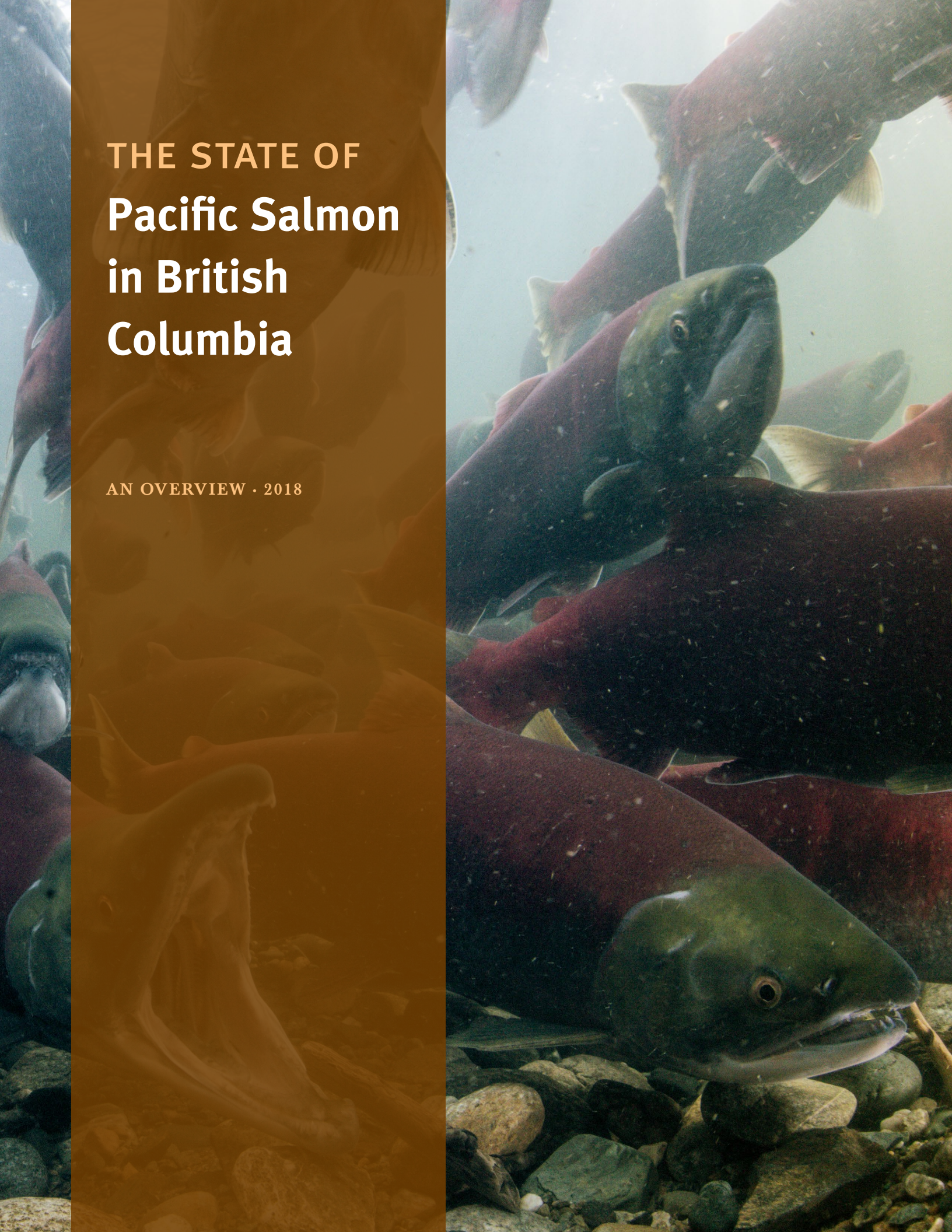


THE STATE OF
Pacific Salmon in British Columbia

AN OVERVIEW · 2018

FOR CITATION

Riddell, B., Connors, K., and Hertz, E. (2018).
The State of Pacific Salmon in British Columbia: An Overview.
The Pacific Salmon Foundation, Vancouver, BC, Canada.

PACIFIC SALMON FOUNDATION

SALMON WATERSHEDS PROGRAM

Pacific Salmon Foundation
300 – 1682 West 7th Avenue
Vancouver, BC V6J 4S6
www.psf.ca

The State of Pacific Salmon in British Columbia

AN OVERVIEW

2018

Pacific Salmon, an official symbol of British Columbia

Cover photograph by Paul Colangelo (paulcolangelo.com).

All watercolour illustrations are by Aimée van Drimmelen (avd-art.com).

The graphic design is by Rocketday Arts (rocketday.com).

This report was created under contract to the Coastal First Nations who provided input to the BC government's Wild Salmon Strategy. The Pacific Salmon Foundation prepared this report over a brief time frame during September 2018 to inform the discussion of the BC Wild Salmon Advisory Council. Following the Wild Salmon Advisory Council's review of the report, some content was incorporated into the Wild Salmon Advisory Council's Options Paper.

BC Gov News backgrounder on BC Wild Salmon Advisory Council
https://news.gov.bc.ca/releases/2018PREM0045-001204

BC Wild Salmon Advisory Council's
Options for a Made-in-BC Wild Salmon Strategy
https://engage.gov.bc.ca/app/uploads/sites/426/2018/11/Wild-Salmon-Strategy-Options-Paper.pdf

BC Wild Salmon Advisory Council's
Recommendations for a Made-in-BC Wild Salmon Strategy
https://engage.gov.bc.ca/app/uploads/sites/426/2019/03/Wild-Salmon-Advisory-Council-Report.pdf

Acknowledgements

Numerous staff in Fisheries and Oceans Canada (DFO) and the Pacific Salmon Commission were invaluable in responding to requests to update data files or direct enquires to published materials. We also thank the advisors from First Nation groups, DFO, and Provincial staff that have enabled the development of the Pacific Salmon Explorer (PSE) tool. The shortness of time to prepare this report clearly demonstrates the value of building tools like the PSE to enhance sharing and reporting of data that is critical to the monitoring and assessment of Pacific salmon.

Executive Summary

The Pacific Salmon Foundation (PSF) provides this report on the present state of Pacific salmon (*Oncorhynchus spp.*) in British Columbia (BC). This report was commissioned by the Coastal First Nations / Great Bear Initiative in their role as Secretariat to the BC Wild Salmon Advisory Council. In this report, we specifically refer to the state of salmon as opposed to a status assessment since the latter requires the existence of abundance targets or biological reference points that do not exist for most BC Pacific salmon. The challenge before us is to summarize the state of over 8,000 combinations of species/streams in BC. Resource managers have never 'managed' each of these combinations and have now developed the concept of salmon 'Conservation Units' under Canada's Policy for the Conservation of Wild Pacific Salmon (2005) that aggregates these combinations into 432 Conservation Units[1] in BC.

Disparity in the available information combined with the limited time available to produce this report, results in various levels of summary by region and species. For BC's North and Central Coast (NCC), we were able to summarize data for all species using the Pacific Salmon Explorer tool (*www.salmonexplorer.ca*). Data for southern BC sockeye (*Oncorhynchus nerka*), pink (*Oncorhynchus gorbuscha*), and chum (*Oncorhynchus keta*) salmon can be similarly summarized, but is unavailable for Chinook (*Oncorhynchus tshawytscha*) and coho (*Oncorhynchus kisutch*) salmon. Reporting for the latter species is based on recent published reviews and Fisheries and Oceans Canada (DFO) files, and focus primarily on southern BC Chinook and Interior Fraser River coho salmon (the latter assessed as Threatened by COSEWIC, 2016). The state of these latter two salmon groups has resulted in significant limitations on coastal communities in southern BC.

1 The Wild Salmon Policy defines these units, called Conservation Units or CUs, as "a group of wild salmon sufficiently isolated from other groups that, if extirpated, is very unlikely to recolonize naturally within an acceptable timeframe".

