFCP and the UFFCA on conservation, the two agencies decided to collaborate on a joint technical analysis of Nechako Chinook and sockeye fisheries management. The technical focus reflects that both the NFCP and the UFFCA are not decision-making agencies and serve as advisory bodies that provide technical support to their respective members.

Specific objectives of this project include:

- Evaluate the status, management and conservation initiatives for Chinook and sockeye salmon that utilize the Nechako River;
- Evaluate and summarize regional trends for Chinook and sockeye production in the Fraser River;
- Review Chinook and sockeye monitoring practices and trends, including an evaluation of the sensitivity of Chinook escapement monitoring as an index for detecting run size changes;
- Evaluate potential stressors on Nechako salmon productivity including climate change and marine survival variations; and,
- Provide recommendations for improved conservation practices.

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[5] NFCP History Report

[6] UFFCA Technical Report

[7] Committee on the Status of Endangered Wildlife in Canada

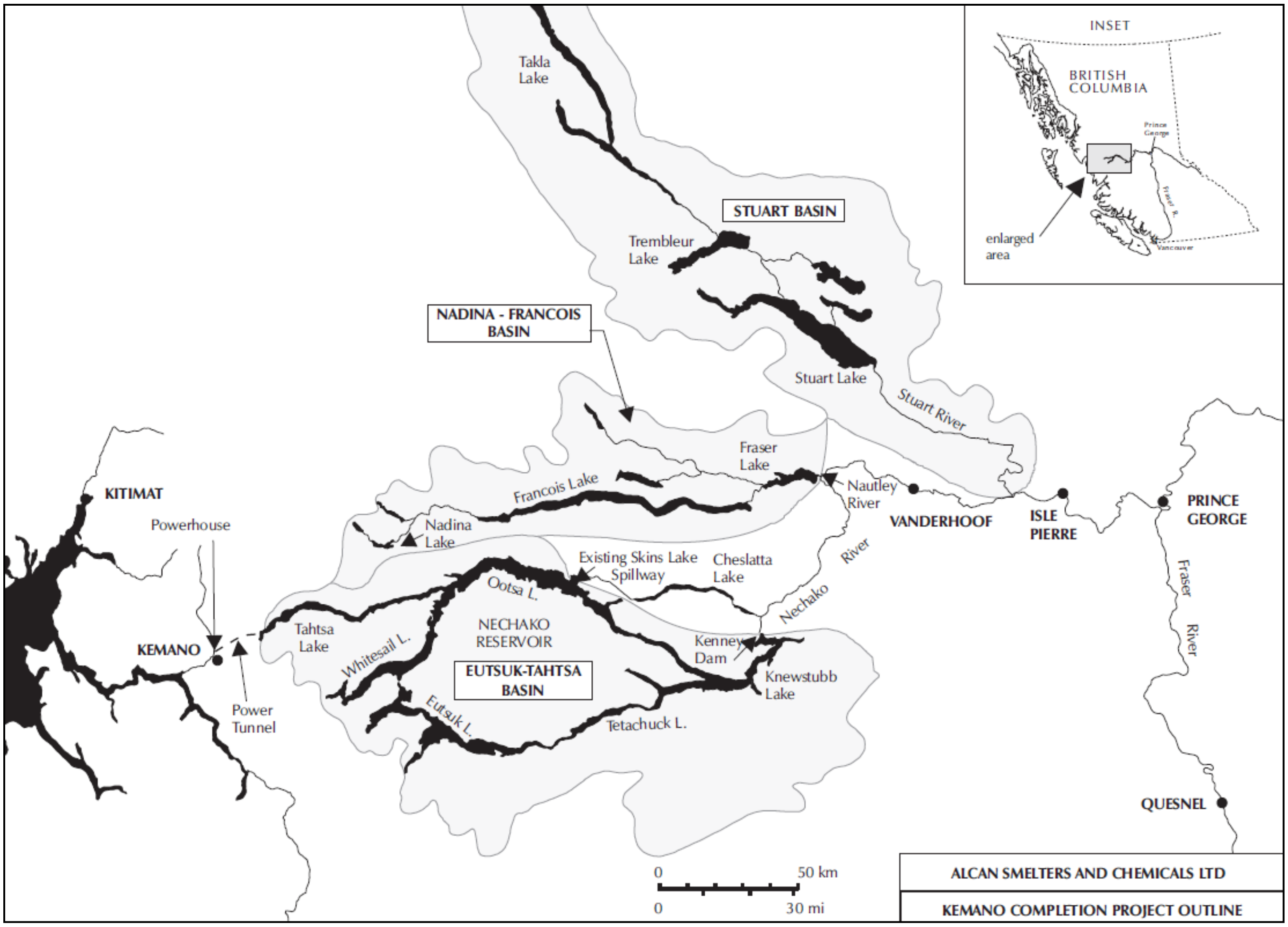

Figure 1. Location of the Kemano Project and the Nechako River in northern BC. Source: NEEF (2001)[8].

[8] NEEF Summary Report

The NFCP Mandate

The Nechako Fisheries Conservation Program[9] was established to implement the *1987 Settlement Agreement* between Canada, B.C. and Alcan The Agreement anticipated modified flows in the Nechako River associated with the Kemano Completion Project (KCP)[10] and the construction of a Kenney Dam Release Facility (KDRF)[11]. The Program was developed to implement an integrated set of monitoring, applied research and remedial measures to ensure the conservation of Nechako Chinook and sockeye salmon that utilize the river as a migration corridor[12]. When the KCP was cancelled by the Province of BC in 1995, the NFCP continued its work in anticipation of altered flows associated with a potential KDRF. Presently, the NFCP operates a base program involving flow management of the Nechako River, Chinook salmon escapement monitoring and communications activities in Northern BC.

The main goals and objectives of the NFCP include:

- Develop and implement a program of remedial measures, monitoring and applied research projects as deemed necessary to ensure the conservation and protection of the Chinook fisheries resource of the Nechako River (the Conservation Goal);
- Ensure that changes to instream habitat conditions do not jeopardize the population of Chinook in the Nechako River;
- Oversee flow management in relation to the Annual Water Allocation;
- Manage the operation of the computer models and protocols necessary to reach decisions on the daily release of cooling water from the reservoir during July and August (Summer Temperature Management Program) to control water temperature in the Nechako River to protect migrating sockeye salmon.

The principal monitoring method in relation to Chinook conservation is to annually estimate and report on Chinook escapement in the river. Escapement estimation methodology has evolved over time and formerly involved Area-Under-the-Curve and Maximum Likelihood Analysis procedures. That method relied upon sequential helicopter overflight counts and an estimate of the residence time of female Chinook in the vicinity of spawning redds. The NFCP conducted escapement surveys between 1988 - 2015. Starting in 2015, the Stock Assessment Division of DFO assumed responsibility for the program and has subsequently provided the estimates based on two overflight surveys and the Peak count expansion method[13].

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[9] NFCP Website

[10] NFCP Technical Data Review

[11] NEEF Summary Report

[12] NFCP History Report

[13] NFCP Technical Data Review

The UFFCA Mandate

The Upper Fraser Fisheries Conservation Alliance[14] promotes accountability in the conservation, protection and sustainable harvest of Upper Fraser fish populations as well as the health of the ecosystem upon which they depend. The UFFCA provides advice and support services to UFFCA member communities (approximately 27 First Nations Communities and Organizations are eligible for participation) on a range of issues from conservation and harvest planning and fisheries management, to environmental assessments and field science. The Alliance's role is to support community-based initiatives, which support the overall UFFCA strategic plan. The Alliance also assists with procuring resources for science and research while developing a continuous program of capacity development.

Further, the Upper Fraser Fisheries Conservation Alliance is a working group that functions without prejudice to Aboriginal rights, including title; through a cooperative agreement with Participating Aboriginal Organizations in the Upper Fraser River Watershed, the parties commit to an open and transparent process that:

- Develops and implements co-operative management for the protection of fish species and the ecosystems upon which fish depend by taking an integrated approach with Aboriginal Organizations in the Upper Fraser River and where appropriate, other parties with an interest in fish;

- Coordinates funding to support the group's initiatives, make better use of resources available, and to eliminate funding competition (where possible) amongst the Parties;

- Benefits aboriginal organizations and their membership by identifying and developing economic opportunities associated with fisheries resources;

- Achieves consensus on short term (up to five years) and long-term (five years and longer) objectives; and

- Develops and implements plans based on the best available science and Aboriginal Ecological Knowledge. UFFCA activities do not limit or replace any bilateral process, interim measure, or other negotiated agreement.

The UFFCA is currently in the process of updating its Strategic Plan and will be improving the Organization's description, mission statement and expanded operations as a result of increased capacity and suite of experience with First Nations.

[14] UFFCA Website

Chinook Salmon

NFCP Chinook Salmon Escapement Monitoring

The *1987 Settlement Agreement* sets out a "Conservation Goal," defined as:

> *… the conservation on a sustained basis of the target population of Nechako River Chinook salmon including both the spawning escapement and the harvest as referred to in paragraph 3.1 of the Summary Report….The total population of Chinook to be conserved is that represented by the average escapement to the river plus the average harvest during the period 1980-1986. Department of Fisheries and Oceans escapement records during this period averaged 1,550 with a range of 850-2,000. In view of the known inaccuracies in spawner count data the working group recognizes that the estimated escapement is on average 3,100 spawning Chinook, but ranges from 1,700 to 4,000. This number is referred to as the target population.*

The highest chinook escapements to the mainstem of the Nechako River before the inception of the NFCP were recorded in 1951 (3,500) and 1952 (4,000) prior to construction of Kenney Dam and the regulation of the Nechako River (Figure 2). Based on information from Jaremovic and Rowland (1988) [15], escapements fell ten-fold with the closure of the dam (1952), but between 200 and 1,500 spawners were reported in the next four years (1953 to 1956) as the last progeny of the pre-dam era returned to spawn. By the fifth year, 1957, no spawners were reported and none were observed in 1958 and 1959. Then in 1960 a total of 75 spawners were reported; escapements slowly increased thereafter. In recent years many annual escapements have exceeded the recorded pre-dam escapements.

The trend in Chinook escapement estimates since 1988 when the NFCP began to enumerate spawners (Figure 2) indicates that the Conservation Goal has generally been met with the exception of 5 years: 1994, 1995, 2007, 2012, 2013 and 2017. The highest escapement over the duration of NFCP monitoring (1988 - 2015) occurred in 2015 when 8,300 spawners were enumerated. In 2017, the recorded escapement was 588 spawners, the lowest observed over the NFCP monitoring period (1988-present).

[15] Review of Nechako River Chinook Salmon Escapements

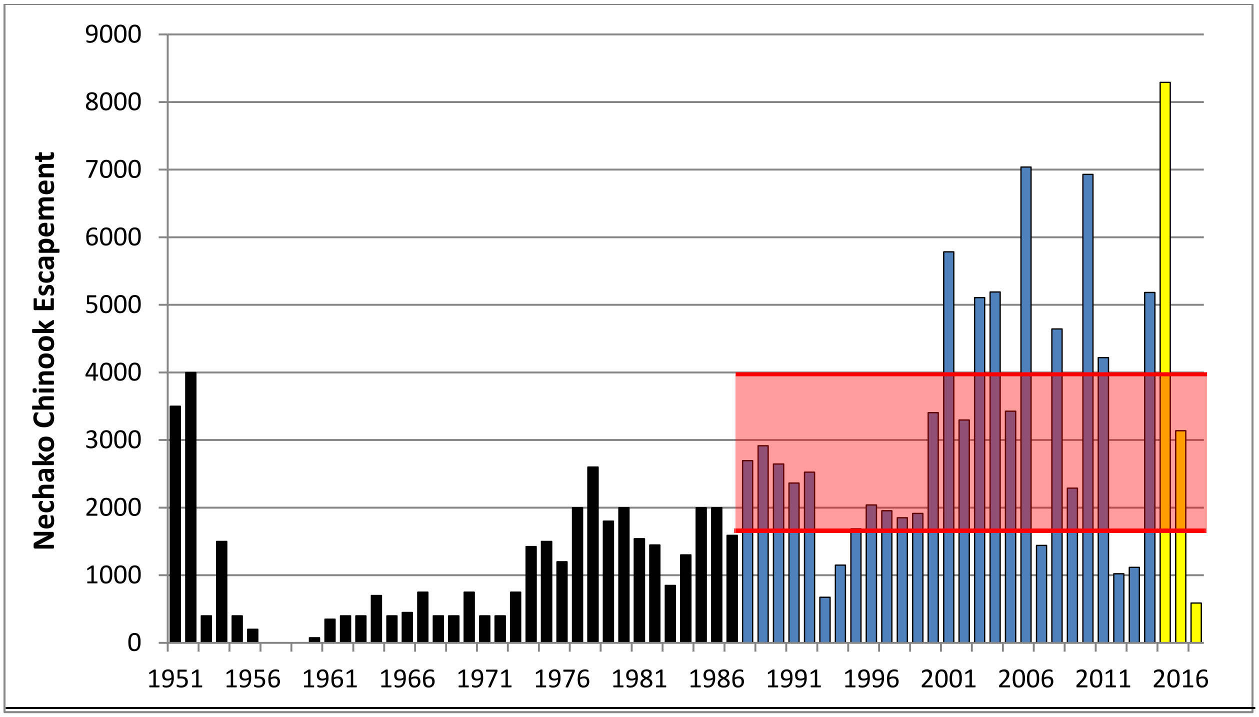

Figure 2. Time series of Chinook escapements to the Nechako River between 1951 - 2017. Black shaded bars indicate pre-NFCP monitoring data from Jaremovic and Rowland (1988); blue bars indicate NFCP monitoring results and yellow bars are DFO estimates provided by the Stock Assessment Division. Red-shaded rectangle indicates the upper and lower limits of the Conservation Goal established as part of the *1987 Settlement Agreement*.

Conservation

Wild Salmon Policy

The Wild Salmon Policy (WSP) was finalized in 2005 following six years of drafting and consultation. At the time, it was viewed as a transformative policy that would effectively conserve and protect Pacific salmon biodiversity and support sustainable salmon fisheries.

A key foundation of the WSP is that wild salmon are maintained by identifying and managing "Conservation Units" (CUs) that reflect their geographic and genetic diversity. A CU is a group of wild salmon sufficiently isolated from other groups that, if lost, is very unlikely to recolonize naturally within an acceptable timeframe (e.g. a human lifetime or a specified number of salmon generations). Under the WSP, the status of CUs are monitored, assessed against selected benchmarks and their status reported publicly. Where monitoring indicates low levels of abundance of a CU, a full range of management actions to reverse declines including assessment of habitat, enhancement and harvest measures will be assessed to guide and implement appropriate management measures to restore the health of the CU.

In the original WSP there were six strategies and action steps within the policy which provide the framework for WSP implementation. These will be streamlined in a revised version of the WSP to be finalized later in 2018.

Strategy 1	Monitoring of wild salmon status (CUs) • identify conservation units • develop criteria to assess CUs and identify benchmarks to represent biological status • monitor and assess status of CUs
Strategy 2	Assessment and monitoring of habitat status • document habitat characteristics within CUs • select indicators and develop benchmarks for habitat assessment • monitor and assess habitat status • establish linkages to develop an integrated data system for watershed management
Strategy 3	Inclusion and monitoring of ecosystem values • identify indicators to monitor status of freshwater ecosystems • integrate climate and ocean information into annual salmon management processes
Strategy 4	Integrated Strategic Planning • implement an interim process for management of priority CUs • design and implement a fully integrated strategic planning process for salmon conservation

Strategy 5	Annual program delivery • assess the status of CUs and populations • plan and conduct annual fisheries • plan and implement annual habitat management activities • plan and implement annual enhancement activities
Strategy 6	Performance review • conduct post-season review of annual workplans • conduct regular reviews of the success of the WSP

Under the WSP, status assessments are undertaken to classify CUs into one of three assessment categories shown below.

Status		**Definition**
	Red	"… established at a level of abundance high enough to ensure there is a substantial buffer between it and any level of abundance that could lead to a CU being considered at risk of extinction by COSEWIC"
	Amber	"While a CU in the Amber zone should be at low risk of loss, there will be a degree of lost production. Still, this situation may result when CUs share risk factors with other, more productive units"
	Green	"identifies whether harvests are greater than the level expected to provide on an average annual basis, the maximum annual catch for a CU, given existing conditions…there would not be a high probability of losing the CU"

Assessment actions that are prescribed under the WSP include:

Status		**Assessment Actions**
	Red	"...a detailed analytical assessment will normally be triggered to examine impacts on the CU of fishing, habitat degradation, and other human factors, and to evaluate restoration potential...detailed stock assessments will identify the reasons for the change in status...CUs in the red zone ...will be identified as management priorities...the protection and restoration of these CUs will be primary drivers for harvest, habitat, and enhancement planning"
	Amber	"...a detailed analytical assessment may be required to input into Strategies 2 and 3"
	Green	"...a detailed analytical assessment of its biological status will not usually be needed"

Since 2005, there have been a number of challenges associated with the WSP[16]. These include the slow preparation of an implementation plan (to be finalized in 2018). There are also unresolved issues in relation to the implementation of Strategy 3, Integrated Strategic Planning, and the role of CUs in harvest management.

Ecosystem effects related to climate change and reduced marine survival are largely outside of the influence of management. BC salmon habitats are warming to the detriment of salmon and this challenges the sustainability of salmon populations. The WSP is uniquely structured to reflect management approaches suited to these challenges.

> *The WSP will have limited ability to directly protect salmon from climate change, but the policy's premise – to protect diversity and their habitats – is critical to allowing Pacific salmon to adapt to future changes. By maintaining the genetic diversity of wild salmon and the integrity of their habitat and ecosystems, the WSP will help ensure viable wild salmon populations in the future. At the same time, while salmon adjust to these pressures, managers could expect productivity and allowable catches to decline. The importance of protecting diversity and maintaining healthy diverse populations of fish was also recognized as an important strategy in a recent federal government report on climate change impacts and adaptation.*

The spatial distribution of Fraser River and Vancouver Island Chinook CUs is shown in Figure 3. Nechako Chinook, by virtue of their return timing and distribution, are part of the Middle Fraser River Summer CU. Other Chinook populations within this CU include Cariboo, Chilko, Elkin, Pinchi, Quesnel, Stuart, Tachie and Taseko. The status of the Middle Fraser Summer Chinook CU was assessed as amber in 2016 (Figure 4), however the low escapement of Chinook in the Nechako and other MFR Summer Chinook stocks in 2017 implies that this CU may need be re-classified as red-zoned if the declines persist.

There is widespread recognition that Southern BC Chinook populations, including those in the Fraser Watershed, have been declining. This has triggered a number of assessment and planning processes, including an Independent Advisory Panel Report and the Southern BC Chinook Strategic Planning Initiative.

[16] Wild Salmon Policy: Assessment of Conservation Progress

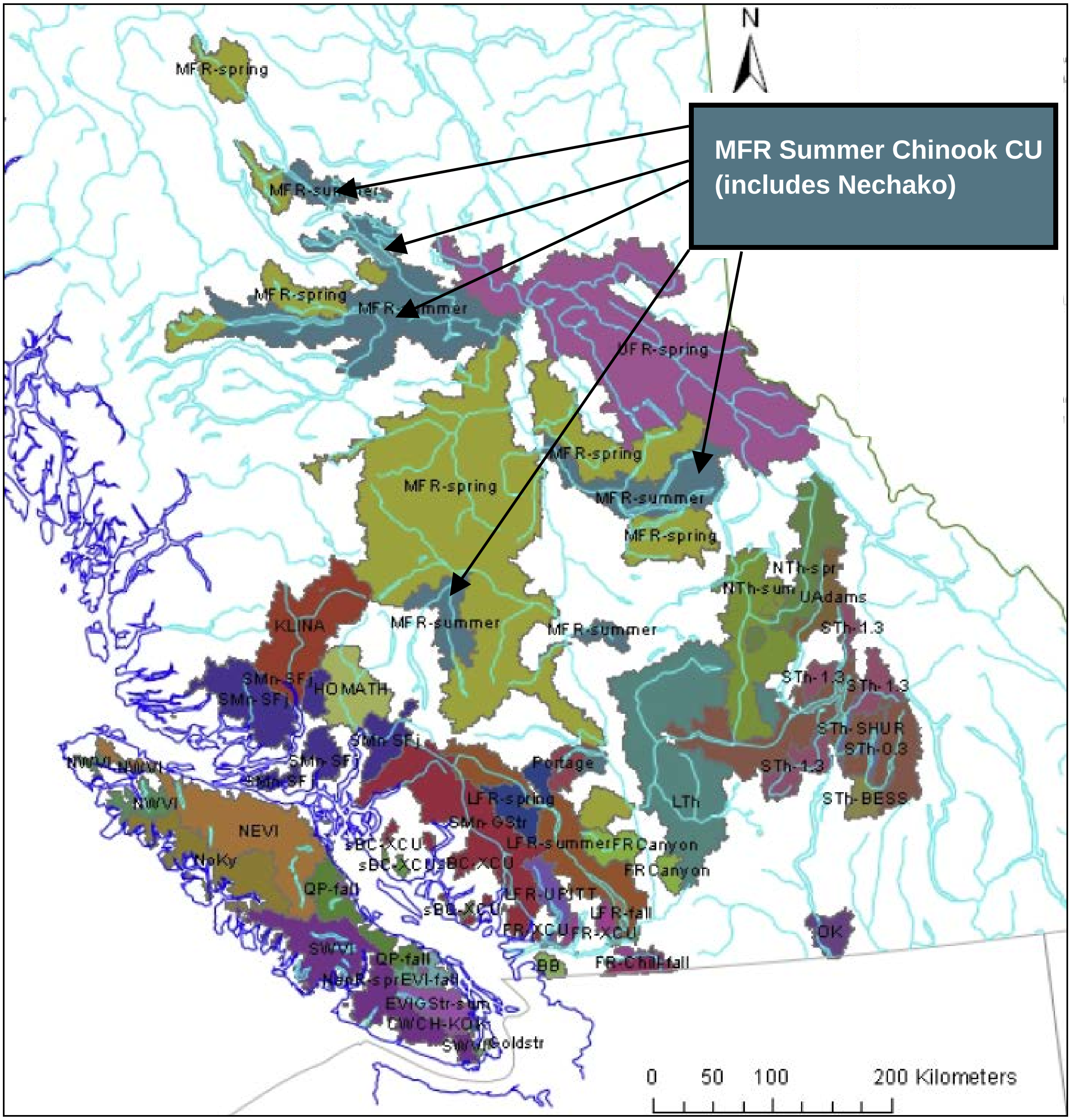

Figure 3. Spatial distribution of 35 Southern BC Chinook Conservation Units[17].