TABLE 1. Results by species and sub-regions of the British Columbia North and Central Coast (NCC). Values show the percent change in salmon abundance from the most recent decade as compared to the full time series (1954–2016).

Regions of NCC	Sockeye	Pink	Chum	Coho	Chinook
Nass	−28%	+11%	−59%	+6%	−22%
Skeena	−26%	−51%	−77%	−29%	−33%
Central	−67%	−23%	−40%	−18%	+16%
Haida Gwaii	+3%	+14%	−54%	−18%	Insufficient Data

Comparing salmon returns (catch plus spawners) for the past decade versus the full time series (1954–2016) for the NCC shows declines ranging from –21% to –45% (Table 1), and in southern BC declines of –43% for sockeye, +24% for pink, and –14% for chum salmon.

Note that steelhead trout (*Oncorhynchus mykiss*) have not been incorporated into this analysis, but is commented on separately in the report. A common issue we found in the NCC across all species was that poor marine survival in the past decade has enhanced the rate of decline in many areas. Recent poor marine survival has similarly impacted southern BC. For Fraser River sockeye, returns since 2007 are the poorest in the time series with the exception of the late-run Fraser sockeye in 2010 and 2014. Fraser pink salmon show a positive trend for southern BC in aggregate, but returns for Fraser pink salmon have declined in 2015 and 2017. Southern BC chum salmon show a modest decline, but returns in more recent years have been stronger.

The state of coho salmon returns in southern BC and the Fraser River is much weaker than in the NCC. Poor marine survival since the mid-1990s has resulted in extensive fishery restrictions since 1998. Unfortunately, recent published assessments conclude that low productivity largely due to marine survival rates will continue to limit recovery of these coho salmon and that fishery restrictions should continue. Much of the recent considerations have focused on Interior Fraser River (IFR) coho salmon (region above Yale in the Fraser River basin). DFO considers IFR Coho salmon to be in the 'cautious' zone based on modest improvements in spawning escapements, however total abundance remains weak compared to pre-1990s levels (escapements were only achieved due to extensive fishery restrictions). DFO staff in the interior Fraser River basin are concerned about the recent wildfires and the impacts they will have on salmon spawning habitats. Coho salmon returns in the northern Transboundary Rivers are substantial and noteworthy. Returns in the Taku River (one of several transboundary systems) are similar to the recent 10-year average.

Chinook salmon throughout BC are experiencing a widespread decrease in productivity due to marine survival rates, but these rates are highly variable between years and rivers. Summaries for Chinook in this report draw on an important DFO review (DFO 2018 [1]) on the state of escapements, marine survival rates, and ocean exploitation rates. Reductions in marine survival rates were initially observed in southern BC [2], but have now extended north through the Skeena, Nass, and Transboundary Rivers. To compound these issues, a recent study has also identified that variation in productivity between Chinook populations coast wide are increasingly coherent and will amplify changes in abundances of Chinook salmon. There is also evidence to suggest that marine survival for Chinook is affected by local habitat conditions and that mitigation of habitat pressures could benefit Chinook production.

The report also includes a brief summary of steelhead trout in BC. Production of steelhead trout varies from critically poor in the interior Fraser River (Endangered and at imminent risk of extinction, COSEWIC 2018 [3]), to recently decreased in southern BC (non-Fraser) and Central BC, to stable to positive in Northern BC. However, the recent returns in Northern BC do reflect reductions in ocean fishing due to the weaker returns of sockeye and pink salmon.

This report also includes a brief summary of the Salmonid Enhancement Program and a discussion on the importance of exercising caution when interpreting long-term data sets, particularly given changes in fishing pressures over long time periods, changing climate, and reductions in survey intensity in annual monitoring programs.

1 http://www.dfo-mpo.gc.ca/csas-sccs/Publications/ScR-RS/2018/2018_035-eng.html

2 https://www.psc.org/publications/workshop-reports/southern-bc-chinook-expert-panel-workshop/

3 https://www.registrelep-sararegistry.gc.ca/virtual_sara/files/cosewic/Ea-SteelheadTrout-v00-2018Feb-Eng.pdf

Introduction

The Pacific Salmon Foundation (PSF) provides this report on the present state of Pacific salmon in British Columbia (BC). This report was commissioned by the Coastal First Nations / Great Bear Initiative in their role as Secretariat to the BC Wild Salmon Advisory Council.

In this report, we specifically refer to the state of salmon, as opposed to a status assessment since the latter requires the existence of abundance targets or biological reference points that do not exist for most BC Pacific salmon. Our intention is to introduce the diversity/wealth of Pacific salmon in BC, present the current level of salmon abundance compared to past observations, and to provide an explanation of significant changes (positive and negative), where possible. The challenge before us is to summarize the state of over 8,000 combinations of species/streams in BC that have been affected by over 100 years of development and use. Resource managers have never 'managed' each of these combinations[1] and have now developed the concept of 'Conservation Units' of salmon under Canada's Policy for the Conservation of Wild Pacific Salmon (2005[2]) that aggregates these combinations into 432 Conservation Units (CUs)[3] in BC (Table 2)[4].

The Council requested reporting in 12 sub-regions of BC, but data was frequently unavailable at that level of organization. This report provides information at multiple levels of organization to include the vast majority of salmon groups within BC, but finer levels of spatial organization could be provided at a later time if desired. Given the short time available to complete this report, PSF has relied on readily available data systems, numerous data files provided by Fisheries and Oceans Canada (DFO) staff to up-date past publications, and recently published advisory documents. These sources are cited for reference. The Pacific Salmon Explorer tool[5] was used to summarize long-term trends in salmon production on BC's North and Central Coast (NCC), but has not been implemented for southern BC. PSF is actively working to compile and analyze similar datasets for southern BC and integrate this information into the Pacific Salmon Explorer. In the interim, we have summarized readily available data

1 Although there are examples when single combinations are managed units of salmon production (e.g., Harrison River Chinook salmon, Adams River sockeye, Wannock River Chinook, etc.), such units are the exceptions.

2 http://waves-vagues.dfo-mpo.gc.ca/Library/315577.pdf

3 The Wild Salmon Policy defines these units, called Conservation Units or CUs, as "a group of wild salmon sufficiently isolated from other groups that, if extirpated, is very unlikely to recolonize naturally within an acceptable timeframe".

4 Based on current data file provided by Diana Dobson, Science Branch DFO (September 6, 2018).

5 www.salmonexplorer.ca

TABLE 2. Number of Salmon Conservation Units in British Columbia

Sockeye	Pink	Chum	Coho	Chinook	Steelhead
253	33	39	41	66	Not defined

for southern BC for sockeye, pink, and chum salmon in the same format we have presented the data for the NCC. Unfortunately, similar datasets are not available for coho or Chinook salmon. The data for coho and Chinook are therefore presented and discussed in separate sections of this report due to disparities in the resolution of the available data. We have also summarized a recent report on steelhead trout to ensure consideration of this important species.

Trends in Salmon Production in British Columbia (1954–2016)

This section provides an overview of the number of Pacific salmon (sockeye, Chinook, chum, coho, and pink) returning to the North and Central Coast and the South Coast of BC over the past 60 years (Figure 1). For each species, we quantify the percent change in salmon returns (catch plus spawners) for the past decade to the full time series (1954–2016). Spawners is the estimated number of fish that make it back to spawning grounds in a given year, while catch is the reported number of fish intercepted in commercial (US and Canada), recreational, and First Nations fisheries. For each species, we quantify the extent to which average abundance over the most recent decade has changed relative to the long-term average.[1]

Data presented for the NCC have been collated and reviewed by teams from DFO, First Nations, and contractors who were involved in the original analyses. Escapement data were sourced from DFO's New Salmon Escapement Database, and then were expanded to account for streams that were not monitored in a given region, and to account for imperfect observer efficiency (see English et al. 2016 for details). Catch data were sourced from the DFO's Fisheries Operating System, and supplemented by models developed by LGL Ltd and DFO when better data was available (e.g., coded-wire tag data for Chinook and coho). For the South Coast, total returns were based on estimates of total spawners and catch from all of the BC South Coast (Ruggerone and Irvine 2018). Harvest in US fisheries of Canadian salmon and harvest within rivers are accounted for in this data. While these data illustrate broad-scale trends in salmon production, the patterns should be interpreted with caution as the data are of varying quality.

As we have access to more detailed data for the NCC through the Pacific Salmon Explorer, we are able to provide a more detailed overview of returns to four sub-regions within the NCC: (1) Nass, (2) Skeena, (3) Haida Gwaii, and (4) Central Coast (Figure 2). For each of these regions, we summarize total returns by species. The data reflect updates to those reported in English et al. (2016). Nass refers to DFO Statistical Area 3, Skeena refers to DFO Statistical Area 4, Central Coast refers to DFO Statistical Areas 5–10, and Haida Gwaii refers to DFO Statistical Areas 1–2.

In this report, we provide more limited assessments for coho and Chinook salmon, and steelhead trout. These assessments are typically focused on 'Indicator Streams' assumed to be representative of other streams (and associated salmon production) in specific regions of the coast. This focused information reflects the recent emphases on southern BC Chinook salmon restoration and reviews of Chinook status, and considerations for Interior Fraser River coho salmon. The latter have severely limited fishing opportunities in southern BC since 1998 and the former was recently the subject of a COSEWIC[2] (Committee on the Status of Endangered Wildlife in Canada) review in June 2018 (not yet reported).

Trends in salmon production in BC will also be influenced by Canada's Salmonid Enhancement Program (SEP) and returns from these efforts are included in many of the trend analyses presented here (for all species to varying degrees). However, specific assessments of production by facility or project were not undertaken in the time provided for this review.

1 We calculated average returns using the geometric mean because, unlike the arithmetic mean, it is insensitive to less frequent, higher return years.

2 https://www.canada.ca/en/environment-climate-change/services/committee-status-endangered-wildlife.html

FIGURE 1. Map of British Columbia showing the North and Central Coast and the South Coast.

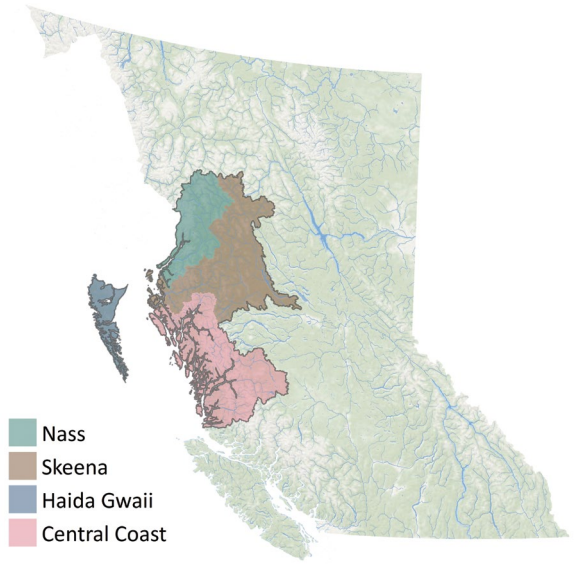


FIGURE 2. Map of the four sub-regions in British Columbia's North and Central Coast: (1) Nass, (2) Skeena, (3) Haida Gwaii, (4) Central Coast.

Canada's Salmonid Enhancement Program

DFO's SEP has objectives to support sustainable harvest opportunities and provide conservation benefits through hatchery production, habitat restoration, and stewardship activities with First Nations and communities. In addition, tagging and recovery of enhanced salmon deliver important stock assessment information necessary for domestic fisheries management and to meet Canada's international obligations under the Canada/US Pacific Salmon Treaty. Also, SEP's long-term strategic enhancement of vulnerable stocks allows for harvest opportunities while conserving and protecting at-risk stocks (e.g., Cultus/Sakinaw Sockeye & Interior Fraser coho populations). This work is critical to supporting Marine Stewardship Council Certification for commercial Pacific salmon fisheries, and consequently ensuring continued industry access to major foreign consumer markets.

SEP hatcheries fall into three main categories (Table 3, on the following page):

- **DFO Major Facilities:** 23 federally run hatcheries and spawning channels that produce over 90% of adult salmon resulting from hatchery releases.
- **Community Economic Development Projects (CEDP):** 20 facilities operated by community groups and First Nations supported by DFO contributions, with technical oversight from local DFO community advisors.
- **Public Involvement Projects (PIP):** 127 projects operated mostly by volunteers, with some technical assistance from DFO community advisors. There are a wide range of sizes from classroom incubators to substantial hatcheries.

This report has not independently assessed the returns to these enhancement programs, but SEP has the potential to produce large numbers of Pacific salmon. Evaluation of the adult returns to these facilities would

TABLE 3. Total number of SEP or SEP supported facilities and projects in different regions of British Columbia.

Facility Type	Central Coast	Fraser River	Georgia Strait	North Coast	West Coast Vancouver Island	Total
Public Involvement Projects	2	40	54	19	12	**127**
Community Economic Development Projects	3	2	7	4	4	**20**
DFO Majors	1	9	7	3	3	**23**
Total	**6**	**51**	**68**	**26**	**19**	**170**

TABLE 4. Average annual predicted adult returns to catch and escapement from all SEP facilities, based on average number of releases from 2013 to 2016 and 'bio-standard' survival rates.

	Central Coast	Fraser River	Georgia Strait	North Coast	West Coast Vancouver Island	Total
Chinook	11,057	56,353	49,648	7,275	197,846	**322,179**
Chum	110,351	140,372	333,578	58,604	429,369	**1,072,275**
Coho	1,198	68,461	62,057	24,490	42,628	**198,834**
Pink	1,013	151,304	286,871			**439,189**
Sockeye	3,577	203,972	5,279	2,135,156		**2,347,984**
Total	**127,197**	**620,462**	**737,432**	**2,225,526**	**669,843**	**4,380,460**

be a significant, but worthwhile, undertaking. However, given the time available, this task could not be considered for this report. However, SEP[1] staff have provided estimates of the project production capacity given the present level of enhancement programs (Table 4)[2]

Care in Interpretation of Salmon Data

With the widespread reductions in fishing, loss of escapement survey coverage, and changes in biological characteristics being observed, one needs to be aware of the limitations of data used to assess trends in production and/or assess the biological status of individual salmon populations. Particular topics to consider include (1) data quality, (2) data quantity and consistency over space and time, (3) inferences, sampling designs/expansions used in drawing conclusions, (4) production vs productivity, and (5) biological sampling data.

Quantity and Quality of Data. There has been a substantial decrease in the numbers of streams (quantity) surveyed annually for escapement monitoring (English, 2016). The decrease has been greatest for species/streams combinations that have historically been monitored using visual surveys, but some more expensive surveys (mark-recapture or indicator streams) have also been terminated. These changes mean that any cumulative indices of escapement may not be a consistent annual index. But, it is also possible that if fewer streams are being surveyed, they are now being enumerated more precisely.

The issue of the quality of annual surveys can also be misinterpreted. Typically, when we discuss quality, people will think of the important economic populations (e.g., Babine Lake sockeye, Fraser River sockeye lakes, Chinook key indicators, etc.) that have high quality assessments using counting weirs, electronic counters, mark-recapture methods, DNA assessments, etc. Visually-based surveys are certainly less accurate in monitoring salmon returns, but if visual surveys are conducted consistently over time and area, they can provide informative data on trends over time and species. Therefore, a balance of quantitative methods and visual surveys may be the preferred combination of annual surveys to address the production and the diversity of Pacific salmon within regions. Ideally, these surveys should be conducted within a statistical design to enable drawing broader inferences, but this has not been undertaken in BC.