[17] Source: J. Grout. DFO. "Southern BC Chinook Planning" Presentation to the FNFC AGA Nov. 8, 2016

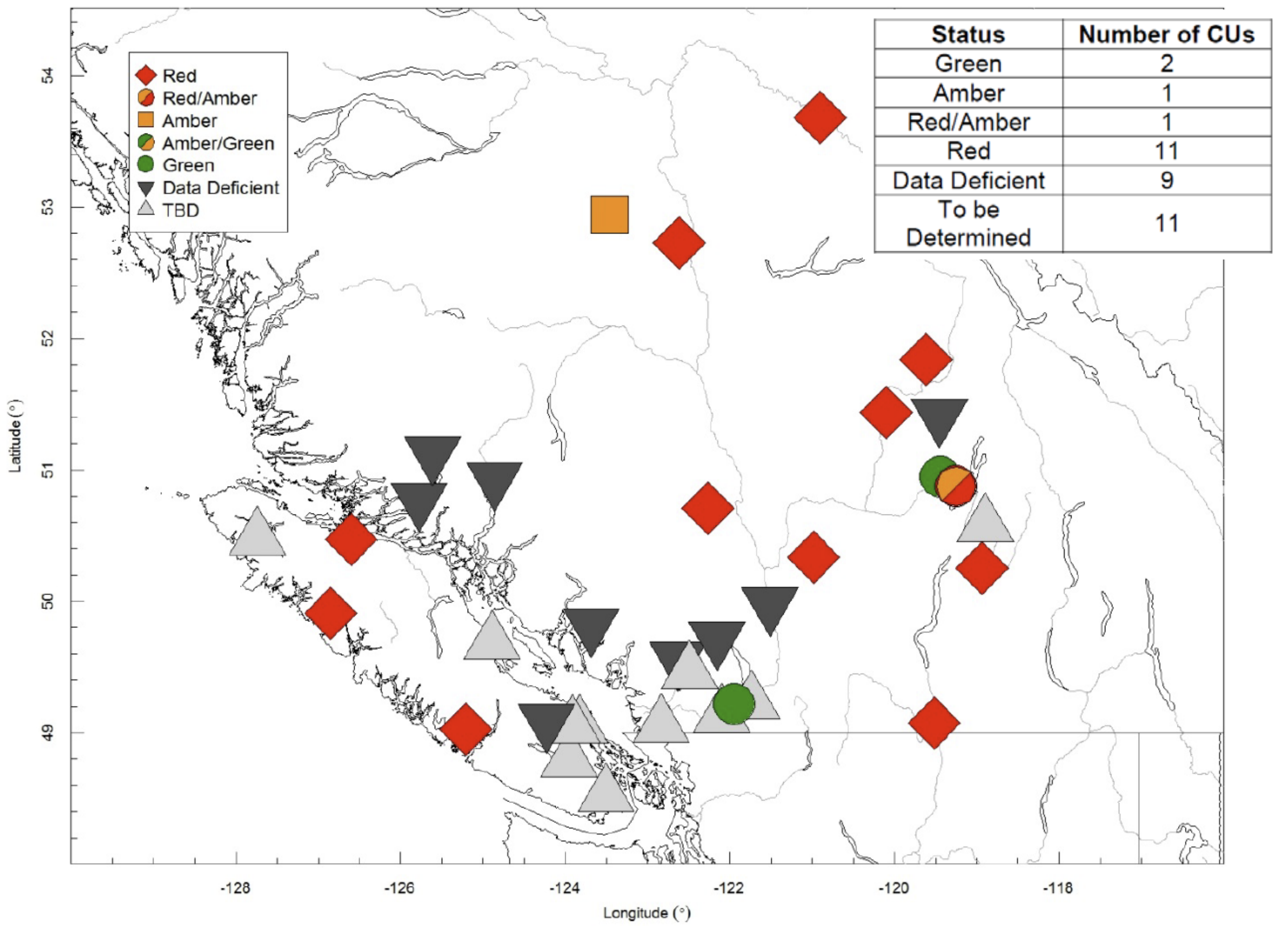

Figure 4. Map of southern BC summarizing DFO workshop consensus on biological status of southern BC Chinook Salmon CUs[18] as of 2016. The amber square box reflects the status of the MFR Summer Chinook CU.

[18] WSP Status of Chinook Salmon in Southern BC

Independent Advisory Panel

In response to growing evidence that Southern BC Chinook salmon are declining, DFO and the Fraser River Aboriginal Fisheries Secretariat convened a scientific workshop between May 22-24, 2013. As part of the investigation, an Independent Advisory Panel was convened to evaluate the relative importance of different factors that may have affected the abundance and productivity of southern BC Chinook salmon[19]. The Independent Panel included six pre-eminent fisheries scientists who reviewed the available evidence related to the underlying causes for the Chinook decline. The following text provides a synopsis of their main findings.

1. Harvest Rate

Catches of BC Chinook have declined over time primarily due to a reduction in commercial landings. Coded Wire Tagging data for Indicator stocks demonstrated that exploitation rate of Southern BC Chinook declined from an average of 75% to an average of 45% between 1973 and 1993. In spite of the reductions in exploitation rate many Chinook stocks have continued to decline. Evidence suggests that most southern BC stocks have experienced reductions in marine survival that have undermined stock productivity, implying that even reduced harvest rates may be too high and are contributing to additional declines in escapements. The Panel suggested methods that may permit more rigorous assessment of Chinook productivity changes in future.

2. Freshwater Habitat

Freshwater habitat degradation could potentially cause a decline in Chinook productivity either via continuous degradation of freshwater habitats through natural causes and/or negative interactions with human-induced stressors e.g. pollution, habitat alienation. Southern BC Chinook CUs show a synchronous decline in freshwater productivity, so there would need to be large-scale freshwater environmental forcing to cause coherence in decreased spawning and freshwater rearing habitat quality.[20] Therefore it seems unlikely that freshwater stressors are sufficient to explain the Southern BC Chinook decline and should be considered as secondary modifiers of production. The Panel indicated that stream discharge and water temperatures can be impacted by flow regulation in many rivers, particularly on Vancouver Island, but the impacts on Chinook production were difficult to elucidate. They concluded that there are no obvious freshwater environmental drivers that could explain recent trends in Chinook salmon spawner abundance.

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[19] Southern BC Chinook Independent Advisory Panel Report

[20] A similar conclusion was reached by the Cohen Inquiry on Fraser sockeye salmon with respect to freshwater habitat conditions.

The main freshwater information gaps included the linkage between river temperature and flow conditions and the survival of spring and summer Chinook smolts, especially in view of future climate change projections[21].

3. Marine Habitat

With the exception of the Thompson summer CU and other salmon stocks with early (prior to May) or late (July or later) entry timing into the Strait of Georgia, Southern BC (SBC) Chinook have shown a synchronous decline implying a mortality factor or production bottleneck in a shared habitat. This implicates marine habitat conditions as the main driver of Chinook productivity variations.

Climate indices, e.g. the North Pacific Gyre Oscillation (NPGO), show cyclic variation over time and influence conditions in marine habitats occupied by salmon. The patterns of the NPGO correlate strongly with a widely shared trend in marine survival derived from dynamic factor analysis. The analysis is complicated since physical and biological oceanographic conditions vary greatly at regional and local scales. Both local and basin-scale oceanographic conditions affect marine survival. Conditions in the marine environment during the first year of marine residency of SBC Chinook salmon appear to act as a key driver in survival and productivity trends. There is strong evidence of direct effects of local marine conditions on the survival of Chinook salmon, especially within the Salish Sea.

Chinook predators may directly affect salmon survival. A number of SBC marine mammal predator populations e.g. seals and sea lions, have increased significantly in recent decades. The Panel concluded that marine mammal predation may now be a more significant mortality factor than fishery removals for SBC Chinook salmon, however, total mortality rate due to both predation and fishing is considerably lower in recent years than pre-1990. The Panel concluded that because total mortality rates from both these sources declined substantially from approximately 1980 through 2003, it is unlikely that these combined factors were driving the general decline in SBC Chinook abundance since 1995.

The life history phase most likely to explain the decline in productivity of SBC Chinook salmon is the first year of ocean residency. Better understanding of ecological processes affecting juvenile life history in the marine environment could contribute to improved Chinook fisheries management practices,. The Salish Sea Marine Survival Project, operated by the Pacific Salmon Foundation is currently carrying out a 6-yr integrated research program (2012-2018) to investigate juvenile salmon ecology in the Salish Sea which will provide relevant information to inform future management response strategies for SBC Chinook. This includes tracking juvenile Chinook marine survival via coded-wire tagging and tag recovery of hatchery indicator stocks. The Panel commented that coded-wire tagging of selected wild stocks should also be

[21] The Nechako is somewhat unique in the Fraser Watershed as river temperatures and flows are closely monitored by the NFCP. The Summer Temperature Management Program collects relevant Nechako River data during the Chinook migration period, however to date this information hasn't been utilized for Mid-Fraser Spring and Summer Chinook fisheries management.

considered in future to provide information on marine survival for CUs that are not represented by hatchery indicator stocks. They called for better estimates of mortality rates and their inter-annual variability to provide insight into the mechanisms affecting marine survival.

4. Hatcheries

The Panel made reference to the WSP that requires hatchery management in a manner which is consistent with the conservation of wild salmon populations. The evaluation identified concerns related to the compatibility and coordination of the DFO Salmonid Enhancement Program with the objectives of the WSP. In particular, serious risks were identified for "wild" populations where there are high hatchery proportions in the enhanced populations and low proportions of wild salmon as well as straying of hatchery fish into “wild” unenhanced populations. This is a major concern in West Coast Vancouver Island and Strait of Georgia Chinook CUs that have extensive hatchery programs. In the Middle-Upper Fraser River, Thompson River, and Lower Fraser CU groups, hatchery programs have been reduced to levels where risk is small. The Panel called for an independent comprehensive assessment of hatchery programs cutting across the range SBC Chinook salmon CUs to improve monitoring programs and develop the essential actions needed to reform hatchery operations.

The Panel concluded that there was insufficient information to assess the degree to which hatcheries have been a stressor and contributor to observed declines in SBC Chinook salmon. A suite of monitoring strategies and research activities were proposed to improve the ability to understand and manage the interactions between hatchery practices and wild Chinook salmon production.

5. Pathogens

Existing information was insufficient for the Panel to draw any conclusions on whether pathogens and associated diseases have contributed to the reduction in Chinook production in Southern BC. A number of plausible mechanisms were identified e.g. effects on swimming ability, growth and reproduction, but appropriate quantitative evidence regarding the distribution, magnitude and frequency of either direct or indirect impacts was unavailable.

The Panel recommended improvements in monitoring of pathogens and disease occurrence in both hatcheries and natural populations particularly for Chinook pathogens. Additionally, more research was identified to address the dynamics of disease expression, interactions with environmental conditions and the potential role of hatcheries in the persistence of pathogens and risk of transmission to natural populations. The Panel also recommended more in-depth consideration of the interaction between salmon farm pathogens and the hatchery and natural populations of Chinook salmon.

6. Climate Change

The Panel concluded that it is highly likely that climate variation and change has been a factor influencing Chinook productivity in the past and will have increasing impacts in the future. Effects are likely mediated through changes in temperature, stream flow volume and seasonality, reductions in glaciers, increases in pathogens, non-indigenous species and contaminants as well as changes in the marine environment. Climate change effects in the Fraser River mainstem include an earlier-timed freshet and a significant increase in summer temperatures. Further, most SBC Chinook populations have been faced with increasingly stressful thermal conditions during return migrations and projected future warming will increase stress on SBC Chinook populations.

The Panel recommended an analysis of past and potential future impacts of climate change on SBC Chinook salmon that considers the diversity of life history types, the complex topography of SBC and diversity of stream types and the potential for behavioural adaptation of Chinook to respond to changing conditions. The need for a strategic plan and an effective monitoring design was identified. A detailed assessment would include designation of ‘indicator stocks' or populations strategically situated to represent the major life history types of Chinook salmon. Other factors that would need to be considered include annual variation in freshwater and marine survival; exploitation estimates including total fishing mortality by age; quantitative monitoring of spawning escapements by age (including losses during up-stream migration, retention of eggs and pre-spawning mortality of females), and hatchery produced first-generation returns.

7. Overall Conclusions

Within SBC, the clearest indication of the decline in Chinook salmon is within the Fraser River. However, the Panel could not attribute particular causes to the declines other than inferring that low early marine survivals and climate variations have been primary contributing factors and there have likely been secondary contributions from each of the other factors considered at the workshop (harvests, freshwater habitats, hatcheries, pathogens, and climate change and variation). Due to the complexity associated with the fisheries assessment process, it was not possible to quantitatively assess the relative likelihood of different factors contributing to trends in the productivity of SBC Chinook salmon stocks. The Panel did, however, identify factors that likely contributed to the decline in spawning abundance over the past 12 to 15 years.

Habitat considerations included freshwater, estuarine and marine habitats and freshwater habitats utilized for spawning, rearing and migration. However, there was no evidence to suggest that the variation in patterns of decline or increase observed in recent years among CUs is related to land-use activities and water uses. For marine habitats, environmental conditions during the first year of marine residency of SBC Chinook salmon were considered to be a key driver of recent trends in survival and productivity. Both local and larger scale oceanographic conditions are likely involved. In general, smaller fish have higher natural mortality rates than large fish which supports the Panel's primary research recommendation to focus on early marine periods.

The highest priority follow up from the analysis was for DFO and collaborating entities to undertake a critical review of available assessment data and to identify future data and research needs. To monitor the status of CUs and explain causation, a strategic design is needed for an evaluation framework that includes an integrated evaluation of status, ocean conditions, hatcheries, pathogens, freshwater habitat, and harvest for SBC Chinook that are scaled to a monitoring level that will be maintained annually. The Panel recommended new, more collaborative and inclusive processes to address these needs integrating the strengths and resources of First Nations, universities, and other NGOs and communities within a well-designed assessment and monitoring framework. They envisaged the establishment of an integrated network of communities to support DFO and help to maintain abundant and productive Chinook salmon populations.

Southern BC Chinook Strategic Planning Initiative

The Southern BC Chinook Strategic Planning Initiative (CSPI) was initiated in 2011, and is both a process and an assemblage of information as a result of the process. The culmination of the CSPI will be the completion of the *Integrated Strategic Plan for Southern BC Chinook*[22]. This report remains a "Working Draft" due to on-going work and the "living" nature of Chinook management. This section summarizes key pieces of information from the Strategic Report, some of which are taken directly from that document.

The following is an excerpt from CSPI Strategic Plan, and outlines the structure and context of the process, as well as providing context of the CSPI in terms of its' relationship to the Wild Salmon Policy and international management.

> *"The Strategic Plan is nested under the auspices of the Southern BC Chinook Strategic Planning Initiative (CSPI), a bilateral planning process led by First Nations and DFO, with collaboration from multiple interest groups. A DFO/First Nations bilateral steering committee oversees the overall process. The Steering and Planning Committee (SPC) is responsible for the governance of the CSPI process, as per the Terms of Reference, and providing guidance for the development of the Strategic Plan. The SPC includes representatives from First Nations, DFO, the recreational and commercial fishing sectors, and non-governmental organizations. Within the governance structure of the CSPI, the SPC also oversees the activities of the Technical Working Group (TWG), which is composed of scientists and technical experts from DFO, First Nations and other interested parties. The TWG coordinates scientific analyses to evaluate the status of Southern BC Chinook, examines causes for their decline and will continue to support the strategic planning process (e.g. developing performance indicators, analyzing options developed by the SPC, and synthesizing results to facilitate decisions by the SPC)."*

[22] Fraser River Aboriginal Fisheries Secretariat

The overarching objective of the CSPI is:

> *"To develop an Integrated Strategic Plan that accounts for the biological status of southern BC Chinook conservation units, their habitat and the ecosystem, that addresses the causes of any declines, and identifies the management actions necessary to remedy their status where possible. This initiative will depend on the collaboration of First Nations, interest groups and DFO to identify rebuilding actions related to fisheries management, salmonid enhancement and habitat restoration.*
>
> *Deliverables from this process will provide guidance to annual Integrated Fisheries Management Plans, fish culture production plans, habitat restoration work plans and community partnership agreements where possible. It may also inform Pacific Salmon Treaty discussions between Canada and the United States.*
>
> *This strategic plan will be developed in a manner consistent with Strategy 4 of the Wild Salmon Policy, the [DFO's] Rebuilding Guidelines of the Precautionary Approach Framework and the Species at Risk Act."*

The CSPI (Table 1) is a unique process and provides an example of a government-to-government (First Nations - Canada) process where other interested stakeholders have been invited to participate.

Table 1. Goals and objectives associated with the Wild Salmon Policy and the Chinook Strategic Planning Initiative.

Policy or Process	Goals	Objectives
WSP	Restore and maintain healthy and diverse salmon populations and their habitats for the benefit and enjoyment of the people of Canada in perpetuity.	1. Conserve the diversity, distribution and abundance of wild Pacific salmon 2. Maintain habitat and ecosystem integrity 3. Manage fisheries for sustainable benefits
CSPI	Develop an Integrated Strategic Plan that accounts for the biological status of southern BC Chinook conservation units, their habitat and the ecosystem, that addresses the causes of any declines, and identifies the management strategies necessary to remedy their status where possible.	Deliverables from the CSPI process will provide guidance to annual Integrated Fisheries Management Plans, fish culture production plans, habitat restoration work plans and community partnership agreements where possible. It may also inform Pacific Salmon Treaty discussions between Canada and the United States.
Strategic Plan	To restore and maintain the abundance, distribution and diversity of southern BC Chinook salmon for all that rely on them.	Biological/ecological, social, and economic objectives

The Strategic Plan is organized into seven sections:

- **Section 1** introduces the document, including the broader context for the plan and the scope of the current plan;
- **Section 2** summarizes the current state of knowledge about the status and trends of southern BC Chinook;
- **Section 3** describes major threats that may be contributing to the observed trends in southern BC Chinook, as well as major gaps in our knowledge about the trends, the threats, and potential management actions;
- **Section 4** outlines an objectives hierarchy, with objectives for the strategic plan and potential indicators and performance measures;
- **Section 5** identifies a comprehensive set of strategies to address the objectives, threats and knowledge gaps;
- **Section 6** provides a preliminary foundation for the implementation of the strategic plan; and,
- **Section 7** introduces the need for reviewing the performance of the overall plan over time.

Section 4 of the document lists a set of hierarchical objectives prioritized by the CSPI Steering and Planning Committee. These objectives align with the Wild Salmon Policy and the strategic planning document identifies strategies, indicators, performance measures and fundamental objectives for Southern BC Chinook.

Priority Objectives identified under CSPI are:

1. Maintain habitat and ecosystem integrity
2. Conservation - maintain genetic integrity
3. International management - PST obligations
4. First Nations - honour obligations to First Nations
5. Recreational Fisheries - maintain/enrich/increase specified components
6. Commercial Fisheries - maintain/increase specified components
7. Other Fisheries Benefits - reduce management uncertainty, reduce management costs, sustain connection with salmon

Section 5 of the Strategic Planning document outlines strategies to meet the objectives outlined above. The strategies are divided into two general categories (Table 2):

- Process strategies, and
- Learning and Action Strategies.

Table 2. High-level summary of the CSPI strategies. Each strategy is stated in its simplest form.

PROCESS STRATEGIES	
COMMUNICATION, INFORMATION AND COLLABORATION	
Strategy 1	Develop a communication plan for outreach and education about the Strategic Plan
Strategy 2	Develop and implement a data sharing plan
Strategy 3	Promote and encourage local and regional collaborative relationships
Strategy 4	Integrate First Nations Traditional and Local Ecological Knowledge
ASSESSING THE BENEFITS, COSTS AND EFFECTIVENESS OF ACTIONS	
Strategy 5	Implement action-based strategies in a way that allows learning about the effectiveness of actions
Strategy 6	Assess benefits and costs with respect to all affected groups and interested parties
LEARNING AND ACTION STRATEGIES	
MARINE HABITAT AND ECOSYSTEM	
Strategy 7	Protect marine and estuarine habitat important to Chinook salmon
Strategy 8	Improve understanding threats and limiting factors in early marine and estuarine habitats and mitigate
Strategy 9	Improve understanding and mitigation of impacts of disease on Chinook salmon
FRESHWATER HABITAT AND ECOSYSTEM	
Strategy 10	Protect freshwater habitat across CUs, migratory routes and rearing areas to support resilience and diversity
Strategy 11	Identify and remedy threats to freshwater habitat
Strategy 12	Integrate information on upstream and pre-spawn mortality into harvest planning
SIGNIFICANT PROJECTS OR INCREMENTAL/CUMULATIVE DEVELOPMENT	
Strategy 13	Include salmon and salmon habitat as focal area of environmental and cumulative impact assessments
HATCHERY PRODUCTION AND HATCHERY-BASED INDICATOR STOCKS	
Strategy 14	Align production with approved program objectives and monitoring requirements
Strategy 15	Develop/maintain an effective, integrated network of hatchery indicator stocks
Strategy 16	Assess the risks of hatchery programs on spawning/rearing success of wild salmon
Strategy 17	Assess the benefits of production on harvest opportunities and stock rebuilding
Strategy 18	Determine the appropriate level of precaution or risk aversion for CUs or aggregates
Strategy 19	Evaluate the merits of adding new hatchery production, where appropriate
HARVEST	
Strategy 20	Ensure that fishing related mortality does not exceed sustainable removal rates
Strategy 21	Develop an integrated model to evaluate the effects of changes in harvest
Strategy 22	Conduct monitoring and evaluation to assess fishery related mortalities
CLIMATE CHANGE	
Strategy 23	Assess the potential impacts of climate change on Chinook salmon
Strategy 24	Identify opportunities to adapt to the effects of climate change on Chinook salmon
ADDITIONAL MONITORING TO ASSESS STATUS AND TRENDS	
Strategy 25	Develop a network of indicator stocks to represent wild Chinook management units
Strategy 26	Review and incorporate historic information into current data sets
Strategy 27	Monitor CU status and progress toward WSP benchmarks and/or other biological benchmarks

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The Strategic Plan includes with a timeline for implementing the strategies (20 year plan – below, and a detailed 5 year implementation plan), and a recommendation for performance reviews to be conducted every 5 years




TASK	1st generation of Chinook					2nd generation of Chinook					3rd generation of Chinook					4th generation of Chinook				
Year →	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
1. Networking to publicize draft plan, develop partnerships	High	High	High																	
2. Integrate plan into key processes and entities	High	High	High	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
3. Analytical tasks to operationalize actions under the plan[1]	High	High	Low		High					High					High					High
4. Distribution, presentation and publication of final plan			High																	
5. Implement plan's harvest, habitat and hatchery actions	Low	Low	High	High	High	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
6. Monitoring, research and evaluation to support plan	High	High	High	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
7. Annual updates on progress	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦
8. 5-year reviews and updates of the plan					5-year review					5-year review					5-year review					5-year review

High Intensity

Low intensity

5-year review and updates of plan

♦ Annual updates on progress & symposium

[1] Includes various analytical tasks to better understand the impacts and benefits of alternative harvest, habitat and hatchery actions. More intensive analytical tasks will be repeated every 5 years as part of the 5-year review.

Comparison of Upper Fraser Chinook Stocks

Fraser Chinook Management Units

Background

In total there are 17 Fraser Chinook Conservation Units and 4 Management Units. Since 2009 the Fraser Chinook Management Units have been aligned with the Pacific Salmon Treaty Assessment Units.

The Management Unit names identify Fraser Chinook by life history and return timing. For example, the nomenclature Fraser Spring 4_2 refers to return timing (Spring) and life history. "4" is used to denote the year of life these Chinook return to spawn and the subscript "2" refers to the number of winters the juveniles spend in freshwater. Fraser Chinook with subscript 2 are generally referred to as “stream-type” Chinook due to their life history characteristic of overwintering in freshwater as a juvenile. Fraser Chinook with subscript "1" are generally referred to as “ocean-type” Chinook because they do not overwinter in the Fraser River as juveniles. A general observation and distinction between Spring and Summer type Chinook is that Spring-timing Chinook tend to spawn upstream of major lakes, or in systems without lakes (stream-headed), while Summer-timing Chinook spawn in systems moderated by (downstream of) major lakes. Nechako Summer 5_2 Chinook mostly spawn between the Kenney Dam and Vanderhoof.

Fraser Spring 4_2 Chinook

The Fraser Spring 4_2 Chinook management unit refers to the grouping of two Chinook Conservation Units, both of which spawn in the Thompson River watershed: South Thompson Bessette Creek and Lower Thompson Spring. The Nicola River Chinook population is the Coded Wire Tag (CWT) indicator for this management unit, with Spius Creek hatchery as the rearing and tagging facility.

Fraser Spring 5_2 Chinook

The Fraser Spring 5_2 Chinook management unit refers to the grouping of 6 Conservation Units, most of which spawn in the middle and upper Fraser, but includes stocks from the Thompson watershed and the Lower Fraser. The Conservation Units in this management aggregate are detailed in the Table 3 summarizing this section. There is currently no CWT indicator for this management unit.