Production vs Productivity. The difference in these terms is fundamental to understanding the needs for annual stock assessment programs. Catch and spawning abundance are components of the annual production or abundance of a salmon population. To understand the determinants of change in abundance requires consistent annual reporting of catch and escapement (and biological characteristics) that can then relate the number of parental fish to the number of progeny produced. The number of progeny produced per parent is the productivity of a salmon population and determines the harvest rate that, on average, will sustain a given level of production over time. However, the sustainable harvest rate for a population is not constant and must also be monitored (harvest rates could increase or decrease due to habitat modifications, freshwater flows, marine conditions, and climate trends). Since we have clearly seen the influences of habitat and climate change impacts, long-term monitoring of salmon productivity should be a core element of a salmon monitoring program, but such programs are limited in BC.

Biological Characteristics. Biological attributes are key elements of salmon productivity. Essential characteristics include age structure in catch and spawning abundance, fecundity by age and numbers of females that successfully spawn, the sex ratio in the spawning population, and body size at age. Evidence is mounting that changes in these characteristics is occurring in BC's Pacific salmon.

1 Text and data provided by Ryan Galbraith (September 11, 2018).

2 Bio-standards may stem from direct assessment of the stock or may be applied from a representative stock. Uncertainty in the totals associated with varying climatic conditions, changes in fisheries, and precision of the bio-standards is not estimated.

Results

The upcoming seven pages of graphics (pg. 14–20) summarize a large amount of data in order to provide a concise, but high-level, overview of trends in salmon production for most BC salmon populations. As previously stated, similar data do not exist for southern BC Chinook and coho and equivalent summaries are unable to be provided at this time. We do, however, provide more detail on the trends in abundance for Fraser River sockeye salmon by run-timing (management) units (Figure 3) and Fraser River pink salmon (Figure 4). Figure 3 (sockeye run-timing groups) accounts for returns to 2014. Returns in the three following years have been extremely small, but did improve in 2018. Table 5 provides an overview of the total run size (spawners and catch) for each of the four run-timing groups of Fraser sockeye from 2015–2018. The values below were provided in the Annual Reports of the Fraser River Panel (Pacific Salmon Commission, *www.psc.org*), with the exception of 2018 which reflects *preliminary* data (as of September 11, 2018) based on the in-season management process led by the Fraser River Panel and the Pacific Salmon Commission staff.

Fraser River pink salmon had rebuilt in abundance through the 2013 return, but the subsequent two returns have been greatly reduced in abundance (Figure 4). Fishery exploitation rates were appropriately reduced in recent years to conserve the spawning adults.

TABLE 5. Total run size by run-timing for Fraser sockeye salmon. The 2018 value shown for the Late run-timing group is preliminary and based on values provided by the in-season management process led by the Fraser River Panel and the Pacific Salmon Commission as of September 11, 2018.

Run-timing group	2015	2016	2017	2018
Early Stuart	28,700	18,000	45,900	125,000
Early Summer	287,300	240,500	160,100	1,700,000
Summer	1,576,100	529,200	1,048,600	4,344,000
Late	118,100	70,600	216,400	7,400,000
Total	**2,010,200**	**858,300**	**1,470,900**	**13,569,000**

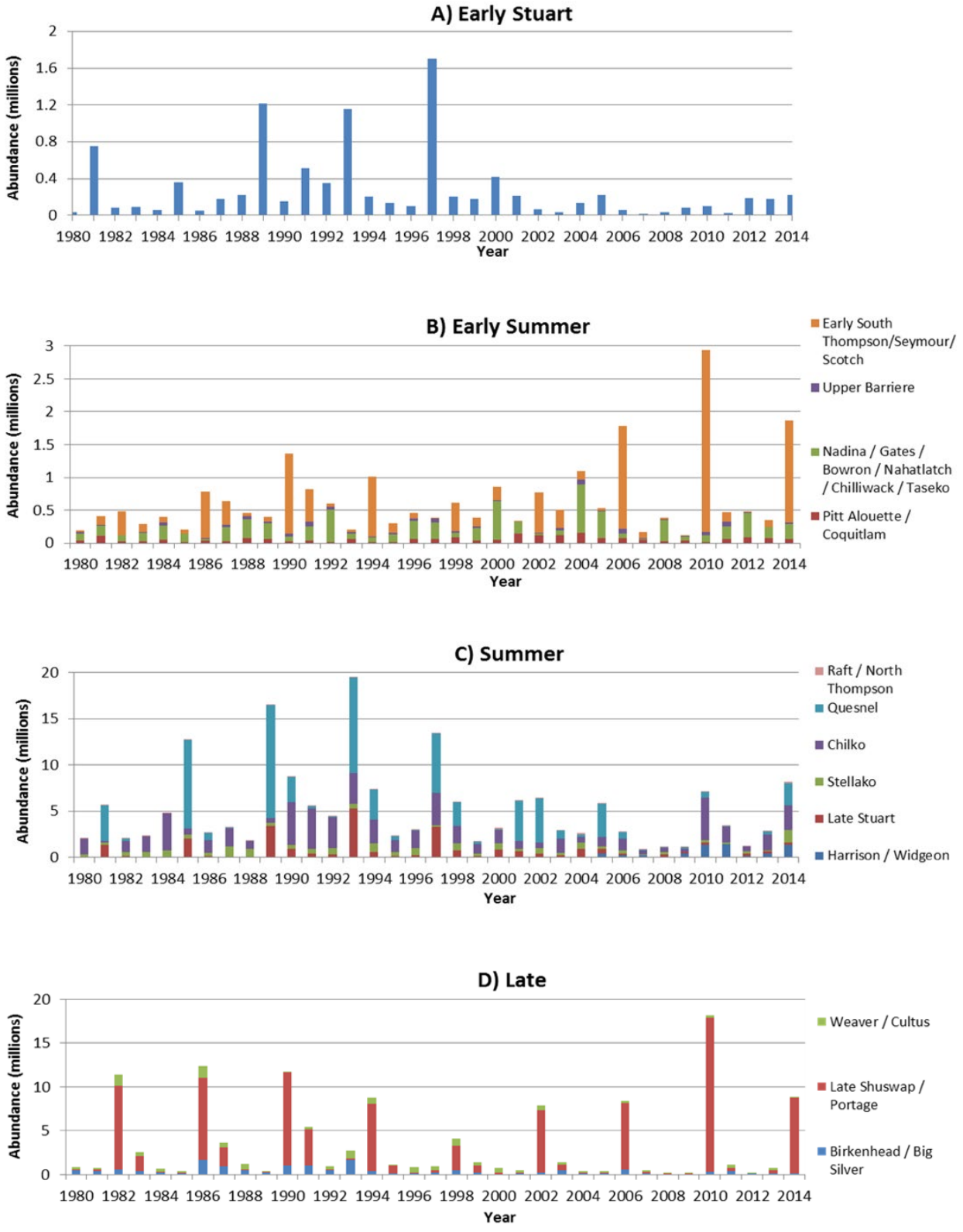


FIGURE 3. Fraser sockeye salmon returns by run-timing groups.