Fraser Summer 5_2 Chinook

The Fraser Summer 5_2 Chinook management unit refers to the grouping of 5 Conservation Units and includes stocks spawning throughout the Fraser watershed. The Conservation Units in this management aggregate are listed in Table 3. There is currently no CWT indicator for this management unit. However, a Chilko River CWT program which relies upon Chehalis River and Inch Creek hatcheries (located in the Lower Mainland) rearing is in development. During 2017 a

CWT jack returned to the Chilko system, which indicates a positive first step towards establishment of Chilko as a potential CWT indicator for this management group.

Fraser Summer 4_1 Chinook

The Fraser Summer 4_1 Chinook management unit refers to the grouping of 3 Conservation Units, one from the Lower Fraser (Maria Slough) and the remaining two from the Thompson system. The CWT indicator for this group is the Lower Shuswap stock.

Fraser Fall 4_1 Chinook

The Fraser Fall 4_1 Fall Chinook management unit refers to a single Conservation Unit, Lower Fraser white, which spawn in the Harrison and Chilliwack rivers. This Conservation Unit is represented by CWT (Chehalis and Chilliwack hatcheries) and also has a bilateral (Canada/US) agreed-upon escapement goal and annual quantitative forecasts.

Table 3. Classification of Fraser Chinook Management Units, Conservation Units and spawning stocks.

Management Unit	Conservation Unit #	Conservation Unit Name	Spawning Stock
Fraser Spring 4_2	16	STh Bessette Creek	Bessette Creek
	17	LTHOM spring	Bonaparte River; Coldwater River; Deadman River; Louis Creek; Nicola River; Spius Creek
Fraser Spring 5_2	4	LFR springs	Birkenhead River
	5	LFR Upper Pitt	Pitt River-upper
	8	FR Canyon-Nahatlatch	Nahatlatch River
	10	MFR springs	Cariboo River-upper; Chilako River; Chilcotin River upper; Chilcotin River-lower; Cottonwood River; Horsefly River; Narcosli Creek; Naver Creek; West Road River
	12	UFR springs	Bowron River; Dome Creek; East Twin Creek; Fraser River-above Tete Jaune; Forgetmenot Creek; Goat River; Holliday Creek; Holmes River; Horsey Creek; Humbug Creek; Kenneth Creek; McGregor River; McKale River; Morkill River; Nevin Creek; Ptarmigan Creek; Slim Creek; Small Creek; Snowshoe Creek; Swift Creek; Torpy River; Walker Creek; Wansa Creek; West Twin Creek; Willow River
	18	NTHOM spring	Blue River; Finn Creek; Raft River
Summer 5_2	6	LFR summers	Big Silver Creek; Chilliwack/Vedder River; Cogburn Creek; Douglas Creek; Green River; Lillooet River; Lillooet River-lower; Lillooet River-upper; Sloquet Creek; Weaver Creek
	9	MFR Portage	Portage Creek
	11	MFR summers	Bridge River; Cariboo River lower; Chilko River; Endako River; Kazchek Creek; Kuzkwa River; Nechako River; Quesnel River; Seton River; Stellako River; Stuart River
	14	STh summer age 52	Eagle River; Salmon River
	19	NTHOM summer age 52	Barriere River; Clearwater River; Mahood River; North Thompson River
Summer 4_1	7	Maria Slough	Maria Slough
	13	STh summer age 41	Adams River; Little River; South Thompson River; Lower Thompson River
	15	Shuswap River summer age 41	Shuswap River-lower; Shuswap River-middle
Fraser Fall 4_1	3	LFR fall white	Harrison River

Upper Fraser Chinook Run Reconstruction

Background

Run reconstruction in its simplest form is an accounting of spawning escapement (the start point) with the addition of estimated catches along the migratory route to an end point, in this case the mouth of the Fraser River. The run is "reconstructed" from terminal spawning areas to a total return abundance at a specific location downstream. Much of the description of the Run Reconstruction model is derived from a 2007 CSAS report[23]. One of the objectives of the present report was to evaluate the run reconstruction information to assess the sensitivity of monitoring Nechako Chinook escapement as an index of Nechako run size and the population's status.

The first Fraser Chinook run reconstruction was conducted in 1994 to estimate abundance, run timing and harvest rates for Nechako Chinook from data spanning the years 1978 - 1993. In 2005, technical advisors to several Fraser First Nations recommended a similar analysis be conducted in order to provide estimates of total Fraser Chinook return for Pacific Salmon Treaty allocation purposes. In 2007, the run reconstruction methods and analysis were peer-reviewed and accepted through the Canadian Science Advisory Secretariat (CSAS). The 2007 paper provided a reconstruction of the 1982 – 2004 Chinook returns to the Fraser River. Since 2007, DFO has utilized the Fraser Chinook Run Reconstruction model (with annual updates to the escapement time series) for pre-season planning, post-season evaluation and more recently in-season management (utilized in conjunction with the Albion Chinook Test Fishery).

Model and Data

Although there have been updates to the model and the data since the 2007 paper, the fundamentals of the analysis remain the same. The key components to the run reconstruction are escapement estimates (timing and abundance) at the finest resolution possible (spawning sites), gear-specific mortalities by fishery and lastly, upstream migration rates (migration rates are assumed and implied based on CWT recoveries and genetic studies of in-river fisheries catches).

Key assumptions in the reconstruction are as follows:

a) The Chinook stocks included in the model adequately represent the run timing and total escapement for Fraser River Chinook;

b) The methods used to derive the annual escapement estimates account for annual variability in survey conditions and survey coverage;

c) The distribution of the annual escapement estimates over the escapement period defined for each stock is consistent with a normal distribution;

d) The fisheries and catch data included in the model adequately represent the timing and location of fisheries that harvest Chinook within the Fraser watershed;

[23] Assessment of Fraser Chinook Returns Using Run Reconstruction Techniques

e) All stocks are equally vulnerable to harvesting when present in a fishery, such that harvests of a stock are proportional to the relative abundance of that stock in that fishery during the fishing period; and

f) The number of days that a stock resides in each fishery is constant throughout the run.

Key uncertainties in the model are related to the assumptions:

a) Escapement estimates for systems such as Taseko, Stuart River and North Thompson are not conducted due to characteristics of those systems making aerial enumeration or mark/recapture unfeasible. The model uses algorithms to “in-fill” missing data, and this is a source of uncertainty (based on a proportion of nearby enumerated stocks);

b) Aerial enumeration of many Chinook stocks in the middle and upper Fraser is subject to weather events, hydrological influence and other natural impacts (such as the wildfires of 2017);

c) An assumption of equal vulnerability by each stock in a fishery is a source of uncertainty and is an assumption that has not yet been tested; and,

d) Uncertainty in catch estimation by fishery and fishery area has not been quantified.

Since 2007 improvements have been made in catch monitoring, the escapement database, escapement estimation in some systems, migration timing (Albion Test Fishery DNA and CWT’s), and estimated residence times in fisheries strata. Recommendations for improvements in model inputs and future research are included in the 2007 CSAS paper, some of which have been addressed since the paper was published.

Despite the assumptions and uncertainties outlined above, the run reconstruction has been shown to track reasonably well with abundances, timing and catch estimates with no major “red flags” identified since its implementation for Fraser Chinook salmon management. Without this procedure, there would be very little information for Middle Fraser and Upper Fraser Chinook, due to the lack of Coded Wire Tag indicators in these systems.

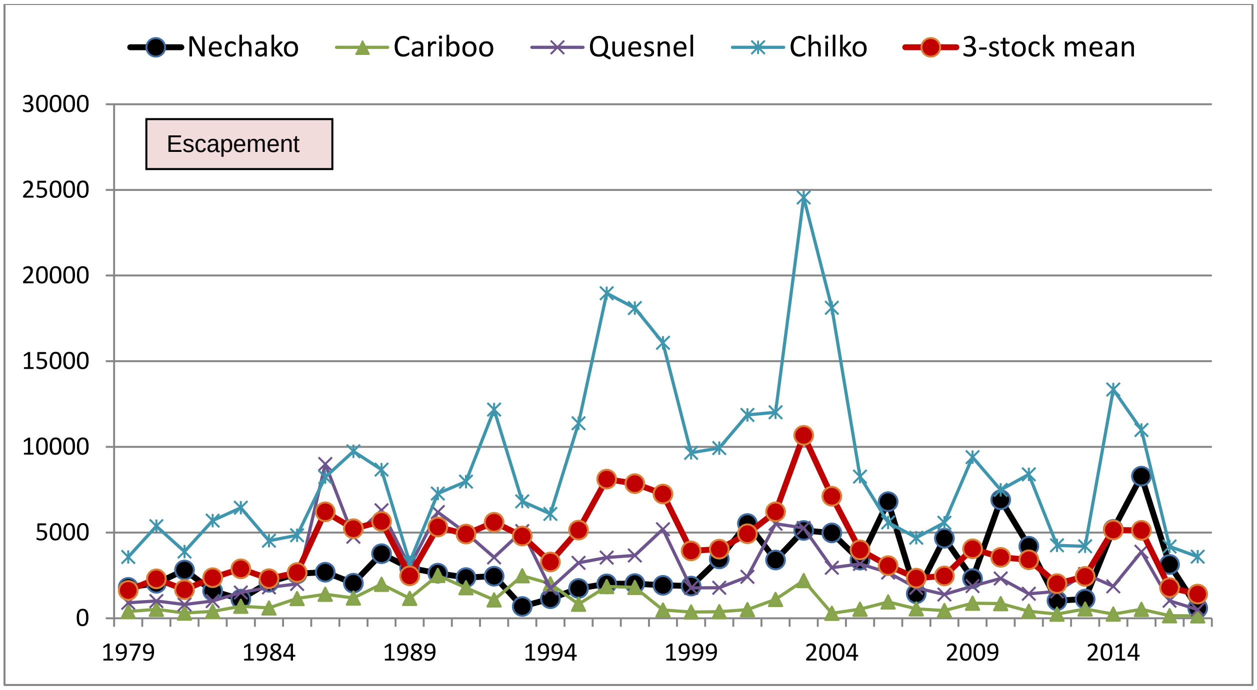
Post-season, pre-season and in-season management processes are dependent on the Fraser Chinook Run Reconstruction. In general, Chinook escapement estimates for the entire Fraser watershed are completed by the end of February, and the escapement workbooks for the model are updated. Catch estimation is also completed by the end of February and updated in the model workbook. When those pieces are completed annually, the model can be run, which in-fills escapement estimates and provides Chinook abundance and catch estimates for individual stocks and the management aggregates for the prior calendar year.

Since 2009, an in-season management model based on the Albion Chinook test fishery and reconstructed terminal runs (produced by the Fraser Chinook Run Reconstruction model) is used to provide management and conservation guidance for Fraser Spring 5_2 and Summer 5_2 Chinook.

Escapement

The Independent Panel that assessed the status and factors for the decline of southern BC Chinook salmon undertook further analyses of mid-Fraser Summer 5_2 Chinook escapements including Nechako, Stuart, Cariboo, Chilko and Quesnel populations. The analysis compared the trends for Stuart, Cariboo, Chilk, and Quesnel Chinook escapements with the Nechako Chinook escapement and showed that Nechako Chinook were clearly different (increasing in comparison with decreasing averaged trends). The escapement data shown in Figure 5 updates the Independent Panel analysis with more recent data and retains a modified stock grouping based on Cariboo, Chilko and Quesnel Chinook. DFO consider that the Stuart Chinook escapement data are unreliable, hence their exclusion from the present analysis.

Comparison of the escapement plots suggests an inverse correlation between the Nechako escapement and the average escapements of the other three stocks. Nechako escapements were relatively low in the 1990's with generally higher escapements than average after 2005.



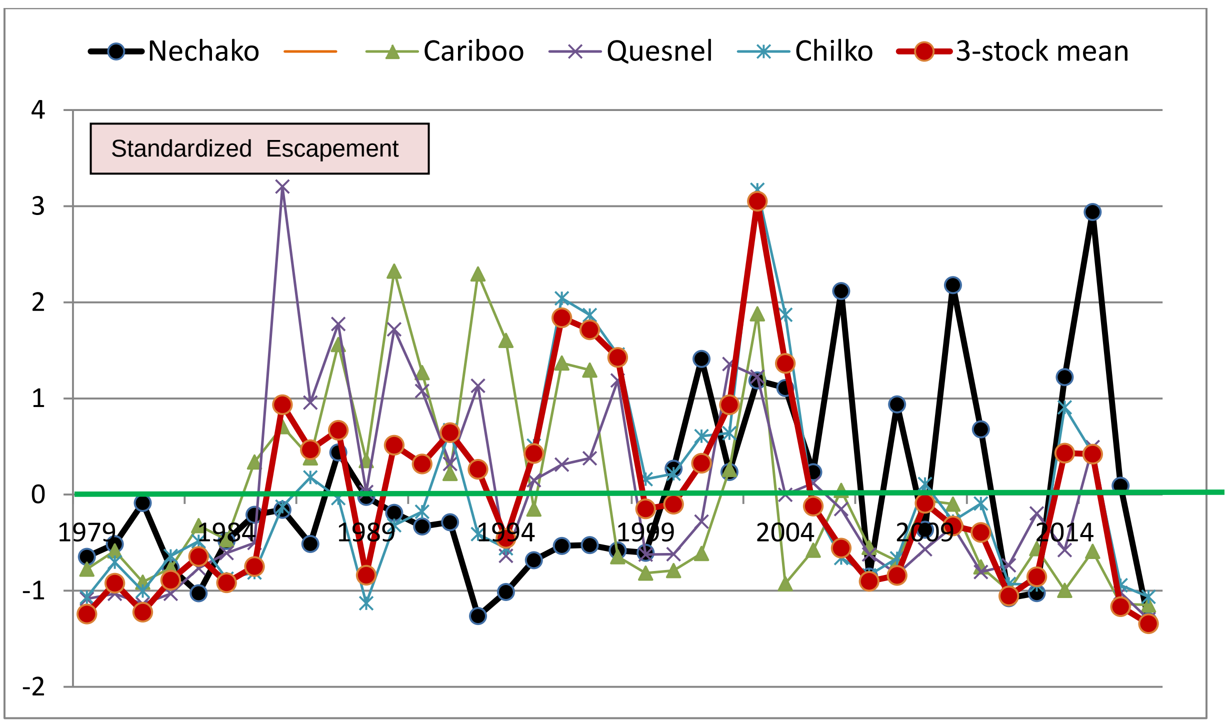
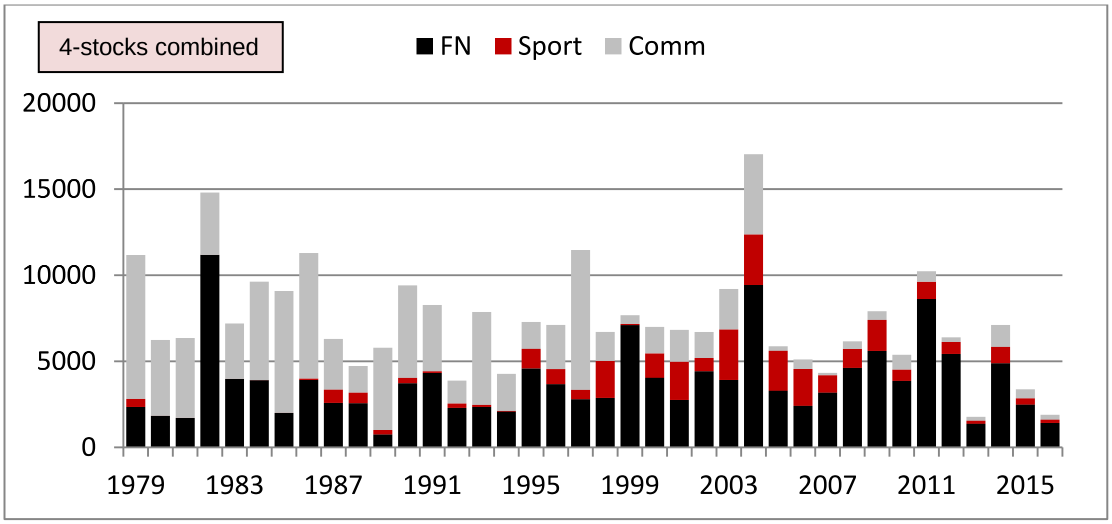


Figure 5. Escapements of mid-summer 5_2 Chinook. The upper plot depicts the DFO escapement estimates and the lower plot indicates the standardized deviations[24] by stream and year; the averaged trend for Cariboo, Chilko, and Quesnel rivers; and the trend for the Nechako River.

[24] a normalized value from a distribution characterized by the mean and standard deviation. This procedure was undertaken to permit comparisons of escapement trends between stocks of different productivity.

In-River Chinook Catch

Fraser River catches for four Chinook stocks combined (Cariboo, Chilko, Quesnel and Nechako) and the Nechako population (Figure 6) showed reductions in Nechako Chinook catches during the 1990's simultaneous with low Nechako Chinook escapements. Nechako Chinook catches were highest in 1982 and 2004 and appeared to be uncorrelated with the escapements in those years. There was an obvious trend in the two data sets whereby the in-river commercial catch dropped substantially over time. Since the mid-1990s most of the catch has been harvested in First Nation Food, Social and Ceremonial fisheries, which peaked in 1982, 2004 and 2011 but have since trended downwards.



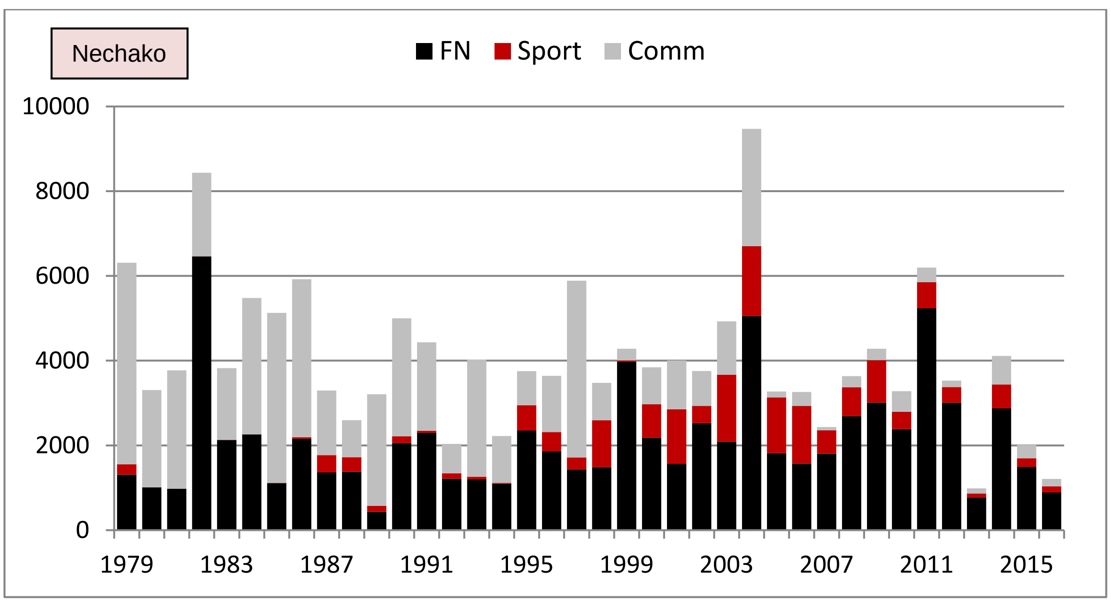


Figure 6. Time series of Chinook catches as estimated in the Fraser Chinook run reconstruction data base for 4 stocks combined (Cariboo, Chilko, Quesnel and Nechako; upper) and Nechako (lower).

In-River Harvest Rate

Estimated harvest rates are provided in the DFO run reconstruction outputs and reflect Chinook catches scaled by the reconstructed abundance (catch / catch + escapement) (Figure 6). Estimated harvest rates were relatively high in the 1980's and have generally decreased over time. The highest Nechako Chinook in-river catches occurred in 1982. During the earlier run reconstruction period (prior to the mid-2000's) there was a substantial commercial harvest of both Mid-Summer 5_2 and Nechako Chinook which has subsequently declined to relatively low levels. Since the mid-1990's, estimated First Nation harvests have increased and comprise the highest proportion of the in-river fishery, although since 2012 overall harvest rates appear to be trending downward. Harvests are taken in the in-river sport fishery in most years. The overall annual harvest rates of Mid-Summer 5_2 and Nechako Chinook are estimated to be below 20% since 2012.

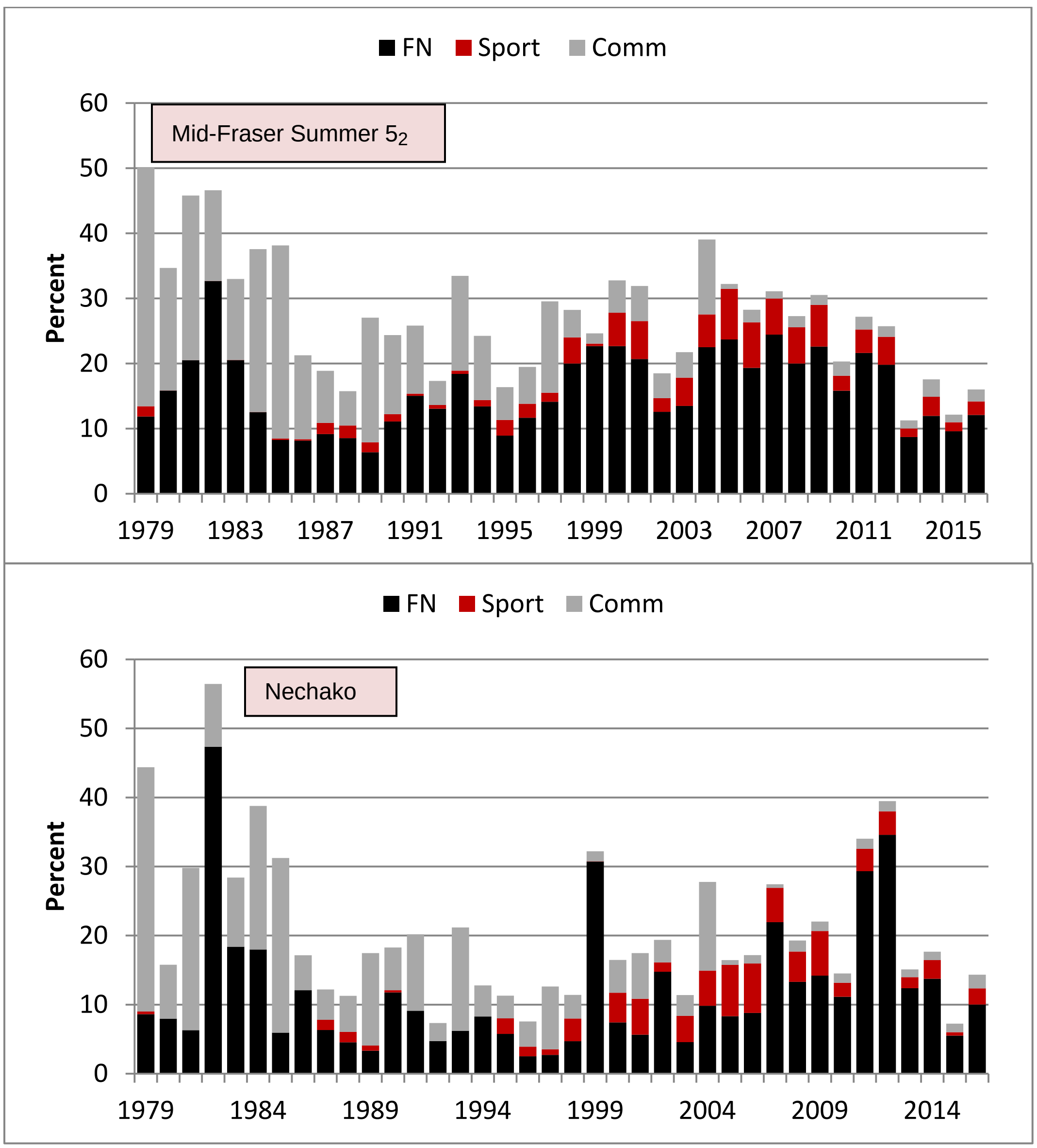


Figure 6. Harvest rate time series for Mid-Summer 5_2 and Nechako Chinook.

Reconstructed Abundance

A time series of Mid-Fraser Summer 5_2 Chinook in-river catches and reconstructed run size (Figure 7) indicates that the run peaked in the early 2000's and declined thereafter. The decline occurred independently of in-river catch suggesting that the productivity of this Conservation Unit is in decline and that the decline occurred independently of harvesting, although this suggestion of declining productivity is based on the assumption that marine catch has been relatively stable or decreasing.

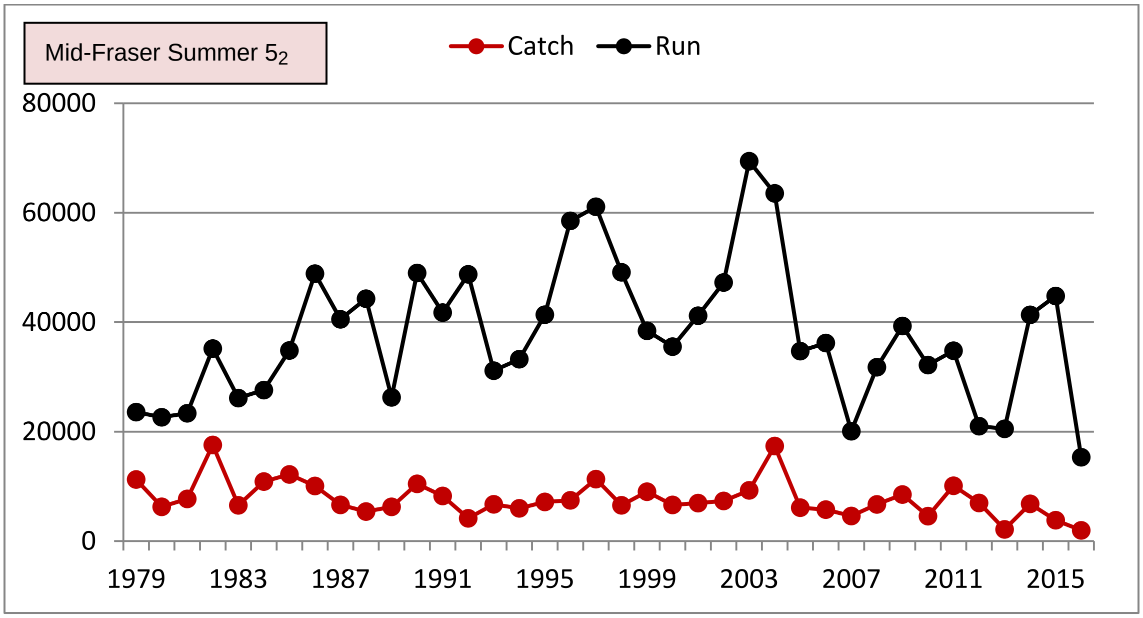


Figure 7. Time series of Mid-Fraser Summer 5_2 Chinook catches and reconstructed run size.

The reconstructed run size for Nechako Chinook, in comparison with Cariboo, Quesnel and Chilko Chinook, indicates a different time trend for Nechako Chinook compared to the other four stocks (Figure 8). There is a suggestion of an inverse correlation such that when the Nechako Chinook run size is low the other three runs are relatively high and vice versa.

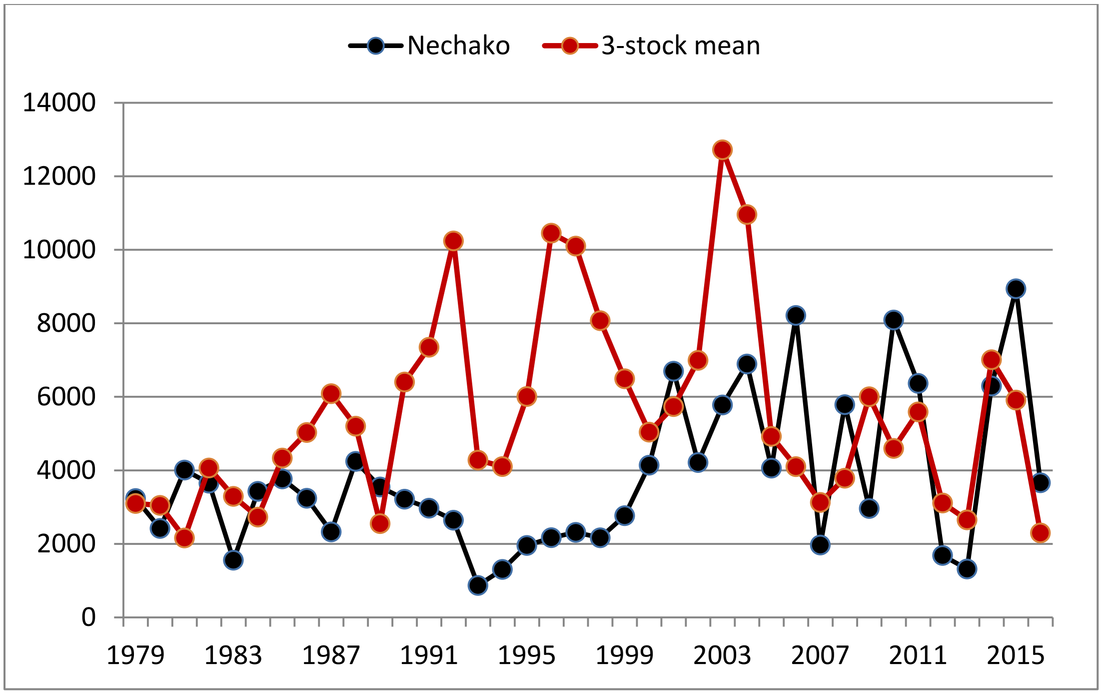
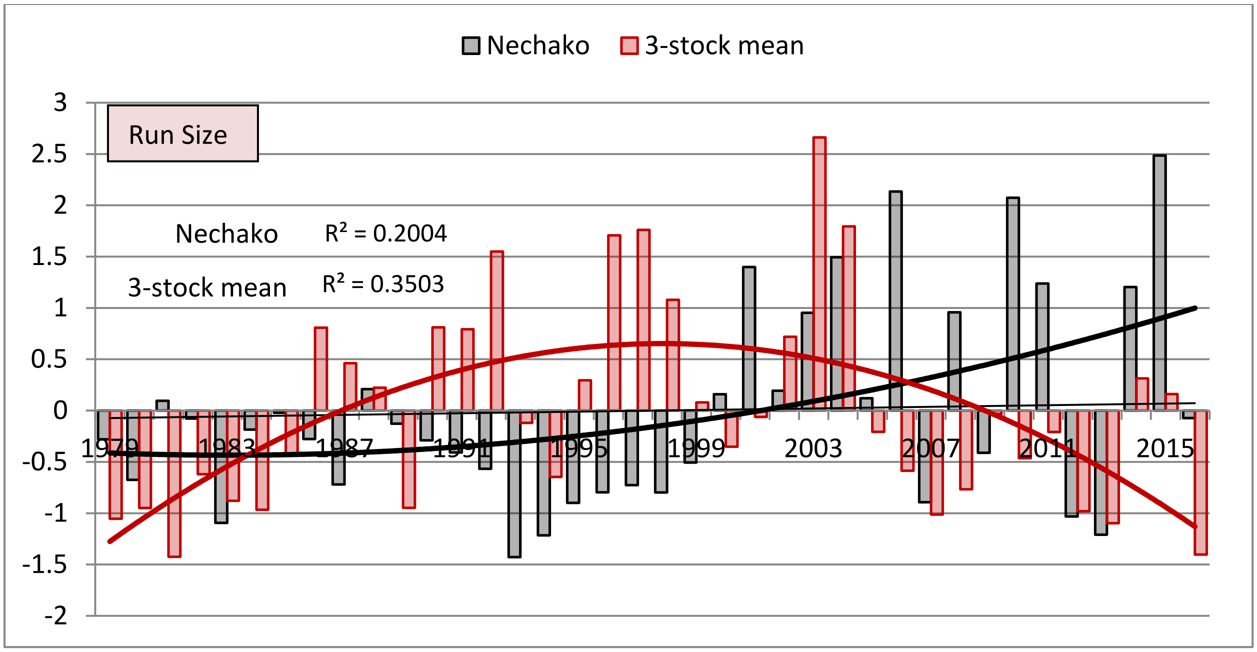


Figure 8. Time series of reconstructed Nechako Chinook run size in comparison with 3-stock (Cariboo, Quesnel and Chilko) mean reconstructed run size.

Comparison Between Escapement and Reconstructed Abundance

Run reconstruction was undertaken to assess the sensitivity of monitoring Nechako Chinook escapement as an index of Nechako run size and the population's status. Figure 9 shows the time series of standardized run size and standardized escapement estimates for both Nechako Chinook and the mean for the 3 reference stocks: Cariboo, Quesnel, and Chilko. Polynomial regressions of these data (Figure 9) reflect an upward trend in the Nechako run sizes and escapements relative to a polynomial curve for the standardized 3-stock run sizes and escapements. Based on the similarities in the run size and escapement patterns, we conclude that the escapement enumeration approach utilized by the NFCP has provided a sensitive and reliable indicator of the status of the Nechako Chinook population.



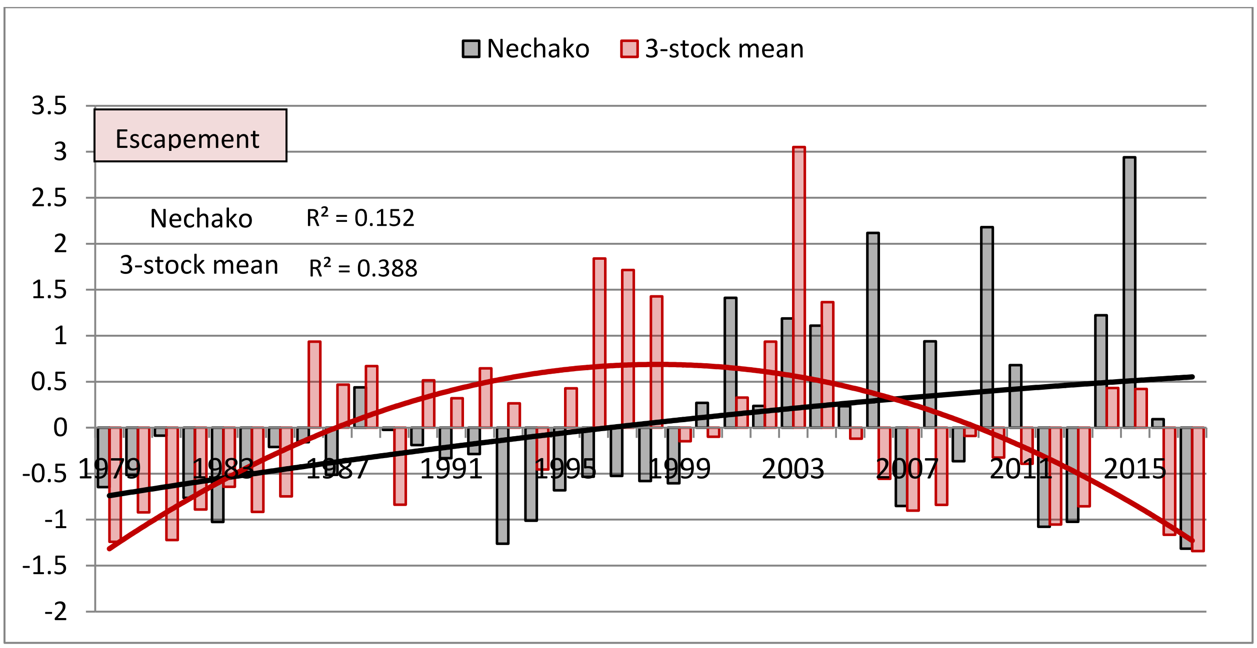


Figure 9. Standardized Chinook run size estimates in the Nechako River and comparative 3-stock mean run sizes (upper) and escapements (lower). Curves are polynomial fits to the histogram data.

Fraser Chinook Return in 2017

Fraser Chinook escapement returns in 2017 were extremely low throughout the watershed. Only 588 Chinook returned to the Nechako spawning grounds.

In order to evaluate whether the low 2017 Nechako escapement was unique to the Nechako Watershed or part of a regional trend, the past 10 years of escapement data were plotted as well as the standardized escapements (Figure 10). These graphs are truncated plots of the data in Figure 5.

The comparison shows that escapements to Quesnel, Chilko and Cariboo in 2017 were all below their recent 10-yr average. All of the stocks, as well as the 3-stock mean escapement, were below the previous 10-year average. Escapements in all of the Mid-Fraser Summer 5_2 Chinook stocks were the lowest across the 10-year time series, and in all cases lower than the 5 year brood escapements.

The conclusion of the analysis is the observed low escapement to the Nechako River in 2017 wasn't unique to the Nechako and occurred simultaneously in other Mid-Fraser Summer 5_2 Chinook stocks. These declining trends occurred more broadly in the Fraser River in 2017 as evidenced by the Albion test fishing catches (Figure 11). This test fishery is operated by DFO in order to establish annual harvest regulations and to support Chinook management decision-making.

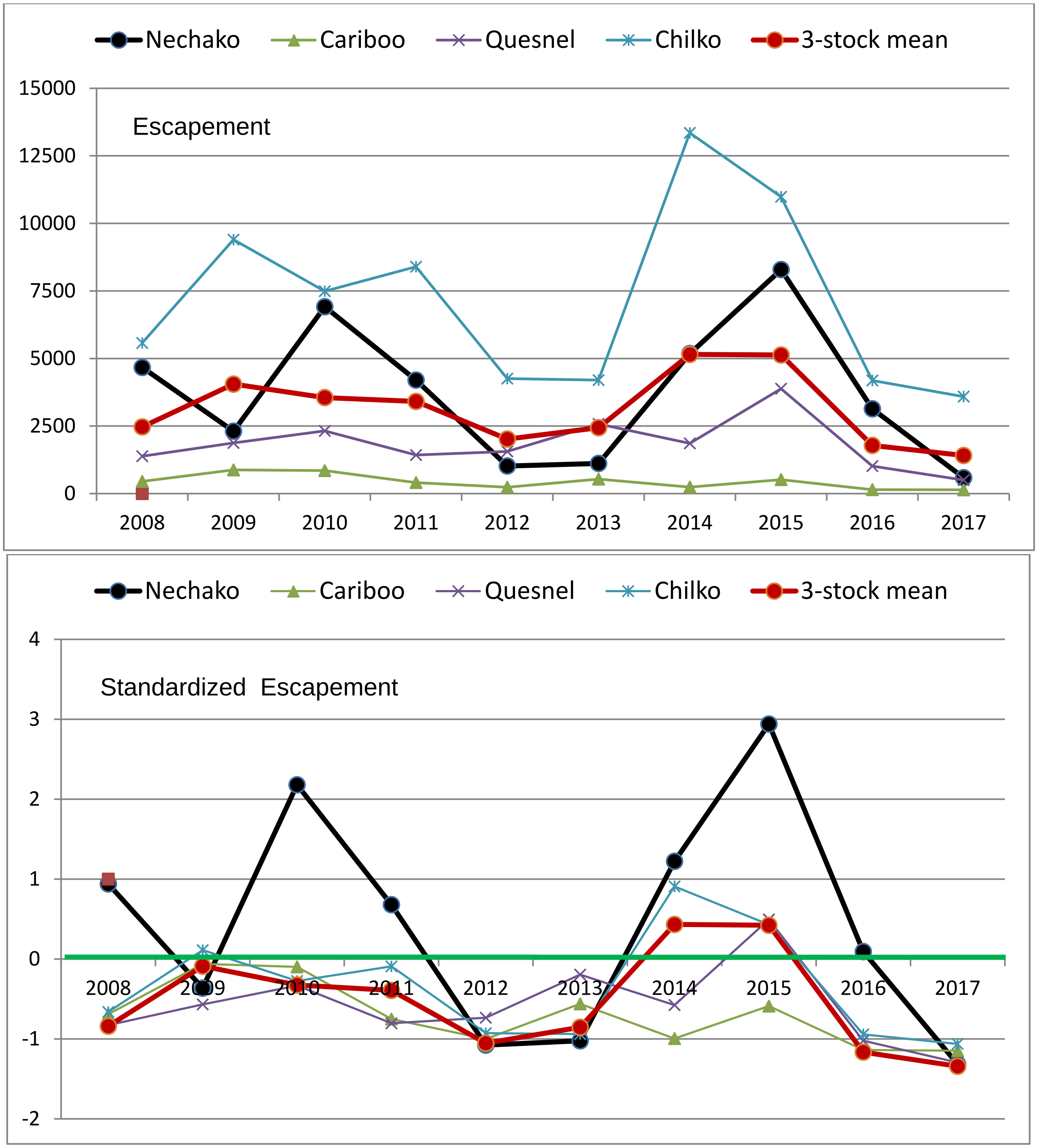
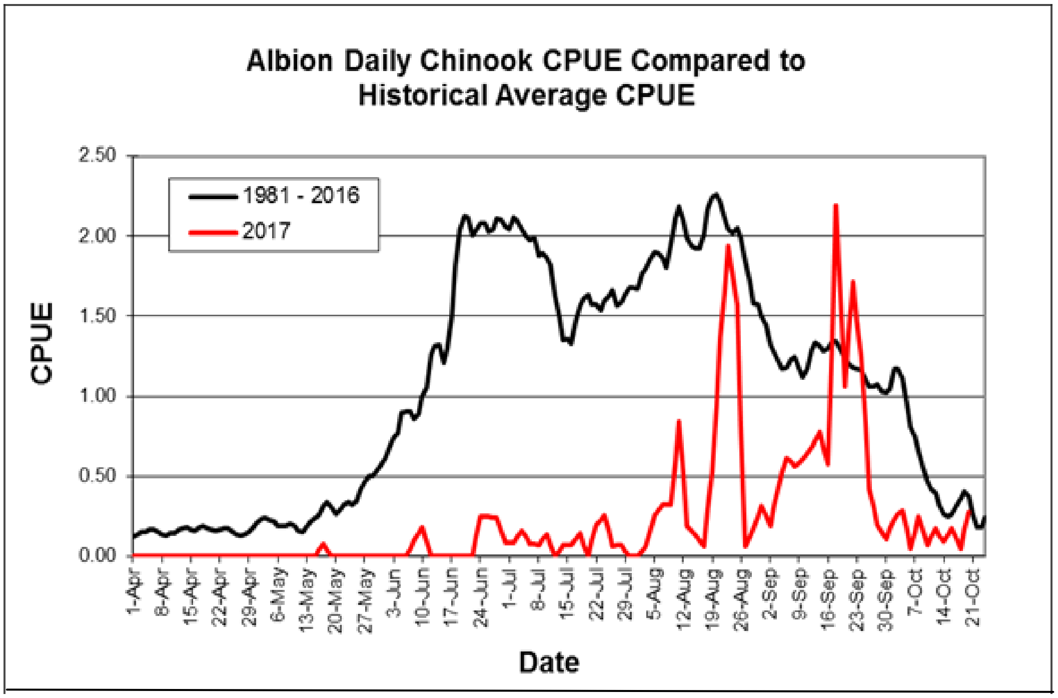


Figure 10. Escapements of Mid-Summer 5_2 Chinook. The upper plot depicts the escapement estimates and the lower plot indicates the standardized time series by stream and year. Standardization was applied to permit comparison of escapement trends for the four stocks which have inherent differences in productivity (upper graph).



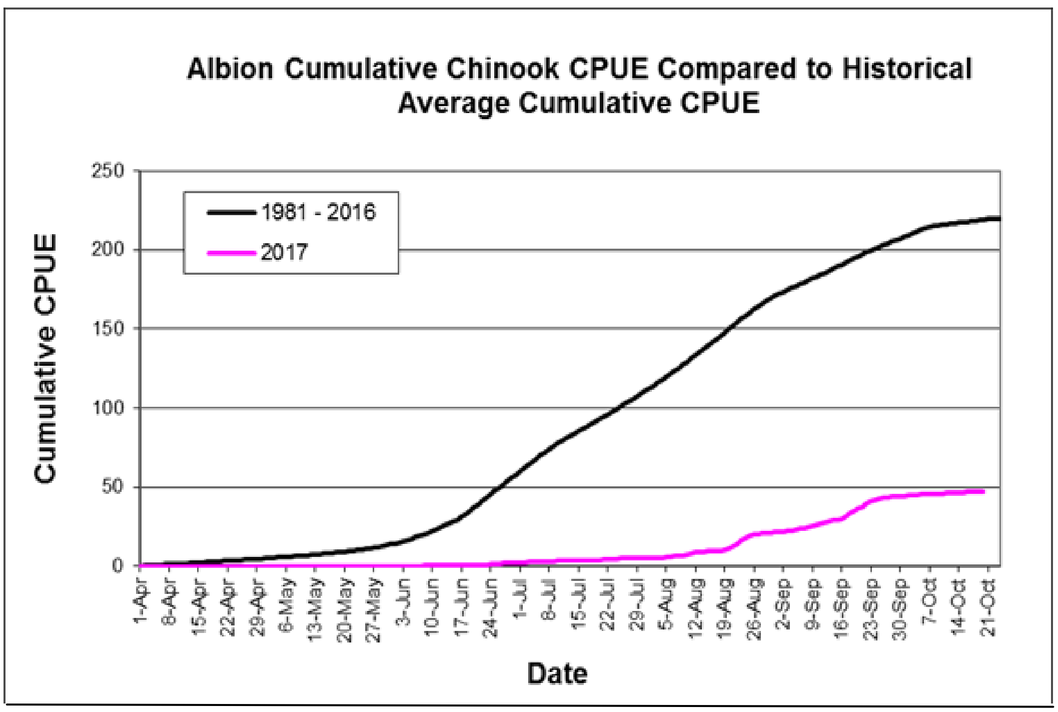


Figure 11. Catches from the Albion Test Fishery[25] in 2017.

[25] Albion Test Fishing Catches in 2017

Sockeye Salmon

Conservation

Wild Salmon Policy

The framework for the Wild Salmon Policy is provided in the Chinook section on p.5-7. Sockeye status assessments were undertaken by DFO and collaborating partners in 2011[26]; 2012[27]; and 2017[28]. The assessments were undertaken to implement WSP Strategy 1 for Fraser River sockeye Conservation Units, of which there are 24, listed below. R = red, A = amber, G = green, RA = red/amber, DD = data deficient, UD = undetermined.