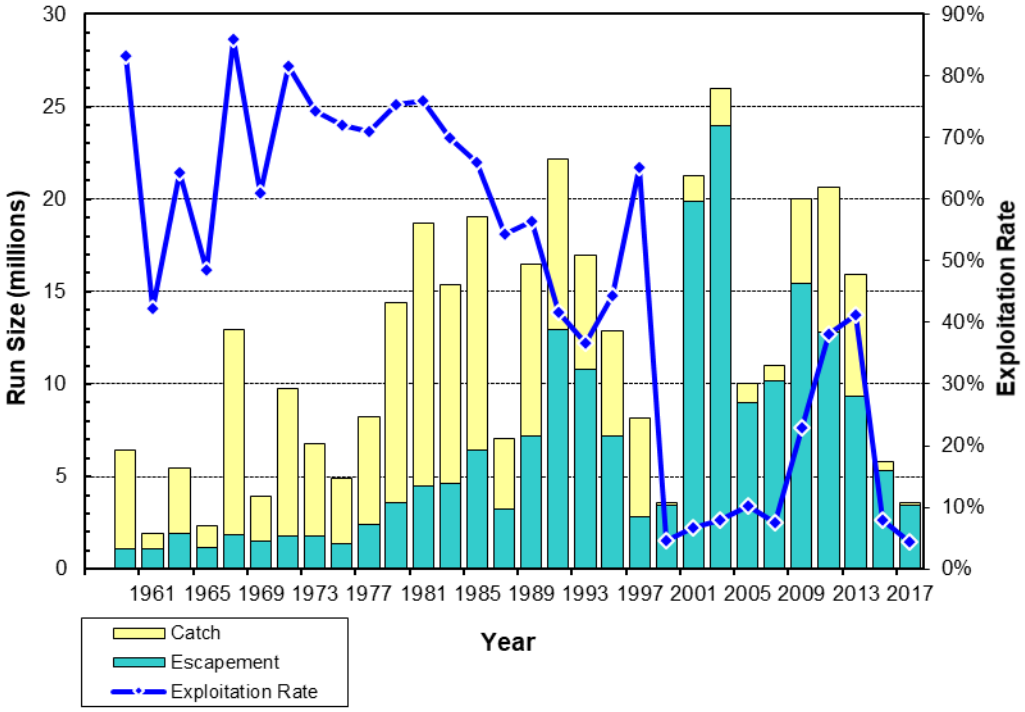
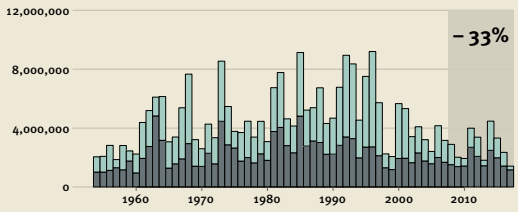


FIGURE 4. Total catch, escapement, run size and exploitation rate for Fraser River pink salmon in 1959–2017.

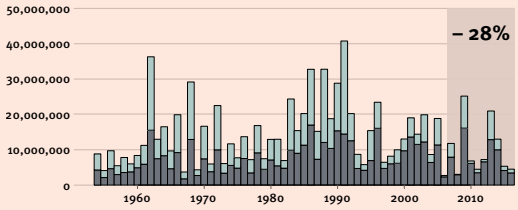
Pacific Salmon
on BC's North & Central Coast

Sockeye



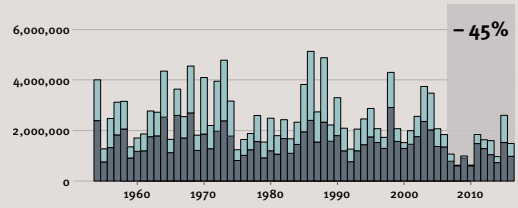
- Sockeye salmon are very abundant on BC's North and Central Coast (NCC). However, since the mid-1990s, sockeye returns have declined. Since this time, annual sockeye returns have remained stable at lower abundances (approximately 3 million spawners).
- Historically, sockeye salmon supported important commercial and First Nations fisheries, but the total catch has declined in recent years.

Pink



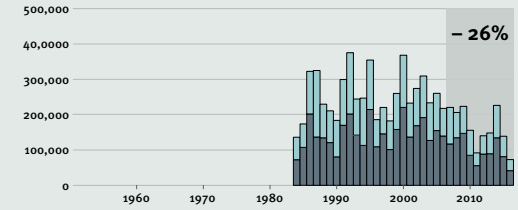
- Pink salmon are the most abundant species of salmon on BC's NCC. However, in recent years, returns have often fallen below their long-term average.
- Pink salmon fisheries are important economic drivers for BC's NCC with commercial harvest rates historically exceeding 50% of the total return. However, commercial fisheries have been much more limited recently with harvest rates in the 20% range.

Chum



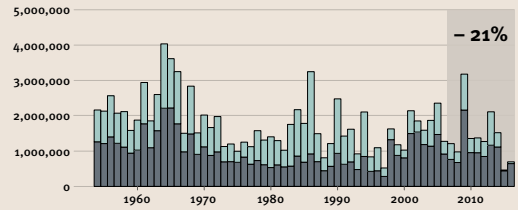
- Chum salmon were historically very abundant however, chum have seen some of the largest declines of all species over the last 10 years.
- The 2018 IFMP objective for wild North Coast chum is to rebuild weak runs while providing opportunities to harvest surplus runs. Recovery plans have been developed for both Skeena and Nass chum.
- Fisheries are largely supported by large-scale hatchery programs (e.g., Bella Coola Hatchery).

Chinook



- Chinook salmon are the least abundant species on BC's NCC, with recent returns well below their long-term average.
- Harvest rates for Chinook salmon remain variable and high (ranging from 34% to 43%) due to interceptions in multiple fisheries.
- The 2018 IFMP outlines an objective of reducing annual harvest of Skeena and Nass Chinook salmon to 25–35% to allow for rebuilding.

Coho

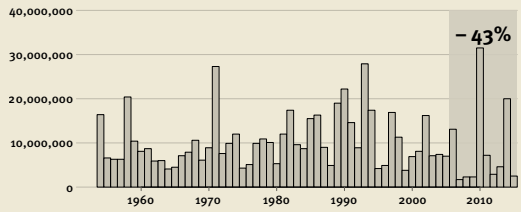


- The abundance of coho salmon on BC's NCC has declined over time. However, reductions in fisheries have maintained relatively consistent numbers of coho reaching the spawning grounds in recent years.
- According to the 2018 IFMP, coho are managed to a Canadian harvest rate of 5–10%.

Bar plots above show the number of returning salmon. Total run size (catch and spawners) for each salmon species returning to the BC NCC for the period 1954–2016. Spawners is an estimate of the number of fish that return to spawn in a given year, while catch is an estimate of the number of fish intercepted in commercial (US and Canada), recreational, and First Nations fisheries. The percentage displayed on each figure is the percent change between the geometric mean over the entire time series and the geometric mean over the most recent decade, with the shaded area depicting the most recent decade. These data have been aggregated to help provide a general picture of salmon returns by species on BC's NCC over the past ~60 years. Data shown is sourced from the Pacific Salmon Foundation's Pacific Salmon Explorer (*www.salmonexplorer.ca*). For specific details on individual data sources or detailed information on individual salmon Conservation Units, please refer to the Pacific Salmon Explorer. A Conservation Unit is a "group of wild salmon living in an area sufficiently isolated from other groups that, if extirpated, are very unlikely to be recolonized within an acceptable timeframe" (Fisheries and Oceans Canada, 2005).

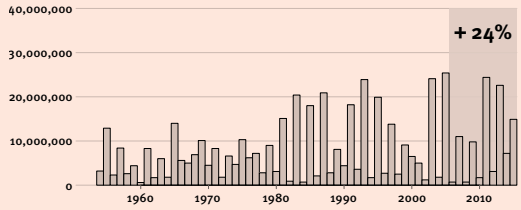
Pacific Salmon
on BC's South Coast

Sockeye



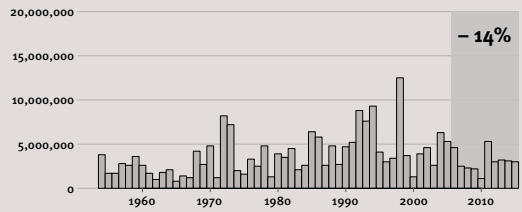
- Sockeye salmon are typically the most abundant of all salmon species on BC's South Coast.
- Sockeye salmon returns to BC's South Coast are currently dominated by the Fraser River with returns ranging from ~850,000 to 28 million fish, though returns to systems on the west coast of Vancouver Island can exceed 1 million sockeye.

Pink



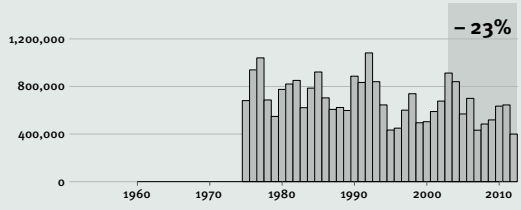
- Pink salmon are the second most abundant species to return to BC's South Coast, with odd-numbered return years being much larger than even-numbered return years due to the large return size for odd-numbered Fraser pink salmon.
- Pink salmon are currently doing well on BC's South Coast, with average abundances over the last 10 years well above their long-term average.

Chum



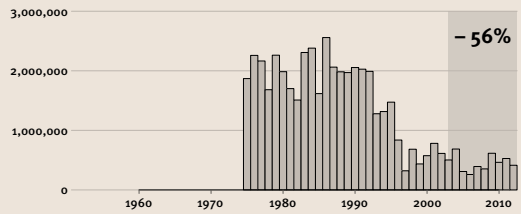
- On BC's South Coast, chum salmon are more abundant than Chinook, but less abundant than pink or sockeye.
- In the most recent decade, chum abundances have been below their long-term average, but similar in abundance to the period from the 1950s to the 1970s.
- One population, Nimpkish, chum is the subject of a recovery plan.

Chinook



- Chinook salmon are the least abundant salmon species on BC's South Coast.
- In the most recent decade, Chinook abundances have been below their long-term average. In the years since 2012, many Chinook populations have declined precipitously.
- COSEWIC has designated 11 populations of Chinook on the South Coast as Endangered, four as Threatened, and one as of Special Concern.

Coho

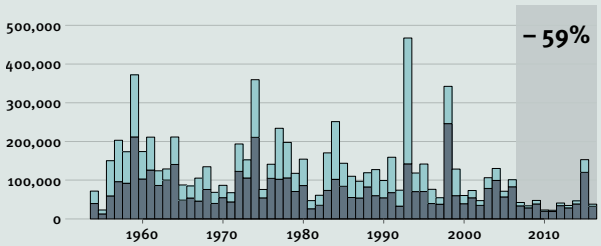


- The abundance of coho on the South Coast has declined markedly over the past sixty years.
- Due to conservation concerns in the late 1990s, commercial coho fisheries on BC's South Coast have been severely curtailed. Despite these management measures, coho abundances remain low relative to their long-term average.
- COSEWIC has designated the Interior Fraser population of coho as Threatened.

Bar plots above show the number of returning salmon. Total run size (catch and spawners) for each salmon species returning to the BC South Coast for the period 1954–2015. Spawners is an estimate of the number of fish that return to spawn in a given year, while catch is an estimate of the number of fish intercepted in commercial (US and Canada), recreational, and First Nations fisheries. The percentage displayed on each figure is the percent change between the geometric mean over the entire time series and the geometric mean over the most recent decade, with the shaded area depicting the most recent decade. These data have been aggregated to help provide a general picture of salmon returns by species on BC's South Coast over the past ~60 years. For sockeye, due to their cyclic abundance, the data in the shaded area only represents two dominant generations. The data shown are from Ruggerone and Irvine (2018). The data shown above for Chinook and coho salmon are derived from Ogden et al. (2014). These two figures were added after the initial assembly of this report as new data became available. A Conservation Unit is a "group of wild salmon living in an area sufficiently isolated from other groups that, if extirpated, are very unlikely to be recolonized within an acceptable timeframe" (Fisheries and Oceans Canada, 2005).

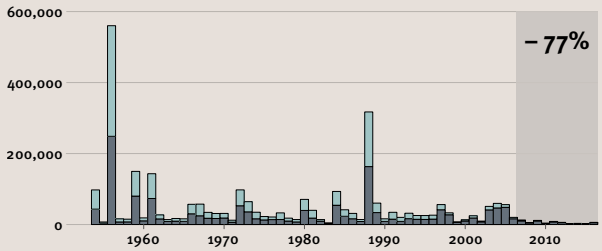
Chum
on BC's North & Central Coast

Nass



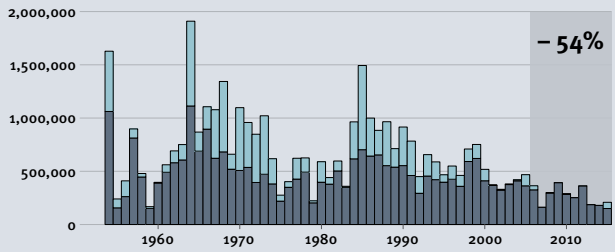
- Nass region chum salmon are comprised of 3 Conservation Units.
- The Portland Canal-Observatory Conservation Unit is the largest with an average return of between 15,000 to 20,000 chum.
- In recent years, chum salmon abundances have fallen well below their long-term average.
- Fisheries and Oceans Canada (DFO) considers Nass wild chum depressed and management actions are being taken to maintain low fishery impacts.

Skeena



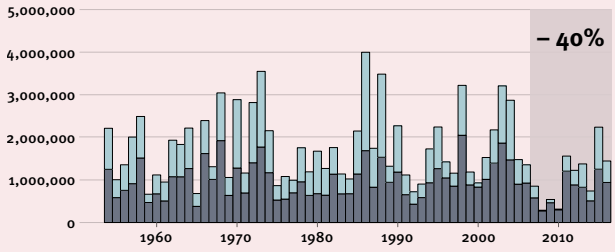
- 4 chum salmon Conservation Units spawn within the Skeena River watershed.
- Lower Skeena chum is the largest Conservation Unit based on the number of spawners (average spawner abundance from 2011–2014 was approximately 3,500).
- Skeena chum salmon are also considered depressed and rebuilding plans have been developed by DFO to support their recovery.

Haida Gwaii



- 5 chum salmon Conservation Units spawn in Haida Gwaii.
- The east Haida Gwaii and West Haida Gwaii chum Conservation Units have had the largest returns recently, with average abundances over 75,000.
- In recent decades, chum salmon in the region have declined with returns below their long-term average.

Central Coast

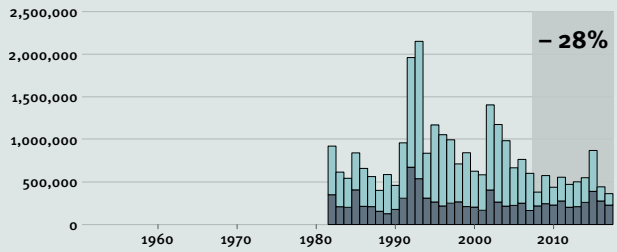


- 9 chum salmon Conservation Units are found on BC's Central Coast, and 5 of these have recent average returns of over 100,000.
- Large-scale chum hatcheries exist on the Bella Coola and Kitimat Rivers to support commercial fisheries.
- Chum returns are below their long-term average. Returns have rebounded in recent years from historic lows observed between 2007–2010.

Bar plots above show the number of returning salmon. Total run size (catch and spawners) for chum salmon returning to each of the four regions on BC's NCC (Nass, Skeena, Central Coast, Haida Gwaii) for the period 1954–2016. Spawners is an estimate of the number of fish that return to spawn in a given year, while catch is an estimate of the number of fish intercepted in commercial (US and Canada), recreational, and First Nations fisheries. The percentage change on each figure is the percent difference between the geometric mean over the entire time series and the geometric mean over the most recent decade, with the shaded area depicting the most recent decade. These data have been aggregated to help provide a general picture of chum salmon returns in each NCC region over the past ~60 years. Note that the large decline shown for Skeena chum is an artefact of the large data point in 1956, which is highly uncertain and may reflect changes in enumeration methods. Data shown is sourced from the Pacific Salmon Foundation's Pacific Salmon Explorer (*www.salmonexplorer.ca*). For specific details on individual data sources or detailed information on individual salmon Conservation Units, please refer to the Pacific Salmon Explorer. A Conservation Unit is a "group of wild salmon living in an area sufficiently isolated from other groups that, if extirpated, are very unlikely to be recolonized within an acceptable timeframe" (Fisheries and Oceans Canada, 2005).