2017		2012		Conservation Unit	Cyclic	Stock
R		R		Bowron-ES		Bowron
R		R		Cultus-L		Cultus
R		R		Takla-Trembleur-EStu	cyclic	Early Stuart
R		R*		Taseko-ES		Miscellaneous Early Summers
R		R		Widgeon – River		Miscellaneous Lates
R		A		Harrison (U/S)-L		Weaver
R		UD		Seton-L		Seton
R	A	R	A	Quesnel-S	cyclic	Quesnel
R	A	R	A	Takla-Trembleur-Stuart-S	cyclic	Late Stuart
A		R		Nahatlatch-ES		Miscellaneous Early Summers
A		A		North Barriere-ES		Fennel & Miscellaneous Early Summ
A		A		Kamloops-ES		Raft & Miscellaneous Early Summ
G		A	G	Shuswap-ES	cyclic	Scotch, Seymour, Mis.Early Summ
A		G*		Lillooet-Harrison-L		Birkenhead
A	G	R		Nadina-Francois-ES		Nadina
A	G	R	A	Chilliwack-ES	cyclic	Miscellaneous Early Summers
A	G	R	A	Francois-Fraser-S		Stellako
A	G	A		Anderson-Seton-ES		Gates
A	G	G		Harrison (D/S)-L		Miscellaneous Lates
A	G	G		Shuswap Complex-L	cyclic	Late Shuswap
G		A	G	Pitt-ES		Pitt
G		G*		Chilko-S & Chilko-ES agg.		Chilko
G		G		Harrison River – River Type		Harrison
DD		DD		Chilko-ES		Chilko

There are presently five red-status Fraser Sockeye CUs in the Upper Fraser River watershed (Figure 12): Bowron-ES, Takla-Trembleur-Early Stuart, Taseko-ES, Quesnel-S, and Takla-Trembleur-Stuart-S. There are a few exceptions in the Upper Fraser watershed: the status of Francois-Fraser-S and Nadina-Francois-ES has improved from red or red/amber to green/amber between the 2012 and 2017 WSP status assessments; and the Chilko-S and

[26] Integrated Biological Status Assessments in Fraser Sockeye

[27] Evaluation of Uncertainty in Fraser Sockeye WSP Status

[28] Fraser Sockeye Wild Salmon Policy Re-assessment

Chilko-ES aggregate was green in both assessments. This sockeye CU aggregate continues to be the most productive in the Upper Fraser.

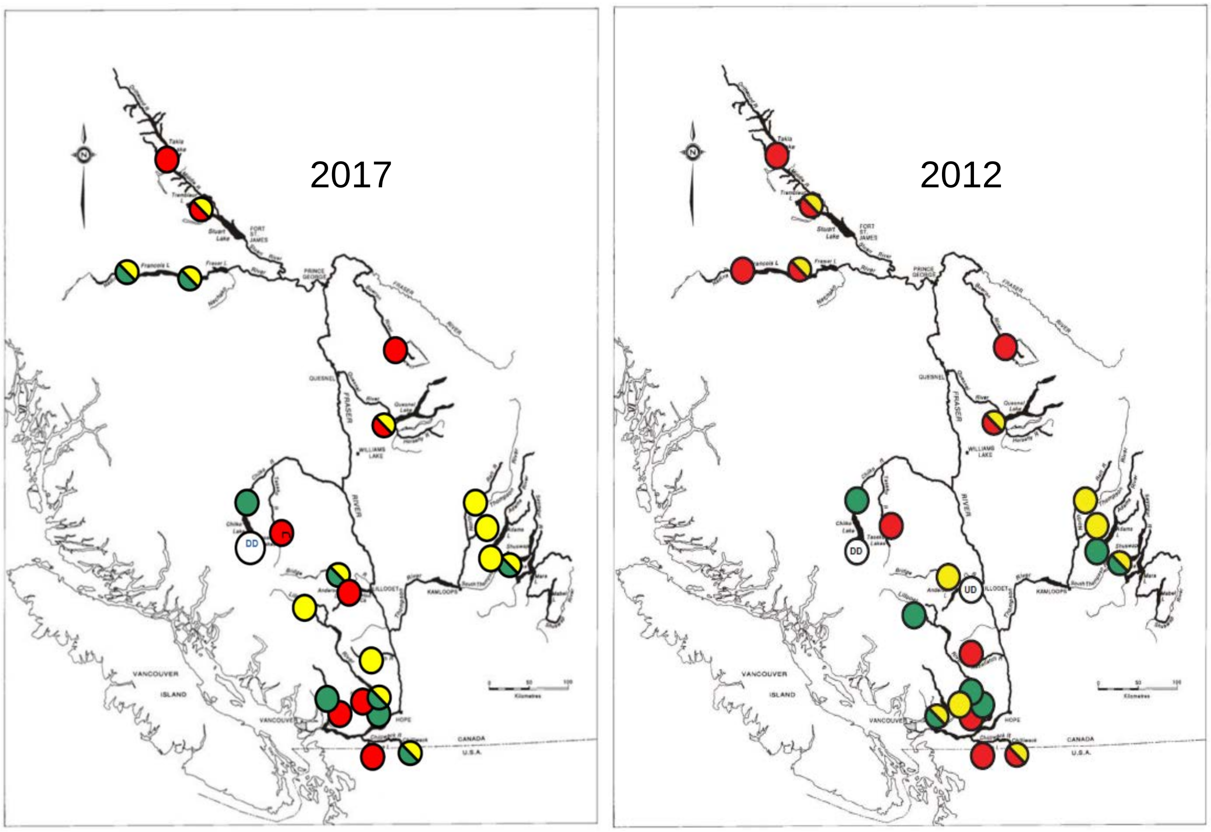


Figure 12. WSP status assessment for 24 sockeye CUs in the Upper Fraser.

The key factors in the WSP status assessment that contributed to placing these CUs in the red status zone are described in Table 3 of the 2018 Canadian Science Advisory Report[29]. For Early Stuart all the WSP metrics were in the red status zone: short term trends and long term trends were in the red-status zone, the relative abundance metric was in the red status zone, and productivity for this CU has been declining. Late Stuart had a mixed red/amber relative abundance metric status across probability levels and model forms, short-term trends were in the red status zone, and productivity has declined.

In spite of a large amount of WSP work, no detailed analytical assessments have occurred, as required under the WSP and described on p.6. As a result, no specific recovery actions have occurred, since recovery plans have not been developed. For red-zoned CUs the WSP states:

> "...a detailed analytical assessment will normally be triggered to examine impacts on the CU of fishing, habitat degradation, and other human factors, and to evaluate restoration potential...detailed stock assessments will identify the reasons for the change in status...CUs in the red zone ...will be identified as management priorities...the protection

[29] 2017 Fraser Sockeye Salmon integrated biological status re-assessment under the WSP

and restoration of these CUs will be primary drivers for harvest, habitat, and enhancement planning"

The Upper Fraser red-zoned sockeye CUs that use the Nechako River and which therefore require WSP assessments and recovery plans include Takla-Trembleur-EStu (Early Stuart) and Takla-Trembleur-Stuart-S (Late Stuart).

2017 COSEWIC Status Assessment

The 2017 COSEWIC assessment of Fraser River sockeye[30] listed eight Fraser sockeye populations (Designatable Units; DUs) as *Endangered*, two as *Threatened* and five as *Special Concern*. The 24 Fraser sockeye DUs under COSEWIC are equivalent to the 24 Fraser sockeye WSP Conservation Units.

The following sockeye DUs utilize the Nechako River as a migration corridor during upstream adult/spawner migration and downstream smolt emigration.

Status	Designatable Unit	Nechako River Utilization
Endangered	Early Stuart	Migrates through lower Nechako, up Stuart River to spawning grounds
Endangered	Late Stuart	Migrates through lower Nechako, up Stuart River to spawning grounds
Special Concern	Francois	Migrates through lower and middle Nechako, up Nautley River to spawning grounds
Not at risk	Nadina (has spawning channel)	Migrates through lower and middle Nechako, up Nautley River to spawning grounds

The two *Endangered* populations, Early Stuart and Late Stuart sockeye (spawning areas shown on Figure 13) were assessed by the UFFCA in 2008[31]. These two populations are also red-zoned under the Wild Salmon Policy. The COSEWIC assessment summaries for these two DUs are described below.

[30] COSEWIC. 2017. In Press. COSEWIC assessment and status report on the Sockeye Salmon *Oncorhynchus nerka,* 24 Designatable Units in the Fraser River Drainage Basin, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xli + 179 pp.

[31] UFFCA Technical Report

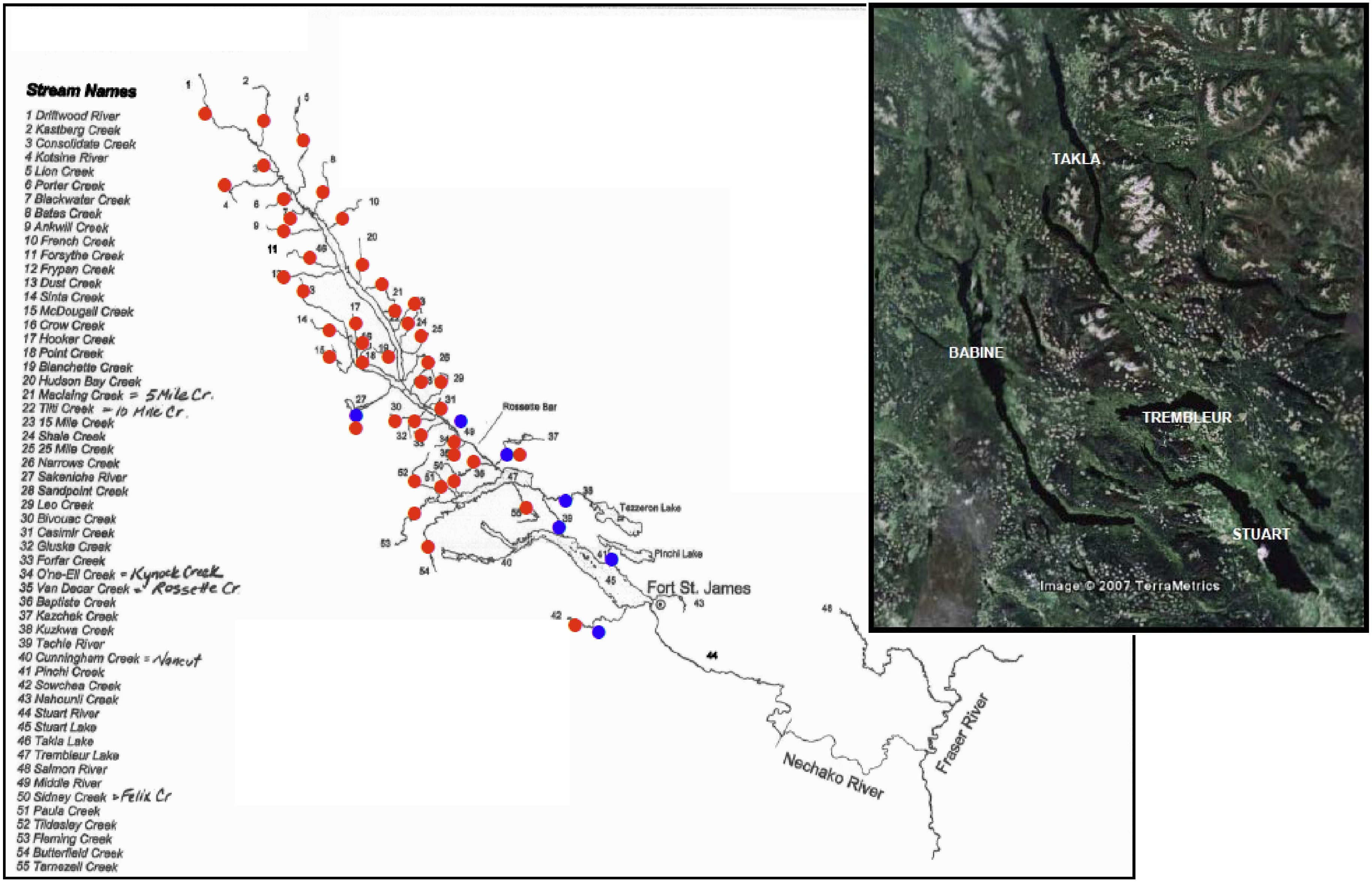


Figure 13. Distribution of Early Stuart (red dots) and Late Stuart (blue dots) sockeye spawning tributaries in the Stuart Lake system. These salmon utilize the Nechako River as a migration corridor between Prince George and the confluence of the Stuart and Nechako Rivers at Finmoore.

COSEWIC suggested that the *Endangered* Early and Late Stuart Sockeye designation was associated with their exposure to marine and freshwater threats which are causing habitat quality to decline. For Early Stuart sockeye the number of mature individuals has been declining steadily for over 20 years and despite reductions in fishing mortality, productivity is currently low. For Late Stuart sockeye the number of mature individuals has been declining steadily for 3 generations yet removals by fishing have remained high.

COSEWIC further assigned a threat impact of High - Medium for Early Stuart sockeye and identified several threats:

- Fisheries removals "because the Sockeye population from this DU is declining and fishing is likely contributing to the decline[32]";
- Depressed marine survival also poses a medium to low level of threat to this DU;
- Freshwater temperature extremes also pose a threat to Sockeye from this DU;
- The Fraser River is expected to continue to warm throughout the 21st century which could lead to severe losses during adult migrations en-route to spawning grounds; and
- Warmer winters and earlier snow melt are expected with climate change and alterations in the timing of the freshet predicted to affect this early run time DU.

[32] This statement in the draft (In Press) COSEWIC report is inaccurate. DFO have adopted a conservative management strategy, including roiling window fishing closures, in order to conserve Early Stuart sockeye.

DFO Environmental Watch Program (EWatch)

EWatch[33] is a collaborative science advisory program that conducts monitoring and research to provide information related to near-real time fisheries management of Fraser salmon. The information is based on the accumulated understanding of freshwater salmon migration and the interaction with environmental conditions.

In general, the EWatch Program compiles near real-time Fraser watershed environmental monitoring information such as discharge (Figure 14), temperature (Figure 15), and snowpack and combines it with biological data to develop quantitative models for evaluating and forecasting the influence of environmental conditions on freshwater salmon migration.

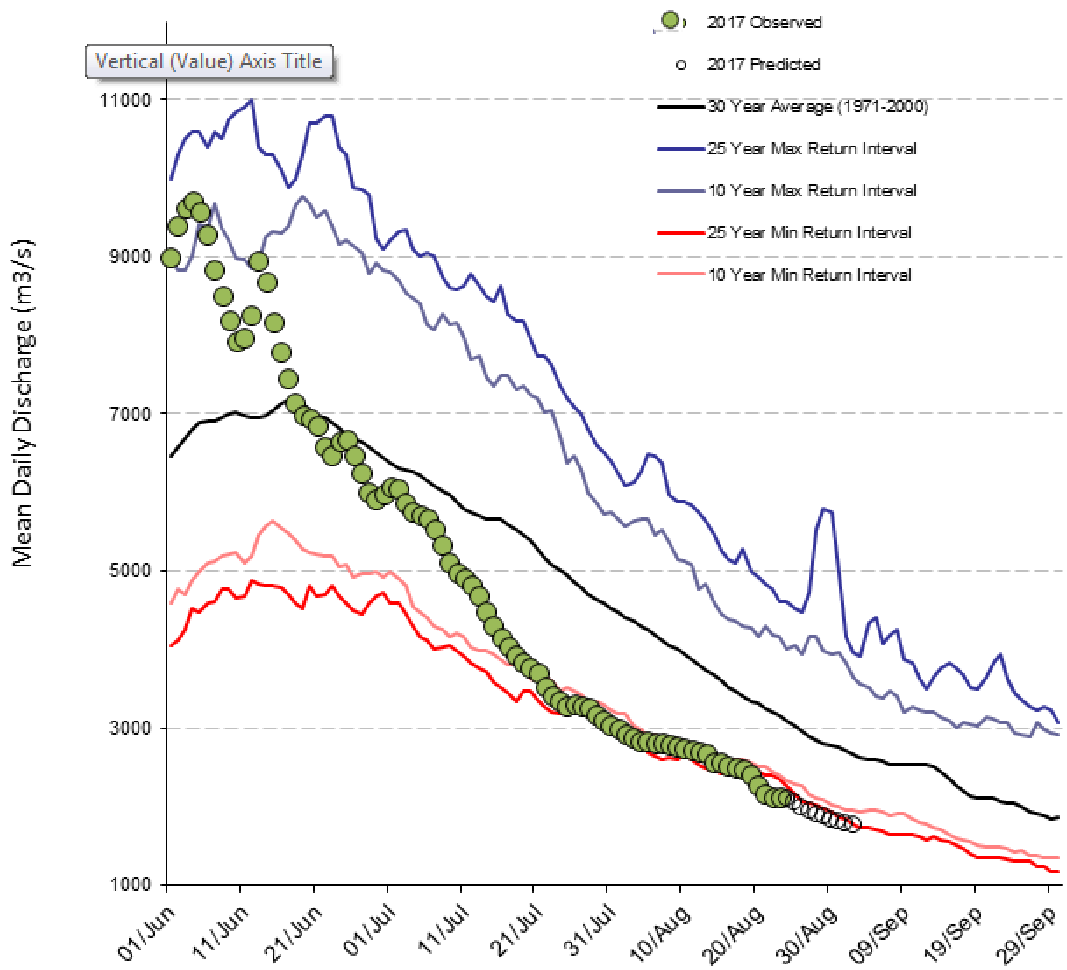


Figure 14. EWatch daily discharge data published on August 24, 2017 and utilized to evaluate sockeye migration conditions in the Fraser River at Hope, BC.

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33 Fraser River Environmental Watch

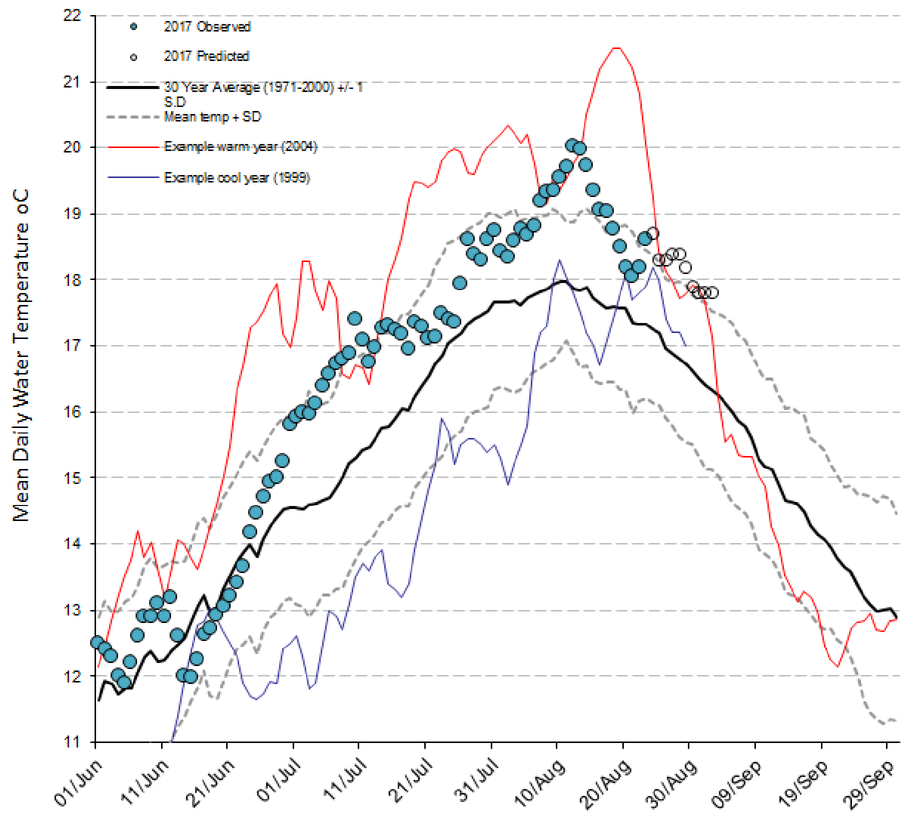

Figure 15. EWatch daily temperature data published on August 24, 2017 and utilized to evaluate sockeye migration conditions in the Fraser River at Hope, BC.

Critical water temperatures for migrating sockeye include:

- 18°C - Decreased swimming performance
- 19°C - Early signs of physiological stress and slow migration
- 20°C - Associated with high pre-spawn mortality and disease
- 21°C - Chronic exposure can lead to severe stress and early mortality

The severity of effects on migrating sockeye is related both to the absolute temperature and the duration of exposure.

In addition to publications and technical reports, the EWatch Program provides pre-season and semi-weekly in-season reports (early-July through mid-September). These reports are utilized by fisheries managers including the Fraser River Panel of the Pacific Salmon Commission and others in the prediction of *en-route* loss and pre-spawn mortality associated with adverse environmental conditions.

Over the past decade, the EWatch has evolved to become an integral part of the Fraser sockeye in-season management system. In recent years, the program has reported record high early spring flows during spring freshets, and high air/water temperatures that have created significant *en-route* losses and pre-spawn mortality for certain sockeye CUs. Fraser River discharge conditions are a particular concern for the Takla-Trembleur-Early Stuart CU, since this CU migrates first among Fraser Sockeye CU's during spring freshet. Water flows above 7,000 cubic meters per second (cms) can result in signs of physiological stress, and Hell's Gate becomes a hydrological barrier to migration at flows above 9,000 cms.[34; 35] There also have been years when temperatures are below or above the physiological optimum for Takla-Trembleur-Early Stuart, which can reduce their swimming performance. Fraser River temperature conditions are a particular concern for the Takla-Trembleur-Stuart-S CU and other CUs that migrate upstream of Hells Gate.

[34] 2015 Supplement to the Pre-Season Forecasts for Fraser Sockeye

[35] 2016 Supplement to the Pre-Season Forecasts for Fraser Sockeye

Cohen Commission Findings[36]

The Cohen Commission undertook a set of integrated scientific investigations designed to elucidate causes for the 2009 Fraser sockeye collapse as well as the long term sockeye decline which started in the 1990's. Following analysis of the scientific reports and the consideration of testimony from witnesses, the Cohen Inquiry concluded:

> "Given our limited understanding of how the many identified stressors actually affect Fraser River sockeye and how regional processes affect many different sockeye stocks, prudence dictates that neither be ruled out. The available evidence has identified a risk that both Fraser River-specific stressors and region-wide influences may have contributed to the long-term decline."

In support of the Inquiry, a set of integrated scientific investigations were undertaken to evaluate the causes for the 2009 Fraser sockeye collapse as well as the long term sockeye decline which started in the 1990's. Key scientific findings included:

1. The Fraser sockeye decline is part of a regional sockeye decline extending from Washington and covering all of BC as well as SE Alaska (Peterman and Dorner 2011). This implies a common cause for sockeye declines in a shared habitat, most likely in the marine environment.

2. Mortality processes operating after the smolts emigrate from sockeye lakes and when they return as adults to the Fraser River are the most important ones controlling year-class strength. This was expressed as reduced smolt-to-adult mortality (migration phase including marine) while egg-to-smolt mortality (freshwater phase) remained relatively stable across sockeye conservation units. The investigators (Nelitz et al. 2011) concluded that recent declines in Fraser sockeye are unlikely to be the result of changes in the freshwater environment.

3. A marine cause for the decline is implicated (McKinnell et al. 2012) however the location for the mortality factor couldn't be localized and the Salish Sea, Queen Charlotte Sound and the continental shelf of the Gulf of Alaska were identified as candidate areas where early marine mortality can fluctuate between years.

4. There was a suite of factors investigated that could profoundly influence Fraser sockeye however evidence was insufficient to refute or support their role as causal factors in the sockeye decline. They included disease (Kent 2011; Stephen et al. 2011), contaminants (MacDonald et al. 2011), predation (Christensen and Trites 2011), habitat factors in the Lower Fraser and the Salish Sea (Johannes et al. 2011) and salmon farm impacts (Korman 2011; Connors 2011; Dill 2011; Noakes 2011). These factors could be more accurately viewed as possible contributors to the sockeye decline.

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[36] Cohen Inquiry Reports

References for the technical reports cited in this section are provided in Appendix 3.

5. Warming waters due to climate change are adversely affecting migrating sockeye by means of *en route* and prespawning mortality (Hinch and Martins 2011).

6. The mortality factors described above are best considered as stressors which act cumulatively to reduce sockeye survival (Marmorek et al. 2011).

The cumulative effects analysis (Marmorek et al. 2011) provided a framework to summarize the evidence for different causal factors influencing sockeye survival (Figure 16). Consideration of the weight of scientific evidence led to a conclusion that marine factors were responsible for the decline of Fraser sockeye coupled with the adverse impacts of global warming. Freshwater processes were possible contributing factors but the evidence was weak or contradictory.

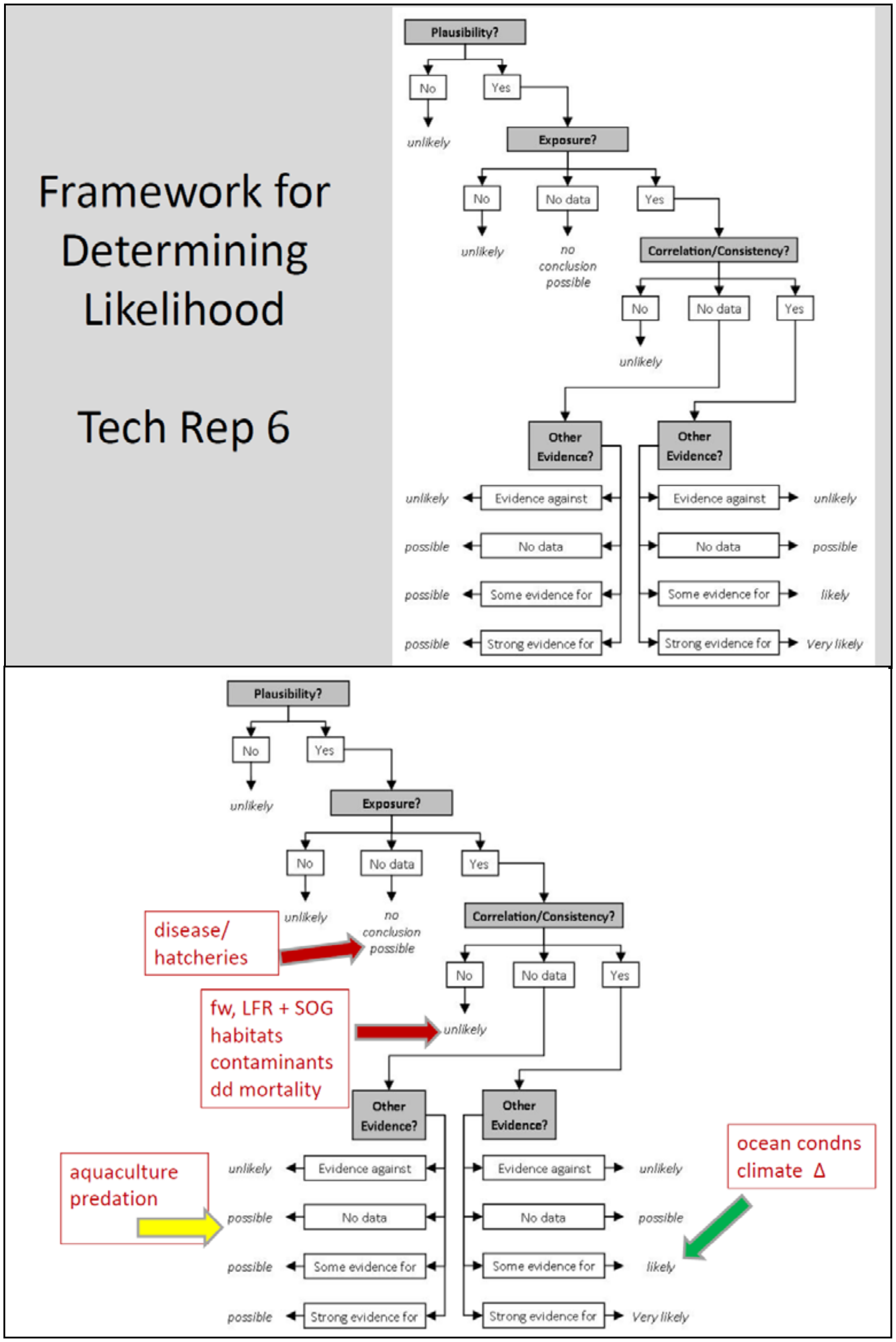


Figure 16. Evaluation of the likelihood of different causal factors underlying the decline of Fraser River sockeye. Green arrow indicates a strong relationship, yellow arrow indicates a possible but uncertain relationship and red arrow indicates that a relationship is unlikely. Source: Marmorek et al. (2011).

Fraser Sockeye Productivity

For the purposes of this report, sockeye productivity refers to the sockeye returns (recruits) per effective female spawner. Data collection for Fraser sockeye began in the 1940's and early 1950's for most of the key Fraser sockeye CUs. Although the Fraser sockeye aggregate productivity has been variable over this time period, in general the productivity was above 7 returns per effective female spawner in the first four decades of monitoring from 1950 to 1990. Productivity declined from 1990 to 2009, triggering the Cohen Inquiry (Figure 17). Fraser sockeye aggregate productivity improved from 2010 to 2013, but again declined from 2015 to 2017. In recent years, this productivity has fallen below replacement of 2 recruits per effective female spawner, which corresponds to the red line in Figure 17.

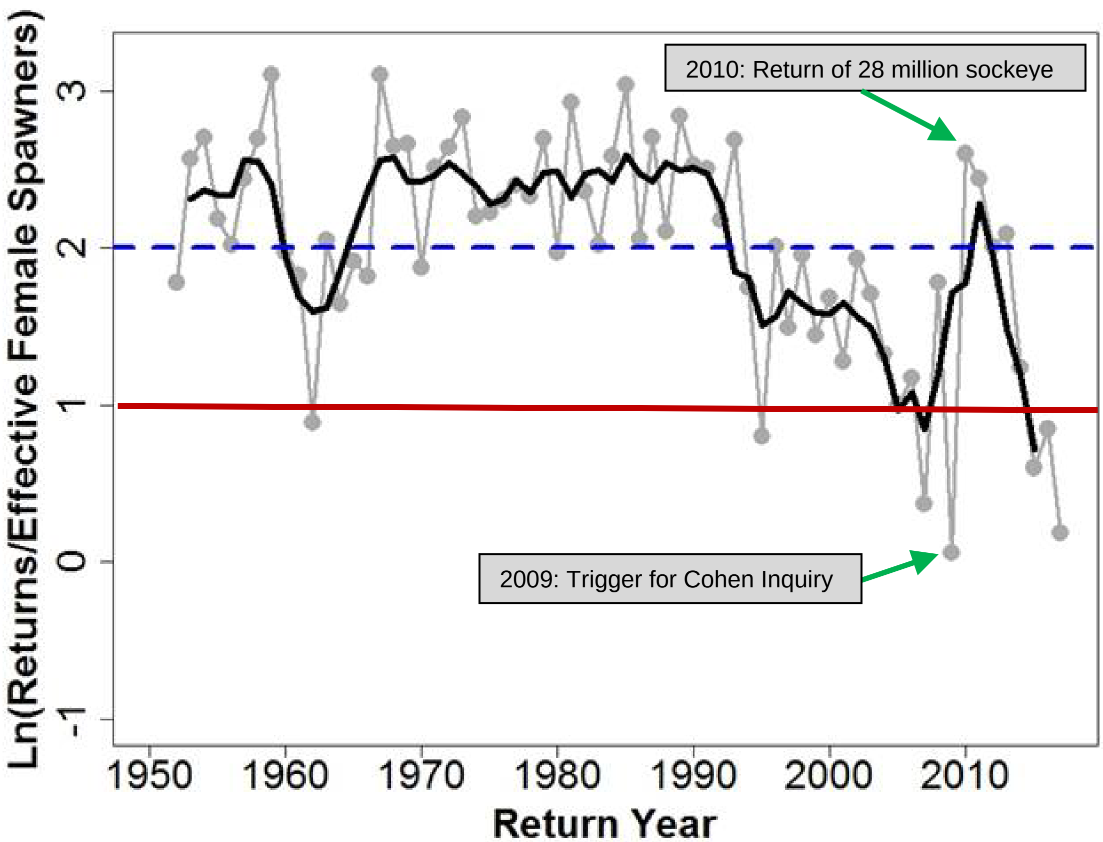


Figure 17. Fraser sockeye productivity expressed as returns per effective female spawner. Black line is the 4-year running average, dashed blue line is average productivity and the red line is the replacement value. Source: Sue Grant, DFO.

Across the individual Fraser sockeye stocks, productivity varies (Figure 18). For Fraser sockeye, stocks correspond to CUs, with one exception: Scotch and Seymour stocks are combined to form a single CU (Shuswap-ES). There are 18 stocks with stock-recruitment data; Cultus is excluded given their productivity time series is confounded by hatchery enhancement.

Productivity has declined across most individual stocks starting in the mid-1990's to the 2005 brood year, which corresponds to the 2009 return year.

Almost all stocks exhibited very poor survival in the 2005 brood year, which suggests a common mechanism across stocks. The poor productivity in 2009 has been linked to marine mechanisms[37].

Productivity was mixed across stocks from 2005 to 2010 brood years, which suggests different factors across stocks influencing trends. Then from 2011 to 2013, most stocks started to exhibit increasingly synchronous poor productivity. In the 2013 brood year (2017 return year), in particular, most stocks exhibited poor productivity, which is likely attributed to warm conditions in freshwater and marine ecosystems. Warm temperatures can affect Fraser sockeye directly throughout their life-history, and also influence their predators and prey in both freshwater and marine environments.

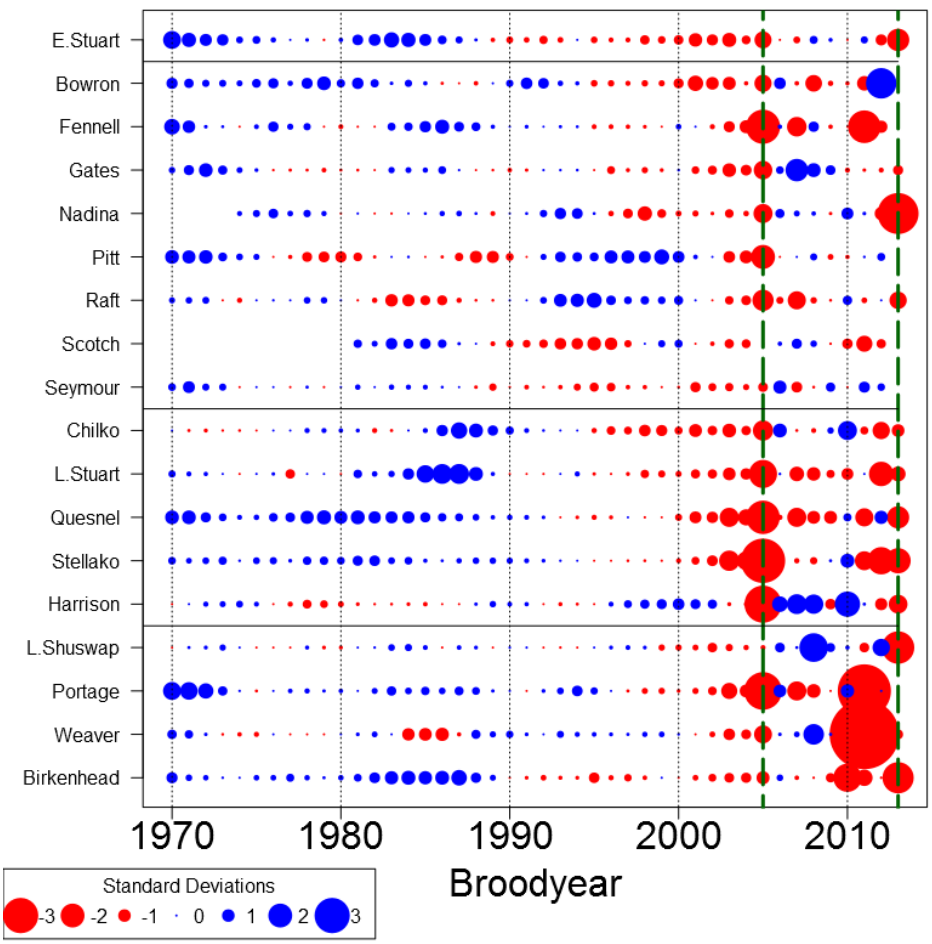


Figure 18. Time series of Fraser sockeye CU productivity variations Source: 2017 Fraser Sockeye Abundance, Productivity Trends and Forecasts NPAFC Doc. 1722.

37 Anomalous Ocean Conditions and Extreme Variability in Fraser Sockeye Production

Many Fraser sockeye stocks have historically and/or continue to show pronounced population cycles known as cyclic dominance[38] . The 2018 Fraser sockeye cycle line is driven by the dominant year of Late Shuswap (Adams Lake) sockeye returns, and this can be seen in the very large 2010 and relatively large 2014 return years (Figure 17). Low sockeye productivity has been linked to poor ocean conditions in recent years. In 2013 a “Warm Blob” of ocean water developed in the Northeast Pacific and remained there until 2016. These warmer ocean conditions increased average ocean temperatures by 3-4^{o}C and extended down to 100 m depths. In addition to the anomalously warm conditions, an El Niño occurred during 2015 and 2016 which affected land-ocean temperatures in the Pacific Northwest, including warmer-than-average Fraser River temperatures, and earlier-than-average spring freshets.

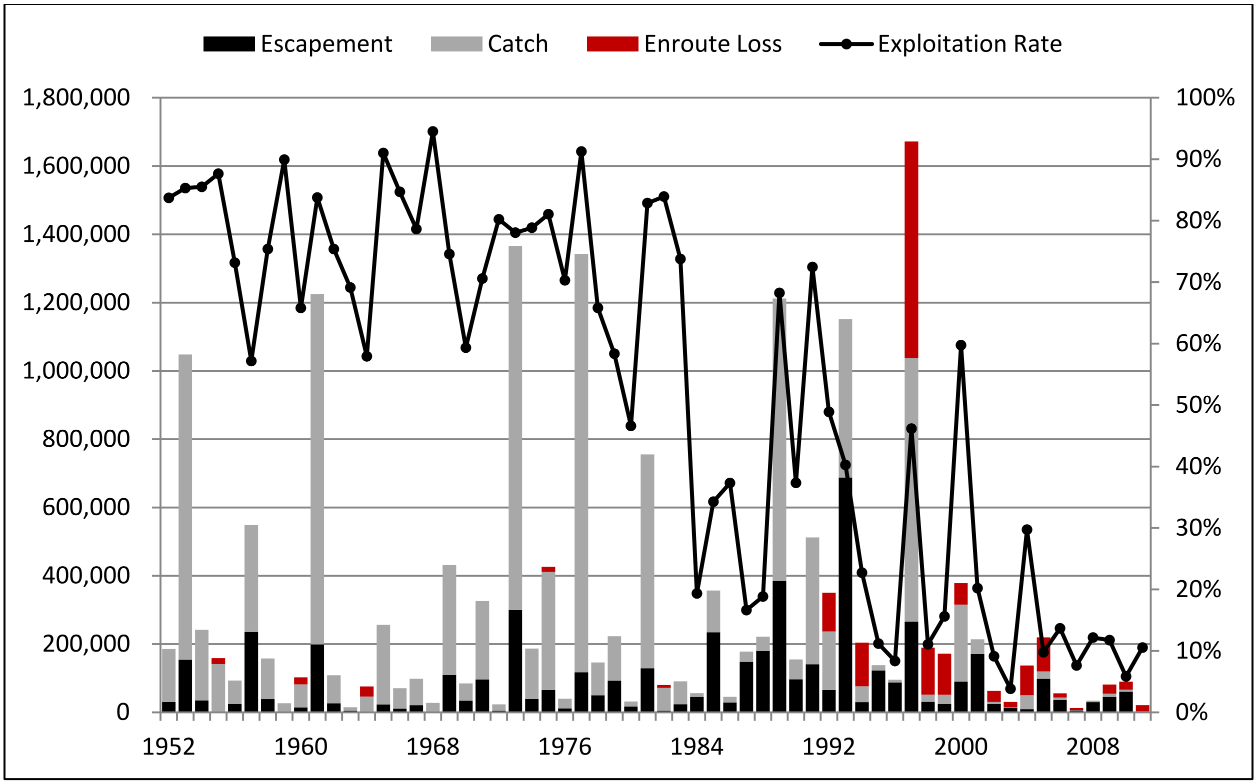
Fraser Sockeye stocks exhibited increasingly poor productivity when these warm conditions developed. In the 2013 brood year (2017 return year), most stocks exhibited synchronously poor productivity. It is expected that 2018 returns will also show below average productivity[39].

Upper Fraser Sockeye Productivity

Additional productivity detail for Early and Late Stuart has been provided in this section due to their WSP CU status as Red or Red/Amber respectively and “*Endangered*” status from the COSEWIC assessment. Trends in escapement and productivity for these two DUs are shown in Figures 19 and 20.

[38] Sockeye Salmon Population Cycles in the Fraser River

[39] 2018 Pre-season Forecasts for Fraser Sockeye



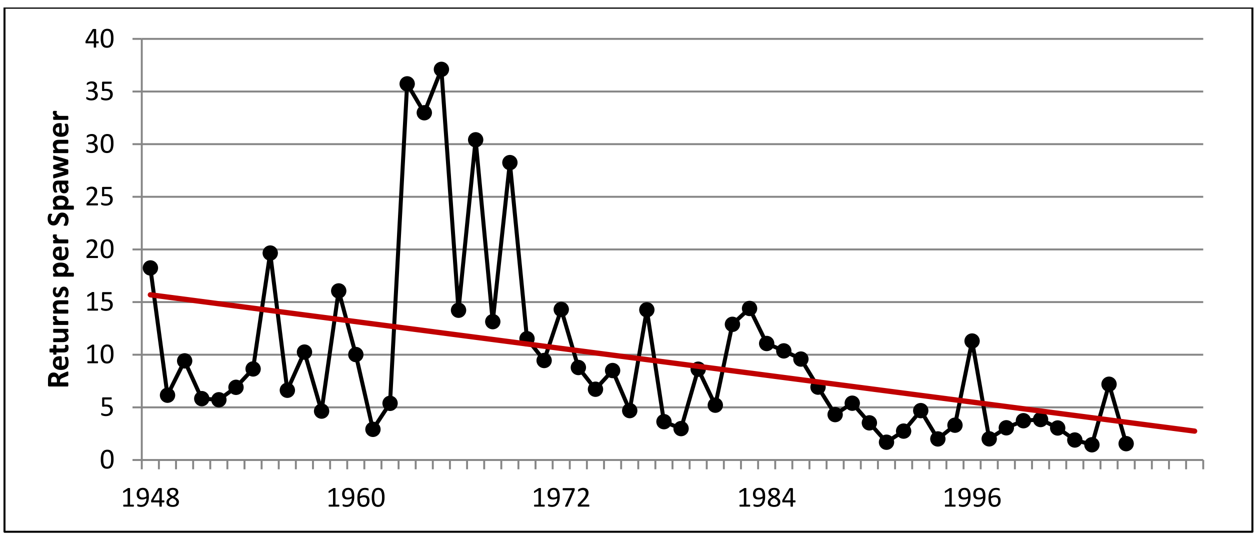


Figure 19. Upper: Trends in escapement, catch, en route loss and exploitation rate for Early Stuart sockeye. Lower: trends in productivity (returns per spawner) for Early Stuart sockeye.

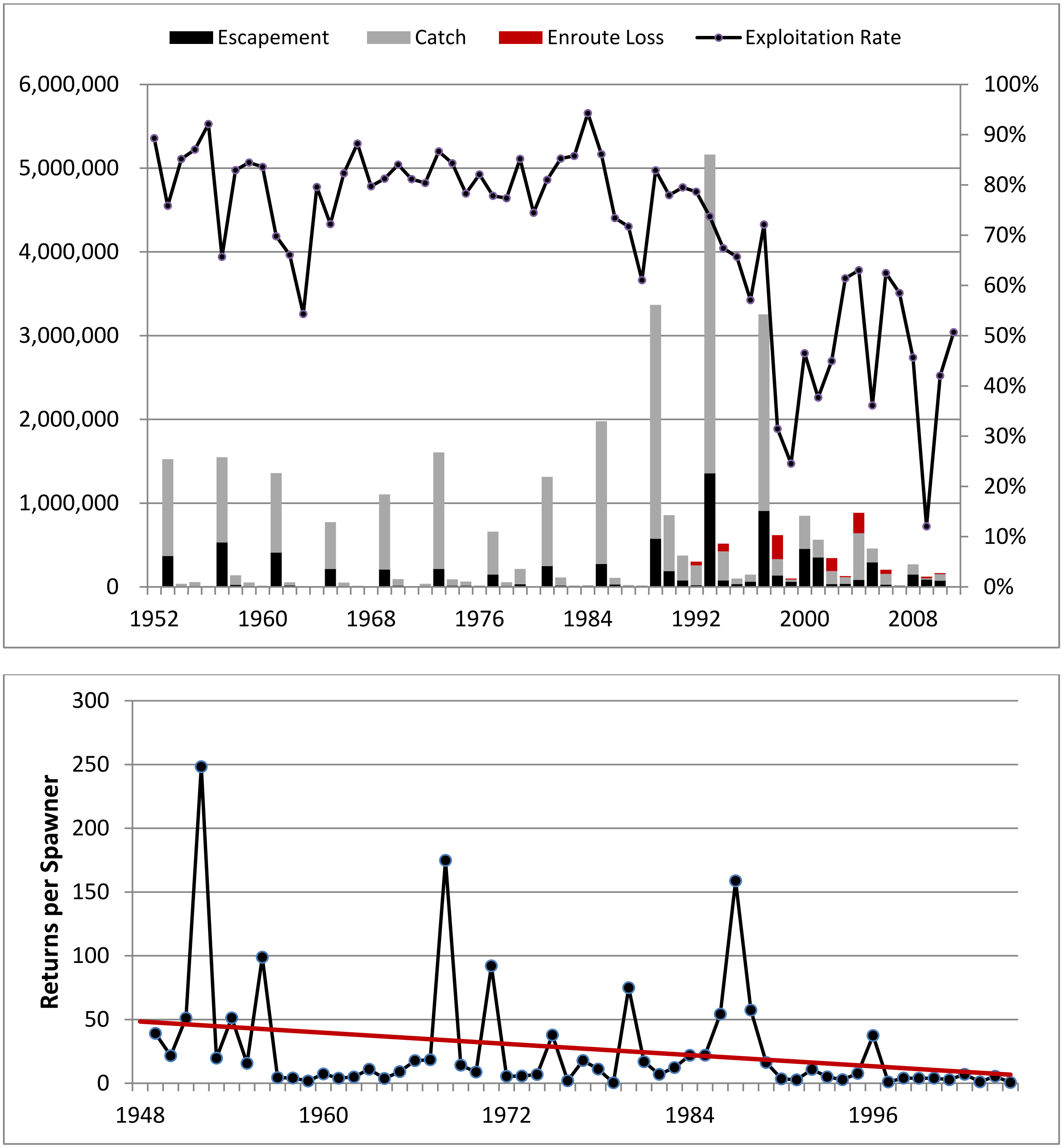


Figure 20. Upper: Trends in escapement, catch, en route loss and exploitation rate for Late Stuart sockeye. Lower: trends in productivity (returns per spawner) for Late Stuart sockeye.

Early Stuart Sockeye

Early Stuart was a strongly cyclic stock on the 2017 cycle line until 1997 (Figure 21). Since that year, the dominant cycle line has returned far below the cycle line average, and is now less dominant when compared to the other cycle lines. In addition to overall decreased productivity (declining returns per spawner), Early Stuart sockeye have experienced many years of significant *en-route* loss due to adverse environmental conditions since 1992: warmer-than-average Fraser River temperatures combined with higher-than-historical-flows aligned with the stock's peak migration timing. Despite fisheries management measures implemented to dramatically reduce exploitation rates due to conservation concerns for Early Stuart, the stock has not recovered to levels approaching average historical productivity.

The UFFCA conducted a series of workshops in 2016 to review data, identify trends, explore causation and identify options for Upper Fraser sockeye conservation and rebuilding, including Early and Late Stuart. The data review did not indicate a decline of freshwater nursery lake productivity as a contributor to overall Stuart sockeye decline, nor were there any large-scale freshwater habitat changes identified which could account for overall productivity changes in these systems. However, there are potential linkages between adverse freshwater environmental conditions and the health of Stuart sockeye. Research has shown that conditions which affect spawning sockeye females can affect the offspring via maternal effects[40] e.g. fry swimming performance[41].