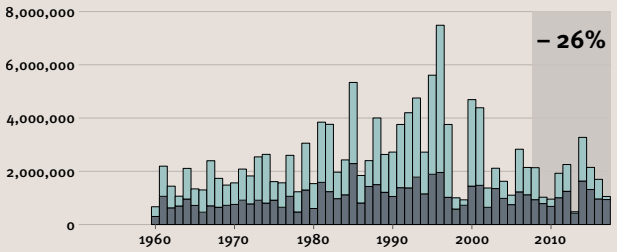
Sockeye
on BC's North & Central Coast

Nass



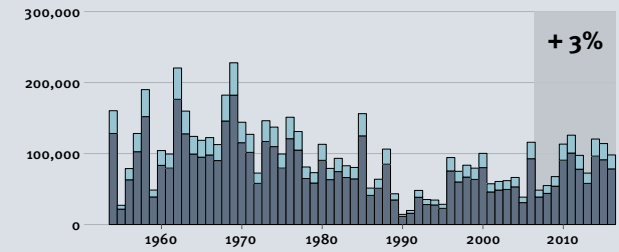
- 10 sockeye salmon Conservation Units spawn in the Nass region.
- Returns to the Nass are dominated by Meziadin lake sockeye, which account for 70% to 80% of total Nass River sockeye returns.
- Sockeye returns are below their long-term average. After a period of peak returns in the early 1990s, returns in the most recent decade have stabilized at a lower level.

Skeena



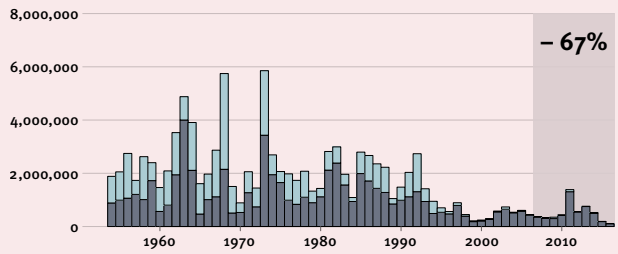
- The Skeena River watershed provides spawning habitat for 30 sockeye salmon Conservation Units.
- Returns are dominated by the enhanced Babine stock, which has spawning channels to increase production.
- Sockeye returns have declined since their peak in the mid-1990s. Harvest opportunities have been greatly diminished in recent years as a result of declining returns.

Haida Gwaii



- 13 sockeye salmon Conservation Units are found in Haida Gwaii.
- The Marian and Mathers Conservation Units are two of the major producers with both having recent escapements of over 15,000 spawners.
- After a period of low returns in the early 1990s, sockeye returns have stabilized and are either at, or slightly above, their long-term average.

Central Coast

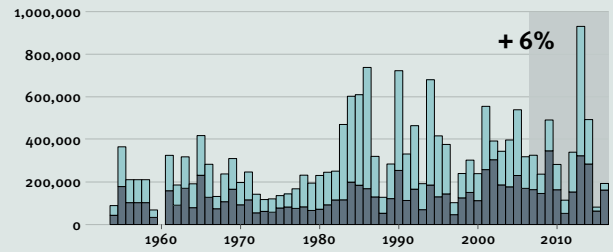


- 85 sockeye salmon Conservation Units are found on BC's Central Coast.
- Historically, returns have been dominated by the Owikeno, Long, and South Atnarko Lakes.
- In recent years, returns to many of these dominant systems are only a fraction of their historical abundance.
- Sockeye from South Atnarko Lakes have been identified as a conservation concern and are currently the focus of recovery planning efforts led by the Nuxalk Nation and Fisheries and Oceans Canada.

Bar plots above show the number of returning salmon. Total run size (catch and spawners) for sockeye salmon returning to each of the four regions on BC's NCC (Nass, Skeena, Central Coast, Haida Gwaii) for the period 1954–2016. Spawners is an estimate of the number of fish that return to spawn in a given year, while catch is an estimate of the number of fish intercepted in commercial (US and Canada), recreational, and First Nations fisheries. The percentage change on each figure is the percent difference between the geometric mean over the entire time series and the geometric mean over the most recent decade, with the shaded area depicting the most recent decade. These data have been aggregated to help provide a general picture of sockeye salmon returns in each NCC region over the past ~60 years. Data shown is sourced from the Pacific Salmon Foundation's Pacific Salmon Explorer (*www.salmonexplorer.ca*). For specific details on individual data sources or detailed information on individual salmon Conservation Units, please refer to the Pacific Salmon Explorer. A Conservation Unit is a "group of wild salmon living in an area sufficiently isolated from other groups that, if extirpated, are very unlikely to be recolonized within an acceptable timeframe" (Fisheries and Oceans Canada, 2005).

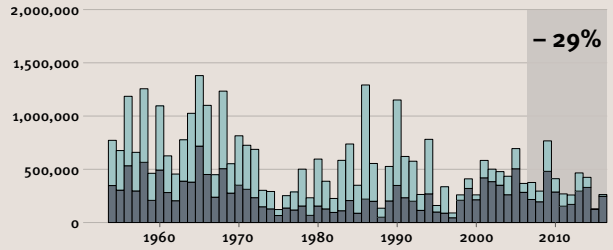
Coho
on BC's North & Central Coast

Nass



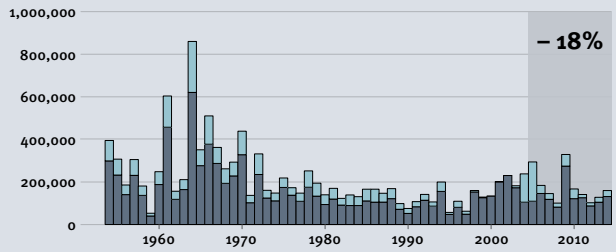
- 3 coho salmon Conservation Units are found in the Nass region.
- Returns are dominated by the Upper and Lower Nass Conservation Units (average returns › 70,000 spawners).
- Overall, Nass coho are doing well with some of the largest recorded returns observed in the most recent decade.

Skeena



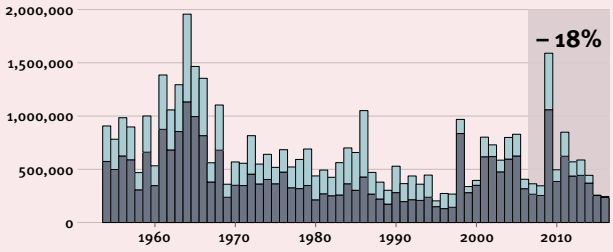
- There are 4 coho salmon Conservation Units in the Skeena River watershed.
- Returns are dominated by the Lower and Middle Skeena Conservation Units (spawner abundance › 100,000).
- Skeena coho have experienced declining returns over the time series with the most pronounced declines observed in the late 1990s. Low returns during this period have been attributed to low to "near-zero" marine survival in the 1997 return year. However, abundances appear to be relatively stable in recent years.

Haida Gwaii



- There are 3 coho salmon Conservation Units in Haida Gwaii.
- The Haida Gwaii-Graham Island Lowlands Conservation Unit has typically the largest escapement, with a recent average escapement of nearly 100,000 spawners.
- Coho are below their long-term abundance after a period of higher returns from the mid-1960s to 1970.