Evidence suggests that the decline in productivity for Early Stuart sockeye is associated with increasingly adverse freshwater migration conditions coupled with poor ocean productivity regimes.

[40] A maternal effect is a situation where an organism is determined not only by the environment it experiences and its genetic make-up, but also by the environment and genotype of its mother.

[41] Maternal Effects on Sockeye Fry Burst Swimming Performance

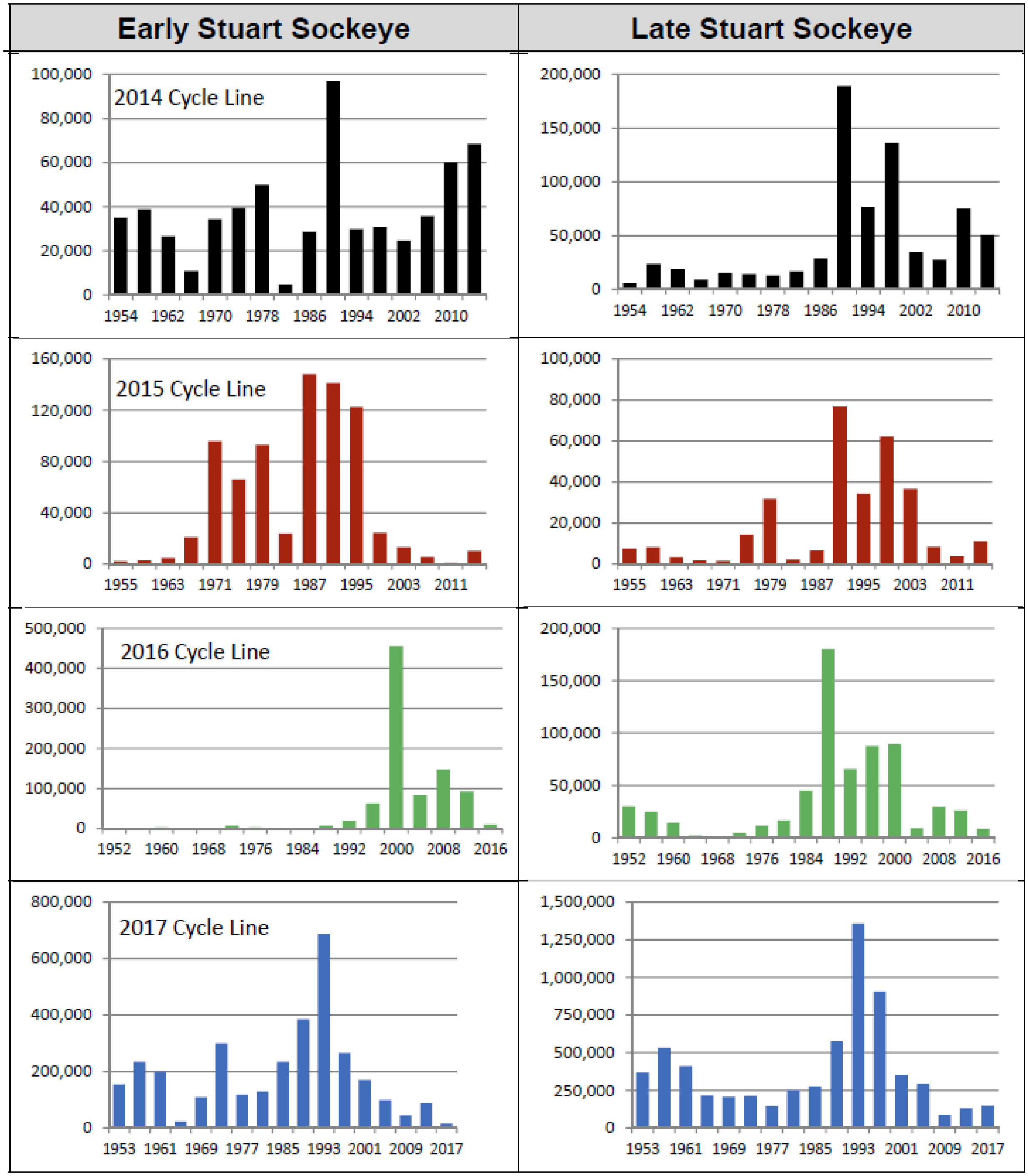


Figure 21. Early and Late Stuart sockeye escapements by cycle line. Note different y-axis scales.

Late Stuart Sockeye

Late Stuart sockeye were also strongly cyclic on the 2017 cycle line until 1997 (Figure 21). A peak escapement in 1993 of over 1.3 Million sockeye was followed by a strong brood escapement in 1997. After 1997, Late Stuart sockeye experienced below average cycle line returns and escapement on this cycle line. 2010 and 2014 escapements were similar in magnitude to escapements of the 2017 cycle line. Late Stuart sockeye have experienced *en-*

route losses in approximately half of the return years since 1992, and although some years show a higher proportion of en-route loss than others, the overall en-route loss pattern does not appear to be of the same magnitude as that of Early Stuarts.

There is a clear decline in productivity in Late Stuart sockeye beginning in 1998 and a decrease in returns per spawner during that timeframe as indicated by the negative trendline over the time series.

In the case of Late Stuart sockeye's decrease in productivity and status, fisheries management has not responded in the same manner as it has for the Early Stuarts. Exploitation rates on Late Stuart sockeye have generally decreased over time, but due to their later timing and co-migration with more productive Summer Run sockeye stocks (such as Chilko) and DFO's aggregate management policy, mixed stock fisheries have resulted in a greater exploitation rate on Late Stuarts than Early Stuarts over their respective lower productivity regimes. The exceptions to this are 1999 (brood year from 1995 which was a very poor return year), 2009, the low return year that triggered the Cohen Inquiry, and more recent years (2015, 2016, 2017) when Fraser sockeye returns were poor. However, Late Stuart exploitation reductions in those years were coincidental with poor returns rather than a specific management directive. In 2018 DFO's sockeye management approach includes 60% exploitation on the Summer Run management unit, depending on aggregate returning run-size.

As described in the Early Stuart section, a review of limnology data for Trembleur and Stuart Lakes (Late Stuart nursery lakes) found those lakes to be sufficiently productive to support at least an order of magnitude greater density of sockeye fry. Therefore, freshwater habitat quantity and quality do not appear to be a factor in the decline in productivity. However, adverse environmental conditions such as higher-than-average migration temperatures and low flows have been present for many years since 2000, and these stressors - combined with low productivity ocean regimes discussed earlier – have likely affected female spawner abundance and resultant offspring.

Discussion

Nechako Chinook

Mid-Fraser Summer 5_2 Chinook were previously assessed as having "Amber" status under the Wild Salmon Policy and have decreased in productivity over the past few years and may require a WSP re-assessment.

Prior to 2017, Nechako Chinook were more productive, as indicated by escapement monitoring validated with run reconstruction data, relative to other Upper Fraser Chinook populations. However during 2017, the situation changed and only 588 Chinook returned to the spawning grounds, the lowest number since the Kenney Dam was constructed. Comparisons shown in Figure 10 indicate that the decline wasn't specific to the Nechako Chinook population and similar decreases in escapement occurred synchronously in the Quesnel, Cariboo and Chilko populations. This observation suggests that productivity decreases associated with juvenile life history stages in the marine environment, where Upper Fraser Chinook juveniles share a similar habitat, are likely associated with the declines. Freshwater factors, including flow regulation, likely play a secondary role in controlling Chinook productivity as evidenced by the results from Nechako Chinook habitat and juvenile monitoring[42] and stable relationships between fry and juvenile densities in relation to adult spawner numbers.

In response to the *Endangered* Status of Southern Resident Killer Whales (SRKW) under SARA, DFO is developing programs to implement the SRKW Action Plan[43]. Reduced Fraser Chinook abundance, the primary SRKW summer food source, has been implicated as a critical factor controlling SRKW recovery[44] prospects. Chinook fisheries are being modified in 2018 to protect SRKW food availability. Nechako Chinook adult return timing places them in SRKW summer feeding habitat in the approach areas of the Fraser River during mid-late July (+/-). In order to recover SRKW it will be necessary to maintain and increase the productivity of Nechako Chinook as well as the other Mid-Fraser Spring and Summer 4_2 and 5_2 Chinook[45] above their present levels.

Concurrently with SRKW chinook salmon management measures, DFO has adopted a 2018-2019 IFMP objective of coast-wide Chinook harvest reductions in the range of 25-35% to address broad declines in productivity. However, no additional fishery management measures have been proposed for Fraser Spring 5_2 and Summer 5_2 Chinook (including Nechako). Based on pre-season consultations and background technical information distributed by DFO in 2018, the challenge with addressing conservation and management concerns with stocks such as

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[42] Assessment tools included fishing inclined plane traps and rotary screw traps to develop fry and juvenile indices for monitoring Nechako River habitat quality. The program ran over 13 years between 1990 - 2010. NFCP History Report

[43] Northern and Southern Resident Killer Whale Action Plan

[44] SRKW Threats and Effective Recovery Plans

[45] previous Nechako Chinook carcass surveys and adult scale sampling by the NFCP has indicated that in some years there can be similar, or even higher percentages of 4_2 Chinook compared to 5_2's

Nechako Chinook is the absence of marine-based assessment capacity at a resolution which can provide both marine distribution or estimates of marine mortality.

Implications of Early and Late Stuart Sockeye Endangered Status

Two of the sockeye populations that use the Nechako River as a migratory corridor, Early Stuart and Late Stuart, have been classified as *Endangered* by COSEWIC and are red-zoned CUs under the Wild Salmon Policy. In 2008, the UFFCA undertook an assessment of these two sockeye populations in view of their importance to Upper Fraser First Nations[46] and, based on available information at the time, identified the need for a COSEWIC assessment for the two populations. While these populations are now designated by COSEWIC as *Endangered*, neither COSEWIC designations nor WSP red-zoned designations by themselves guarantee stock recovery. The designations usefully serve as pre-cursors for recovery and require co-ordinated planning and defined management actions.

Fraser Sockeye COSEWIC designations will go through a legal listing process over the next 18 months. If these CUs are legally listed under the *Species at Risk Act* (SARA) there would be the requirement for recovery and action plans, as well as various prohibitions, and protections.[47] SARA prohibitions require that no person shall:

- kill, harm, harass, capture, or take an individual of a species listed in Schedule 1 of *SARA* as endangered, threatened or extirpated;
- possess, collect, buy, sell or trade an individual of a species listed in Schedule 1 of *SARA* as endangered, threatened or extirpated
- damage or destroy the residence (e.g.nest or den) of one or more individuals of a species listed in Schedule 1 of *SARA* as an endangered or threatened species, or as an extirpated species if a recovery strategy has recommended the reintroduction of the extirpated species into the wild in Canada.

Late Stuart sockeye are part of the Summer management group that includes Chilko sockeye, the most productive sockeye population in the Upper Fraser. If Late Stuart sockeye were SARA-listed, fisheries that encountered them, including all mixed-stock fisheries for Summer sockeye, would have to be considered through a lens of Recovery Potential and Allowable Harm, and administratively managed through SARA.

In the absence of legal listing, proposed revisions to Canada's Fisheries Act include the requirement for rebuilding plans as does Canada's WSP to support recovery actions for red-zoned CUs. However, to date, no detailed analyses of recovery planning has been conducted through the WSP to identify what management actions could be implemented that are within human control related to fisheries, habitat, and enhancement.

[46] UFFCA Technical Report

[47] *Species at Risk Act*

Sockeye Exposure to Warm Water Temperatures

Warm water temperature is a critical issue for Upper Fraser sockeye. The NFCP operates a Summer Temperature Management Program (STMP) from 20 July to 20 August to moderate elevated water temperatures during sockeye migration by manipulating the timing and volume of reservoir water, through Skins Lake Spillway, into the Nechako River. The program has been designed to reduce temperature-related risks during the sockeye migration period. The goal is to minimize occurrences of water temperatures above 20°C in the Nechako River at Finmore (upstream of the Stuart River confluence)[48]. While temperature excursions above 20°C do occur in some years, their magnitude, frequency and duration is reduced by operating the program.

As measured by the DFO Ewatch Program, during recent years there have been warm temperature conditions in the Fraser River and lower than average flows necessitating the application of Management Adjustments that anticipate *en route* mortality in an attempt to ensure that spawning escapement targets are met. Adult migrating sockeye are sensitive to Fraser River temperature conditions between Hope and Upper Fraser spawning grounds. In particular, female sockeye survival can be reduced during passage through hydraulically difficult parts of the migration. Sockeye that experience elevated temperatures (>19°C) between Hope and Prince George can experience further temperature stress during the final stretches of migration prior to reaching their spawning grounds in the Upper Fraser[49]. Cumulative exposure to high temperature coupled with upstream passage through hydraulically challenging reaches e.g. Hell's Gate, create stress that can be manifested as prespawning mortality as well as *en route* mortality.

Climate Change

Long-distance migrating sockeye populations that swim through the Nechako (e.g. Early and Late Stuart sockeye) are vulnerable to migration mortality (*en-route* loss) associated with climate-related temperature increases upstream of Hope. This is one of several mechanisms associated with climate change that can affect salmon in the Fraser Watershed[50]. Predicted reductions in Late Stuart sockeye survival due to incremental warming are estimated between 9-16% by the end of this century[51].

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48 NFCP History Report

49 Reduced Sockeye Survival Due To High Temperature

50 Effects of Global Warming on Fraser Salmon

51 Effects of Temperature and Climate Warming on Survival of Fraser Sockeye

Causes of Chinook and Sockeye Declines in the Fraser River

Southern BC Chinook are in decline. Low early marine survivals during the first year of marine residence have been identified as a key driver of recent productivity decreases[52] and both local and larger scale oceanographic conditions are likely involved. Other factors considered by the Independent Panel (harvests, freshwater habitats, hatcheries, pathogens, and climate change) were considered as possible secondary contributors. The authors noted that, consistent with the Pacific Salmon Treaty, harvest rate reductions have been imposed in order to rebuild North American Chinook stocks. Simultaneously, reductions in marine productivity have undermined rebuilding efforts so the effect of reduced harvest rate and has been counterbalanced by reduced marine productivity of juvenile and possibly sub-adult Chinook.

As a component of the work of the Independent Panel analysis was undertaken on the productivity (adult returns per spawner) for 24 wild Chinook stocks between Oregon and Western Alaska[53]. The investigators documented shared time trends in productivity that were most closely associated with the North Pacific Gyre Oscillation and with the location of the bifurcation in the North Pacific Current as it reaches the west coast. They concluded that Chinook productivity patterns of separate populations have become more synchronous in recent years, reinforcing the conclusion of the Independent Panel that early marine survival, where different populations of juvenile Chinook share similar marine habitats, is a key driver affecting Southern BC Chinook productivity.

The Fraser sockeye population in aggregate (Figure 17) has shown a decline in productivity (returns per effective female spawner) over the last 7 years. Sockeye productivity in 2017 was below the 1:1 replacement value and similar to the 2009 value that triggered the Cohen Inquiry. Overall the Inquiry concluded that there was "no smoking gun" and that factors in the freshwater and especially the marine ecosystem contributed to the decline. Compelling evidence was provided[54] that the Fraser sockeye decline is part of a regional decline extending from Washington and covering all of BC as well as SE Alaska. This conclusion implies a common cause for sockeye declines in a shared habitat, that includes marine and possibly freshwater ecosystems.

The findings of the Chinook Science Panel and Cohen Commission Inquiry into Fraser Sockeye are similar. Both implicated productivity decreases during early marine life history stages coupled with effects of climate change as being largely responsible for declining Southern BC Chinook and Fraser sockeye. Other factors including those operating in freshwater were best considered as secondary modifiers of aggregate productivity trends. The conclusions reflect that processes operating at regional scales have created synchronous declines in overall productivity between stocks, watersheds and species, in marine habitats utilized by juveniles during their outmigration to the Pacific Ocean.

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[52] Chinook Independent Advisory Panel Report

[53] Covariation of Chinook Productivity

[54] Widespread Decrease in Sockeye Productivity

Monitoring and Assessment

The Stock Assessment Division (STAD) of DFO undertakes annual monitoring for Nechako and other Upper Fraser Chinook and sockeye populations. STAD provides Nechako Chinook escapement estimates on behalf of the NFCP to monitor returns relative to the target population of the *Conservation Goal*. Based on the similarity between escapement and reconstructed Chinook abundance trends (Figure 9) we conclude that escapement monitoring programs have been sufficiently sensitive to detect changing productivity trends in Nechako and other Middle Fraser Summer 5_2 Chinook stocks.

When the *1987 Settlement Agreement* was negotiated a Chinook Conservation Goal between 1700 - 4000 spawners was defined to reflect the mean Chinook escapement to the Nechako over the period 1980 - 1986. The productive potential for Nechako Chinook may have changed since 1987 in response to changes in marine and freshwater habitats or changes in harvesting and fisheries management. Future changes in productivity may also occur in response to climate change. It will be essential to maintain STAD monitoring so that changes in Upper Fraser salmon productivity can be evaluated and understood.

Recommendations

Recovery Plan for Early and Late Stuart Sockeye

Now that Early and Late Stuart have been designated as *Endangered* under COSEWIC and also are in the WSP red status zone, a recovery planning process should be initiated. Evaluating previous sockeye recovery plans (Cultus, Sakinaw) to evaluate "lessons learned" to inform Early and Late Stuart sockeye recovery is recommended as a first step.

Improvements to Marine-Based Monitoring and Assessment for Southern BC Chinook

Preliminary data and background information associated with the Fraser Chinook 5 Year Management Review and Integrated Fisheries Management Plan (IFMP) consultations highlight the lack of information related to Spring 5_2 and Summer 5_2 Chinook in marine areas. A combination of monitoring and assessment of marine fisheries and sampling methods (genetic stock identification and coded wire tag) is required in order to fill data gaps related to productivity changes and their management implications for Fraser Chinook.

Nechako Chinook Salmon Conservation and Indicator Hatchery

The Independent Panel reviewed ongoing management practices and the ability of managers to detect productivity changes via ongoing coded wire tagging (CWT) programs. Among the critical information gaps identified by the Panel was the limited number of indicator stocks, especially the offshore ocean distribution type (stream-type spring Chinook)[55], limiting the ability to estimate total exploitation rate. A feasibility analysis is required for a Chinook conservation and indicator hatchery that would serve as a tagging platform to improve the management and assessment of Upper Fraser Chinook.

[55] Nechako Chinook are Summer Chinook but a similar recommendation also applies.

Appendix 1: Fraser River Chinook Management

Background

The management regime for Fraser Chinook is a mix of international and domestic frameworks, with domestic management occurring under the umbrella of the Pacific Salmon Treaty (PST). The international Chinook management framework is bound by Chapter 3 of the PST, with the current chapter initiated January 1, 2009 and in effect until January 1, 2019. An international Treaty was necessary for conservation and management due to the expansive migratory nature of Fraser Chinook, which results in US interception of Fraser Chinook in Alaska and Washington fisheries. Domestic Canadian Fraser Chinook management is built on policy related to Wild Salmon Policy status and an allocation policy framework for conservation, First Nations Food, Social and Ceremonial (FSC), Recreational and Commercial fisheries in that order of priority. Additional considerations for Domestic management are from the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessments and the Species at Risk Act (SARA).

In Canada, DFO's annual South Coast Salmon Integrated Fisheries Management Plan (IFMP) details management objectives and background information related to domestic fisheries management for Fraser Chinook. Given the scope and complexity of Fraser Chinook policy and management frameworks it is necessary to consider many sources of information when evaluating Fraser Chinook and their management.

International Management

Chapter 3 of the Pacific Salmon Treaty outlines Aggregate Abundance Based Management (AABM) and Individual Stock Based Management (ISBM) regimes. The Fraser Early Chinook Stock Group, which includes Middle and Upper Fraser Chinook, are part of the AABM and ISBM management regimes. Both regimes utilize an abundance based framework for all Chinook fisheries under the PST, guided by scientific advice and information from the Pacific Salmon Commission bi-lateral Joint Chinook Technical Committee (CTC).

AABM fisheries are managed to a numerical limit or total mortality computed from a pre-season forecast or an in-season estimate (although no in-season calculation is currently completed) of abundance and management is at the international level, while ISBM fisheries are constrained to a total catch limit or total adult equivalent mortality rate and managed domestically, or *within the fisheries of a jurisdiction for a naturally spawning Chinook salmon stock or stock group* (PST Chapter 3, page 70). ISBM fisheries are limited to a total adult equivalent mortality of 63.5% of the 1979 to 1982 base period, but can be constrained further for domestic management purposes. The CTC evaluates existing escapement objectives Canada and the US have set for consistency with respect to Maximum Sustainable Yield (MSY) or other biologically based goals.

With the 2009 agreement, AABM fisheries in South-east Alaska and West Coast of Vancouver Island were reduced by 15% and 30% respectively to address conservation concerns brought forward by both Canada and the US. As mentioned above, there are also mechanisms within the PST to reduce impacts of ISBM fisheries due to conservation concerns, including domestic fishery reductions greater than those required under Treaty obligations.

Domestic Management

Domestic management of Fraser Chinook occurs through obligations under the ISBM management of the PST as well as specific management measures related to Canada's allocation policy and conservation concerns, and broken down into several components guided by management objectives outlined in the South Coast Salmon IFMP. DFO's management of Fraser Chinook, in particular mid/upper Fraser Chinook (including the Thompson system) has become increasingly complex over the past decade, to the point where the management resolution is outpacing the tools available to assess and evaluate the management measures against management objectives.

In 2009, conservation concerns for specific stocks of Fraser Chinook identified in the early 2000's led to a domestic grouping of Fraser Chinook (based on genetic stock identification and related research) into life history, migration timing and geographic components at higher resolution than the original "Fraser Early" and "Fraser Early-Timed" designations. In subsequent years, these Chinook stock groupings were further refined by delineation of Chinook Conservation Units (CUs) under Canada's Wild Salmon Policy (2005), with eventual WSP CU status assessment in 2016.

The 2009-2010 IFMP included a major shift in management objectives for Fraser Early-Timed and Fraser Spring and Summer 5_2 Chinook, including a 50% reduction in exploitation rate (compared to 2006 and 2007) for earliest timed Fraser Chinook and ensuring a spawner abundance not less than the 1979 to 1982 base period for remaining Spring and Summer 5_2 Chinook. 2009 was also the first year DFO initiated the use of the Albion Chinook Test fishery as an in-season management tool for Fraser Spring 5_2 and Summer 5_2 Chinook, which has become part of the management structure, with modifications since that time.

DFO begins the new management year for Spring and Summer 5_2 Chinook in March, with a predicted Zone of management based on the Salmon Outlook and other relevant information, with potential management measures in place in the marine areas until mid July, and in freshwater through to the end of October. Historically, the Albion test fishery is initiated in April, but has not started until May in more recent years. The Albion in-season assessment model utilizes the relationship between the Albion test fishery CPUE (for a specific time period) and the estimated Spring and Summer 5_2 Chinook return to the mouth of the Fraser (which relies on the Fraser River Run Reconstruction model). The CPUE for years since 2009 is subsequently used to predict the in-season reconstructed abundance, which is compared to a 3 Zone management system. The 3 Zone approach was implemented in 2012, prior to this time it was a 2 Zone approach. Zone 1 is the worst-case scenario, and Zone 3 is an Abundant return situation. Management actions in Commercial, Recreational and First Nations (marine and freshwater) are dependent on this in-season assessment. A final in-season assessment is provided in mid-June, from which the final Zone of management is identified, and management measures are reflective of the final Zone.

Fraser Spring and Summer 5_2 Chinook Management Zone Approach

Zone	Predicted Return to the Fraser River	Actions
3	Greater than 85,000. Rationale: Manage to meet expected spawner abundance of at least 60,000. Populations rebuilding towards maximum sustained yield (MSY) levels.	First Nations directed fisheries. Directed recreational and commercial fisheries consistent with Allocation policy.
2	45,000 to 85,000. Rationale: Manage to meet expected spawner abundance of at least 30,000 and up to 60,000. Caution is required to avoid population declines. Populations well below MSY levels.	First Nations directed fisheries subject to abundance. By-catch retention/limited directed Fraser recreational fisheries may be initiated. Management actions to reduce by-catch in commercial fisheries.
1	Below or equal to 45,000. Rationale: Expected spawner abundance will likely be 30,000 or less. Significant conservation concerns. Very high risk of extremely low spawning populations.	By-catch retention/limited directed First Nations fisheries. Non-retention/closed recreational and commercial chinook fisheries in the Fraser River and tributaries. Management actions to reduce by-catch in other recreational and commercial fisheries.

Currently, the 2012 Spring and Summer 5_2 management regime remains in place, with an overall management objective of reducing the current overall exploitation rate by 50% from the 2000 to 2006 base period. Fishery management measures (detailed in tables) associated with each Management Zone have been utilized since 2012, with on-going changes to the measures through assessment and consultation.

Fraser Spring 4_2

Fraser Spring 4_2 Chinook return to the Thompson River system, but are included in this management summary because of the timing overlap with middle/upper Fraser Spring 5_2 Chinook, which are combined in a management aggregate including the Middle Fraser Summer 5_2 Chinook. Management actions associated with this life history group have an effect on management for the Spring and Summer 5_2 aggregate (fisheries are limited for conservation, and co-migrating Chinook benefit from these measures). Total mortality distribution for marine and freshwater areas can be estimated from Coded Wire Tag application for this management group, with Nicola Chinook being the stock used as an indicator for the remaining stocks in this group at the domestic and international management level. It is through the annual CWT total mortality estimates that DFO can assess the effectiveness of fisheries management for this management group. There is no in-season assessment or management of this stock group other than pre-season consultations and fisheries planning.

The current IFMP management objective for Fraser Spring 4_2 Chinook, described under *Fishery Management for Stocks of Concern* in the document, has changed very little since 2009 and is as follows: **The objective for Fraser Spring 4_2 Chinook is to conserve these populations by continuing to minimize incidental harvests in Canadian ocean fisheries and to continue fisheries management measures in the Fraser River to limit overall impacts and support rebuilding.**

Fraser Spring 5_2

Fraser Spring 5_2 Chinook do not currently have a Coded Wire Tag indicator stock, but rely on historical information from a CWT program for the Dome Creek stock in place from 2000-2006. This life history grouping is comprised of 2 Conservation Units – Middle Fraser Spring and Upper Fraser Spring. It is the combined grouping of these two CUs with the 5 Summer 5_2 CUs that is assessed and managed under the 3 Zoned Management system. There is a significant migration timing and distribution overlap of Spring 5_2 Chinook in the marine area, lower and middle Fraser. As described earlier, Spring 5_2 Chinook and Summer 5_2 Chinook are assessed in-season and actively managed via the Albion Chinook test fishery and Zoned management. Spring and Summer 5_2 Chinook have the same IFMP management objective, also described under Fishery Management for Stocks of Concern in DFO's document.

Fraser Summer 5_2

Fraser Summer 5_2 Chinook are managed and assessed with Spring 5_2 Chinook. This management group now has a CWT indicator in the Middle Fraser Summers CU – Chilko River. The first CWT jacks returned to the spawning system in 2017 (DFO pers comm.). If this CWT indicator remains funded in the future, CWT Total Mortality Distribution data and estimates can be developed in a similar manner to the Nicola Spring 4_2 CWT indicator. Currently, the Albion Chinook test fishery and Fraser Run Reconstruction are used to actively manage this management group with the Spring 5_2 Chinook under the Zoned Management approach. Nechako River Chinook are part of the Middle Fraser Summers CU, and thus part of the IFMP management objective and active management for Fraser Spring and Summer 5_2 Chinook.

The IFMP objective for the Spring 5_2 and Summer 5_2 Chinook group is as follows: **The objective for Fraser Spring and Summer (age 5_2) Chinook is to conserve these populations consistent with the management zones outlined in the Southern Salmon Integrated Fisheries Management Plan[56].** This objective has changed significantly since 2007 due to changes in stock groupings, assessment and management, but the conservation concern nature of the objective has remained similar.

[56] Section 13 Southern Chinook Salmon Fishing Plan under the Southern ISBM Chinook Section 13.1.4

Chinook Five Year Management Review

The Chinook 5 Year Management Review was initiated in Fall 2016, with the development of a draft Terms of Reference by DFO, with a 30 day public comment period. Since that time, the management review has been in the data compilation and assembly stage, with a small technical group (First Nations and DFO technical personnel) tasked with assembling, itemizing and organizing the data needed to answer key technical questions and address objectives outlined in the Terms of Reference.

The Chinook 5 Year Management Review was requested by First Nations, Recreational and Commercial sectors as well as DFO, beginning in 2016. As described in the Fraser Chinook Management section of this report, 2012 was the year DFO implemented the 3 Zone Management approach for Fraser Spring and Summer 5_2 Chinook, and an objective of an overall 50% reduction in exploitation for this management group from a base period. DFO's management objectives were outlined in a detailed letter, which included DFO's interpretation of priority allocation management (Canadian Commercial sector reduced the most, followed by Canadian Recreational, and finally First Nations fisheries).

The Management Review will be conducted in a two phase approach. Phase 1 is being conducted by a small technical group currently consisting of First Nations and DFO personnel, which is tasked with compiling and analyzing existing information related to Chinook assessment and management. This phase will be opened to more technical participation (technical stakeholder participation) once the available information has been suitably organized for broader input. Phase 2 of the Management Review will focus on management implications stemming from the technical review and consider changes to the management review. The timeline for the review is intended to provide information for inclusion in the 2018-2019 IFMP.

The scope of the Management Review is as follows (from the Terms of Reference – April 13, 2017).

1) Stocks: The focus of the review is on Fraser River Spring 4_2, Spring 5_2 and Summer 5_2 Chinook. While there was some interest expressed to consider other Fraser River Chinook stocks, these stocks will not be within the scope of the review unless there is information that the technical working group considers relevant. (Note: there is information available for coded-wire tag indicator populations for Fraser Summer 4_1 and Fraser Fall (Harrison) Chinook that provide annual summaries of total mortalities by fishery and area.)

2) Fisheries: Impact on Fraser River Spring 4_2, Spring 5_2 and Summer 5_2 in all Canadian First Nations, recreational and commercial salmon fisheries in Northern and Southern BC, including catch and release mortality, will be considered to the extent that is practical. This should consider fisheries where other Chinook stocks or species are the target and Fraser Chinook are incidentally harvested or caught and released. Information on United States fisheries may be included where information is available.

3) Years to include: A minimum of one full Chinook life cycle (2011-2015) will be reviewed; however, a longer time frame (e.g. 10+ years) will be considered where information is available. Recognizing that data for 2016 is not yet available, this information may not be included in the review.

4) Data: All available information from coded-wire tags (CWT), fishery catch and releases, genetic data (DNA), run reconstruction results, and spawner abundance will be provided for the technical review. Additional information, including Aboriginal traditional knowledge, may also be considered where available.

5) Timeframe to complete the work: The original timeline for the review was supposed to produce results by late 2017 or early 2018 to inform the development of the 2018/19 salmon IFMP. This schedule has slipped and the updated timeline is unknown at this point.

Appendix 2: Fraser River Sockeye Management

Background

Fraser River sockeye management[57] is likely the most highly scrutinized, regulated, resourced and most participatory process for Canadian Pacific salmon. Although returns and harvest of Fraser sockeye have declined over the past 120 years, the management structure, stock assessment and applied research is a key element of First Nations, Canadian domestic and Southern US salmon management efforts. Fraser Sockeye management is bound by Chapter 4 of the Pacific Salmon Treaty and subject to extensive planning and implementation on an annual basis.

Fraser River sockeye fisheries - rights-based, commercial and more recently recreational - are of such high importance to Canada and the US that in-season sockeye management and analysis is conducted throughout the return timing and subject to intensive pre-season and post-season analysis. Canada values the Fraser sockeye resource to such an extent that it has conducted several inquiries of the management of this resource, with the most recent being the Cohen Commission inquiry in 2009, following the collapse of the Fraser River sockeye return.

International Management

Fraser River sockeye management is captured under the umbrella of the Pacific Salmon Treaty (PST), which was established between Canada and the United States in 1985. The Pacific Salmon Commission (PSC) – a bilateral body – was established by Canada and the US to implement the PST. Fraser sockeye management is detailed in Chapter 4 of the PST, with the current chapter set to expire at the end of 2019.

At the international level, Fraser River sockeye management is conducted by the bilateral Fraser River Panel, which includes representatives and observers from the governments of Canada and the US, First Nations, Commercial, Recreational and NGOs. Chapter 4 of the PST outlines the framework from which the Fraser River Panel regulates the sockeye fishery and ultimately determines the Total Allowable Catch (TAC) of Fraser River sockeye to be shared in agreed-to proportions between Canada and the US (16.5% US and 83.5% Canada). A portion of Canadian domestic First Nations Food, Social and Ceremonial (FSC) sockeye fisheries (400,000) are exempt from bilateral sharing calculations, but the remainder forms part of Canada's bilateral share of the sockeye harvest. Canada provides an annual pre-season forecast of the Fraser sockeye return by four run timing aggregates representing all Fraser sockeye Conservation Units – Early Stuart, Early Summer, Summer and Late. Canada also provides the escapement targets for the run timing aggregates, from which in-season assessment of sockeye returns will determine the overall TAC after the First Nations exemption, test fishery and Management Adjustments (MA) are applied to each of the aggregates. The

[57] Overview of Fraser Sockeye Harvest Management

Fraser River Panel Area covers the Fraser River approaches and the Lower Fraser River (Figure 22).

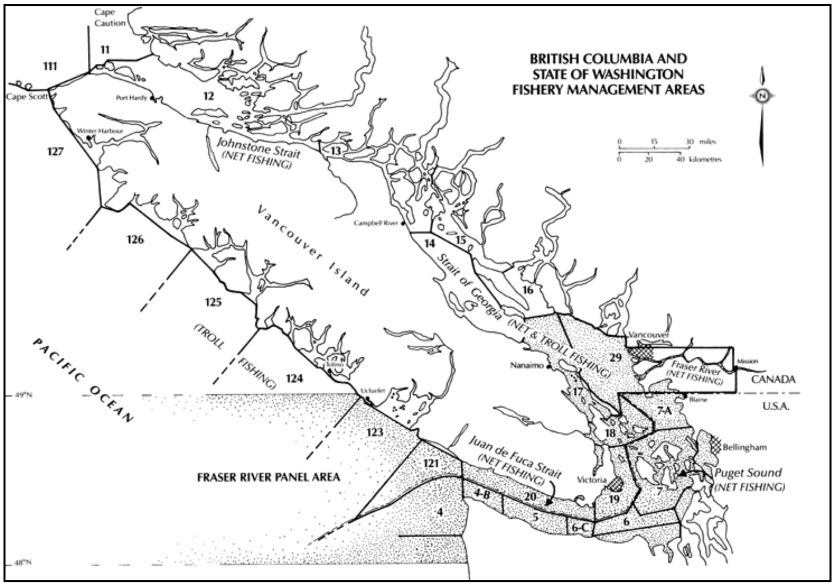

Figure 22. Fraser River Panel Area.

The expected run timing curve for Fraser sockeye passage through Area 20 (Straits of Juan de Fuca) is a key piece of information that combines pre-season return and run timing forecasts in order to provide data for in-season decision-making by the Fraser River Panel of the PSC (Figure 23).

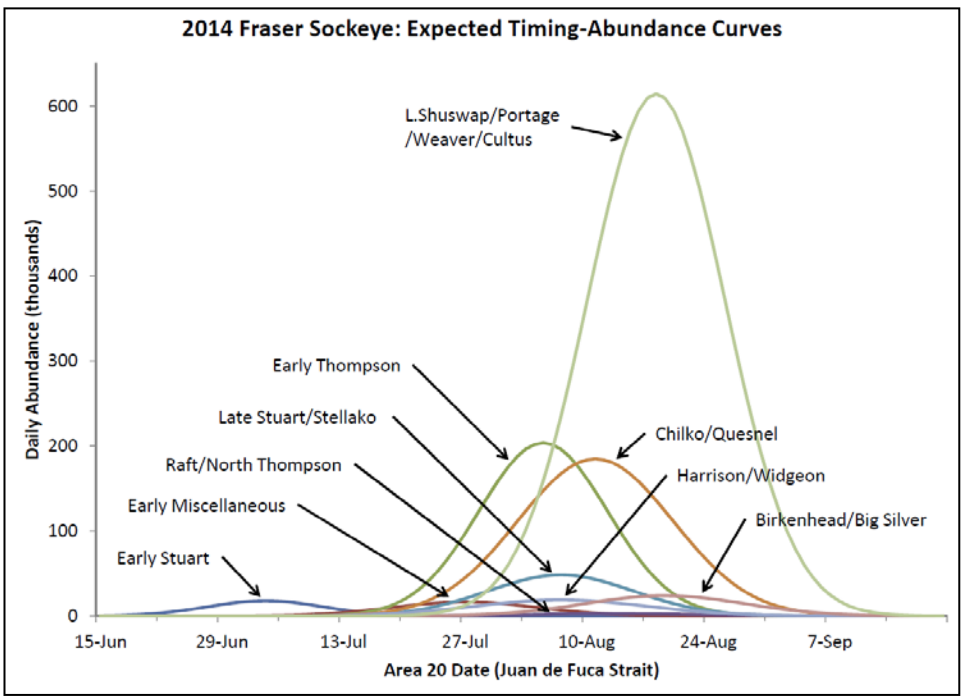

Figure 23. A pre-season run timing curve for Fraser sockeye in 2014[58]. Source: Mike LaPointe, Pacific Salmon Commission

[58] Fraser River Panel Weekly Reports

During the sockeye return season, the PSC assesses and estimates the sockeye abundance in marine areas and the Fraser River using a variety of methods including hydro-acoustics, test fisheries, visual observation, fishwheels and other sources to revise and confirm run size estimates. In addition to stock assessment information, Management Adjustments are applied to the run aggregates based on in-season Fraser River migration environmental conditions and historical data related to en-route loss and pre-spawn mortality. This information is provided to the Fraser River Panel, which meets roughly twice weekly to determine where and when Fraser sockeye fisheries will occur based on the in-season information.

The Fraser River Panel distributes official News Releases and Regulatory Announcements following in-season meetings. These documents summarize the most up-to-date in-season information and sockeye fishery openings and closings by area and time.

Domestic Management

Canada is responsible for providing pre-season return, run-timing, and diversion forecasts as well as escapement targets for Fraser River sockeye to initiate planning for Fraser sockeye fisheries on an annual basis. DFO's process for domestic consultation and information distribution for Fraser sockeye is captured in the Southern Salmon Integrated Fisheries Management Plan (IFMP). The Fraser sockeye forecast is a peer-reviewed process with an annual presentation to the bi-lateral Fraser River Panel at the February Pre-Season Pacific Salmon Commission session. Fraser River Sockeye escapement targets are developed through the IFMP consultation period, with final Ministerial sign-off in June of every year.

Early Stuart

Early Stuart sockeye are the first Fraser River sockeye aggregate to return to the marine-approach areas in Canadian waters and spawn in the upper portions of the Stuart River (a major tributary to the Nechako River - Figure x). With the exception of limited Stuart River First Nations FSC fisheries and extremely limited test fisheries, these sockeye have been subjected to conservation restrictions due to low productivity and overall escapement for the past two decades. Window closures and selective harvest gear management have been used to ensure conservation.

Early Summer Run

Early Summer Run sockeye spawn throughout the Fraser watershed. Variable productivity of these sockeye and overlapped timing with Early Stuart sockeye often constrains mixed stock fisheries on an annual basis. In general, mixed-stock management focusses on fisheries on the latter portion of the migration timing for this aggregate. The only sockeye stock returning to the Nechako system in this timing aggregate the Nadina River run.

Summer Run

In general, Summer Run sockeye are more productive and abundant than Early Summer and Early Stuart sockeye. The Stellako and Late Stuart sockeye are part of this timing aggregate and return to spawn in tributaries to the Nechako River. Except for dominant Adams River sockeye years (2018 cycle), the Summer Run aggregate is the focus for Fraser sockeye management on an annual basis.

Late Run

There are no Late Run sockeye that return to the Upper Fraser River. Adams River sockeye (Late Shuswap) drive the overall abundance of this timing aggregate and are the latest returning sockeye to the marine-approach areas and Fraser River. The dominant cycle line for Late Shuswap is 2018. Since the mid-1990's Fraser sockeye management has been challenged by some years of very high pre-spawn mortality caused by a number of issues including lack of migration delay at the mouth of the Fraser. Conservation concerns for Cultus Lake sockeye within this aggregate and co-migrating Interior Fraser Coho have also constrained harvest opportunities and increased the management complexity of this aggregate.

Pre-Season Return Forecasts

As mentioned in the preamble to this Appendix, Fraser sockeye salmon are managed under a management system that is one of the most sophisticated for any salmon fishery in North America. As part of the management process, DFO generate pre-season forecasts (Table 4) for different Fraser sockeye populations and these numbers outline pre-season expectations for the fishery prior to fishing[59]. Once test fishing starts, the management system places less reliance on the pre-season return forecasts and shifts to an in-season process.

Since 2006, DFO has utilized the Fraser River Sockeye Spawning Initiative (FRSSI) process and model to set Total Allowable Mortality (TAM) rules for each of the Fraser River sockeye run timing aggregates specified in under the Pacific Salmon Treaty[60]. The TAM rules for each of the aggregates specify the escapement targets at a given run size.

Pre-season fishery planning applies forecast sockeye abundances under a range of probabilities to the TAM rules, from which Total Allowable Catch is calculated. Canada is responsible for regulating all Fraser sockeye fisheries occurring in Canadian waters. Canadian domestic allocation policy prioritizes Fraser sockeye management in the following order: Conservation (escapement targets), First Nations FSC fisheries, Commercial fisheries and finally Recreational Fisheries. DFO utilizes FSC Communal Licences to shape fishery management to "deliver" Fraser sockeye to FSC Communal License areas in the marine areas, and throughout the Fraser River watershed.

[59] 2018 Pre-season Fraser Sockeye Pre-Season Return Forecasts

[60] Harvest Rules for Fraser River Sockeye Salmon

Table 4. Pre-season forecast for Fraser River sockeye in 2018.

Run timing group / Stocks	Forecast Model [a]	Probability that Return will be at/or Below Specified Run Size: 10%	25%	50%	75%	90%
Early Stuart	*Ricker (Ei)*	*37,000*	*54,000*	*84,000*	*133,000*	*199,000*
Early Summer		**584,000**	**1,102,000**	**2,155,000**	**3,765,000**	**6,587,000**
(total excluding miscellaneous)		***393,000***	***674,000***	***1,175,000***	***2,168,000***	***3,750,000***
Bowron	*Ricker (Pi)*	*7,000*	*12,000*	*20,000*	*35,000*	*59,000*
Upper Barriere (Fennell)	*Power*	*9,000*	*14,000*	*25,000*	*46,000*	*80,000*
Gates	*Larkin*	*11,000*	*20,000*	*38,000*	*76,000*	*149,000*
Nadina	*MRJ*	*45,000*	*81,000*	*153,000*	*291,000*	*518,000*
Pitt	*Larkin*	*22,000*	*32,000*	*53,000*	*84,000*	*130,000*
Scotch	*Larkin*	*89,000*	*166,000*	*330,000*	*750,000*	*1,513,000*
Seymour	*RickerCyc*	*210,000*	*349,000*	*556,000*	*886,000*	*1,301,000*
Misc (EShu) [b]	*R/S*	*186,000*	*416,000*	*956,000*	*1,546,000*	*2,736,000*
Misc (Taseko) [c]	*R/S*	-	-	-	*1,000*	*1,000*
Misc (Chilliwack)	*Ricker*	*2,000*	*5,000*	*11,000*	*25,000*	*53,000*
Misc (Nahatlatch) [d]	*R/S*	*3,000*	*7,000*	*13,000*	*25,000*	*47,000*
Summer		**1,470,000**	**2,473,000**	**4,344,000**	**7,669,000**	**13,173,000**
(total excluding miscellaneous)		***1,442,000***	***2,417,000***	***4,250,000***	***7,473,000***	***12,778,000***
Chilko	*4-PowJuvPi; 5-Sib*	*833,000*	*1,345,000*	*2,259,000*	*3,801,000*	*6,098,000*
Late Stuart	*R1C*	*55,000*	*88,000*	*149,000*	*251,000*	*401,000*
Quesnel	*RickerEi*	*292,000*	*573,000*	*1,148,000*	*2,223,000*	*4,152,000*
Stellako	*Larkin*	*229,000*	*347,000*	*559,000*	*895,000*	*1,454,000*
Harrison [e]	*3-Ricker; 4-sibling*	*13,000*	*33,000*	*87,000*	*225,000*	*548,000*
Raft [e]	*Ricker (PDO)*	*20,000*	*31,000*	*48,000*	*78,000*	*125,000*
Misc (N. Thomp. Tribs) [e & f]	*R/S*	*2,000*	*4,000*	*7,000*	*15,000*	*31,000*
Misc (N. Thomp River) [e & f]	*R/S*	*25,000*	*50,000*	*84,000*	*175,000*	*354,000*
Misc (Widgeon) [g]	*R/S*	*1,000*	*2,000*	*3,000*	*6,000*	*10,000*
Late		**3,174,000**	**4,794,000**	**7,398,000**	**11,370,000**	**16,934,000**
(total excluding miscellaneous)		***3,164,000***	***4,776,000***	***7,363,000***	***11,303,000***	***16,818,000***
Cultus	*power (juv) (Pi)*	-	*1,000*	*1,000*	*3,000*	*6,000*
Late Shuswap	*RickerCyc*	*3,045,000*	*4,548,000*	*6,923,000*	*10,415,000*	*15,091,000*
Portage	*Larkin*	*22,000*	*44,000*	*102,000*	*234,000*	*479,000*
Weaver	*Ricker PDO*	*38,000*	*78,000*	*150,000*	*318,000*	*655,000*
Birkenhead	*Ricker (Ei)*	*59,000*	*105,000*	*187,000*	*333,000*	*587,000*
Misc Harrison/Lillooet [g]	*R/S*	*10,000*	*18,000*	*35,000*	*67,000*	*116,000*
TOTAL SOCKEYE SALMON		**5,265,000**	**8,423,000**	**13,981,000**	**22,937,000**	**36,893,000**
(TOTAL excluding miscellaneous)		***5,036,000***	***7,921,000***	***12,872,000***	***21,077,000***	***33,545,000***

a. See Table 4 for model descriptions

b. Misc. Early Shuswap uses Scotch & Seymour R/EFS

c. Misc. Taseko uses Chilko R/EFS

d. Misc. Nahatlach uses Early summer-run stocks R/EFS

e. Raft, Harrison, Misc. North Thompson stocks moved to Summer run-timing group

f. Misc. North Thompson stocks use Raft & Fennel R/EFS

g. Misc. Late Run stocks (Harrison Lake down-stream migrants including Big Silver, Cogburn, etc.), and river-type Widgeon use Birkenhead R/EFS

Appendix 3: Cohen Inquiry Technical Reports

Christensen, V. and A.W. Trites. 2011. Predation on Fraser River sockeye salmon. Cohen Commission Tech. Rept. 8:129p. Vancouver, B.C.

Connors, B. 2011. Examination of relationships between salmon aquaculture and sockeye salmon population dynamics. Cohen Commission Tech. Rep. 5B. 115p. Vancouver, B.C.

Dill, L.M. 2011. Impacts of salmon farms on Fraser River sockeye salmon: results of the Dill investigation. Cohen Commission Tech. Rept. 5D. 81p. Vancouver, B.C.

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