Central Coast

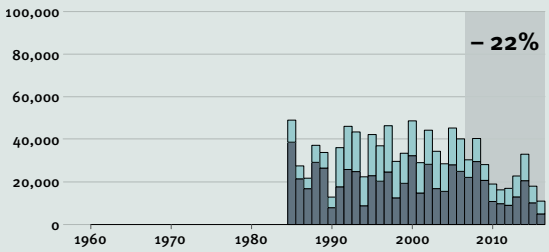


- 8 coho salmon Conservation Units spawn on BC's Central Coast, 4 of which have current average returns of approximately 100,000.
- Returns are dominated by the Rivers Inlet Conservation Unit which has an average spawner abundance of ~145,000 spawners.
- Two hatcheries in the region (Snootli Creek and Kitimat River) produce coho.
- Coho have declined slightly over the time series with some records suggesting that coho spawning abundance declined by 50% between the 1960s and 1970s.

Bar plots above show the number of returning salmon. Total run size (catch and spawners) for coho salmon returning to each of the four regions on BC's NCC (Nass, Skeena, Central Coast, Haida Gwaii) for the period 1954–2016. Spawners is an estimate of the number of fish that return to spawn in a given year, while catch is an estimate of the number of fish intercepted in commercial (US and Canada), recreational, and First Nations fisheries. The percentage displayed on each figure is the percent change between the geometric mean over the entire time series and the geometric mean over the most recent decade, with the shaded area depicting the most recent decade. These data have been aggregated to help provide a general picture of coho salmon returns in each NCC region over the past ~60 years. Data shown is sourced from the Pacific Salmon Foundation's Pacific Salmon Explorer (*www.salmonexplorer.ca*). For specific details on individual data sources or detailed information on individual salmon Conservation Units, please refer to the Pacific Salmon Explorer. A Conservation Unit is a "group of wild salmon living in an area sufficiently isolated from other groups that, if extirpated, are very unlikely to be recolonized within an acceptable timeframe" (Fisheries and Oceans Canada, 2005).

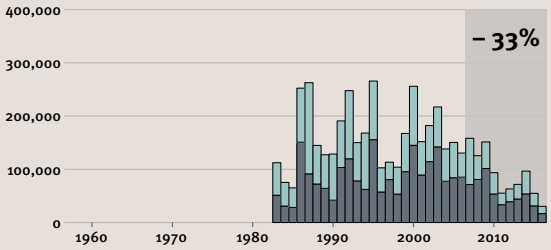
Chinook
on BC's North & Central Coast

Nass



- There are 2 Chinook salmon Conservation Units that spawn in the Nass region.
- Returns are dominated by the Upper Nass Conservation Unit, with recent average returns in excess of 10,000.
- The time series for Chinook only spans back to 1985, limiting our ability to infer longer-term trends.
- However, based on the available data Chinook returns have declined since the mid-1980s reaching historic lows in the most recent year for which there is data.

Skeena



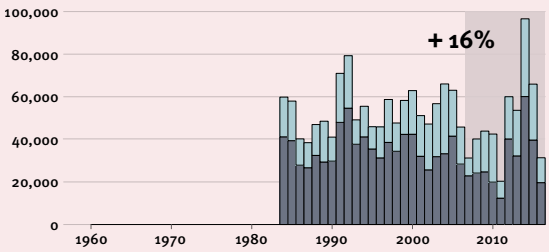
- 12 Chinook salmon Conservation Units spawn within the Skeena River watershed.
- The Middle Skeena - Large Lakes and Kalum-Late Conservation Units are the largest, with current abundances of approximately 25,000 and 12,000 spawners, respectively.
- Chinook returns have been declining since the late 2000s leading to recent reductions in harvest rates to support conservation and promote rebuilding.

Haida Gwaii

[data deficient]

- There are 2 Chinook salmon Conservation Units on Haida Gwaii.
- Neither have sufficient data to determine total returns or trends in abundance.

Central Coast

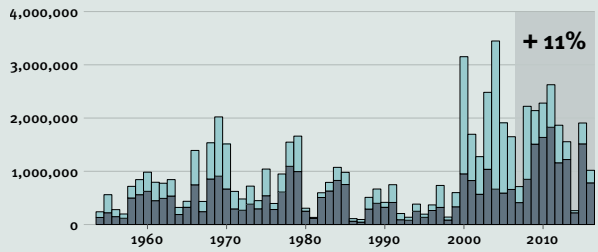


- 7 Chinook salmon Conservation Units spawn on BC's Central Coast.
- The Bella Coola-Bentinck Conservation Unit is the largest with an average return of nearly 15,000 spawners.
- Chinook are doing well on the Central Coast with record returns observed within the most recent decade.

Bar plots above show the number of returning salmon. Total run size (catch and spawners) for Chinook salmon returning to each of the four regions on BC's NCC (Nass, Skeena, Central Coast, Haida Gwaii) for the period 1985–2016. Spawners is an estimate of the number of fish that return to spawn in a given year, while catch is an estimate of the number of fish intercepted in commercial (US and Canada), recreational, and First Nations fisheries. The percentage displayed on each figure is the percent change between the geometric mean over the entire time series and the geometric mean over the most recent decade, with the shaded area depicting the most recent decade. These data have been aggregated to help provide a general picture of Chinook salmon returns in each NCC region over the past ~30 years. Data shown is sourced from the Pacific Salmon Foundation's Pacific Salmon Explorer (*www.salmonexplorer.ca*). For specific details on individual data sources or detailed information on individual salmon Conservation Units, please refer to the Pacific Salmon Explorer. A Conservation Unit is a "group of wild salmon living in an area sufficiently isolated from other groups that, if extirpated, are very unlikely to be recolonized within an acceptable timeframe" (Fisheries and Oceans Canada, 2005).

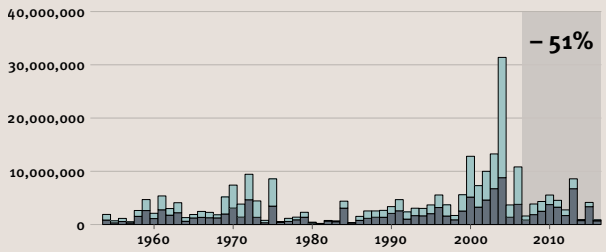
Pink Salmon
on BC's North & Central Coast

Nass



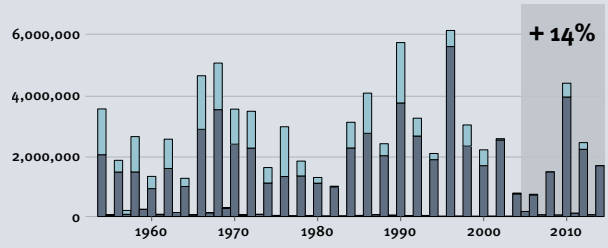
- There are 4 pink salmon Conservation Units that spawn in the Nass region.
- Reliable escapement data only exists for two Conservation Units: Nass-Skeena Estuary and Nass-Portland-Observatory.
- Pink salmon are above their long-term average experiencing a period of higher than average returns since 2000, and a record return in 2005.

Skeena



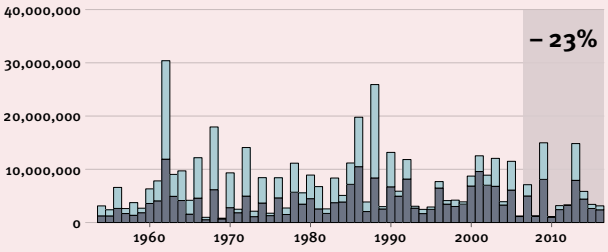
- 5 pink salmon Conservation Units spawn in the Skeena River watershed.
- Returns are dominated by the Nass-Skeena Estuary Conservation Unit, which had a record return of nearly 5 million spawners in 2014.
- The large percent change in returns over the most recent generation is mainly driven by the high returns from 2000–2006. Returns in the most recent decade are similar to the period from 1954–2000.

Haida Gwaii



- 6 pink salmon Conservation Units are found in Haida Gwaii.
- Haida Gwaii is strongly dominated by the even year-class of pink salmon.
- Pink salmon returns have been highly variable over the time series with recent returns above their long-term average.

Central Coast



- There are 5 pink salmon Conservation Units that spawn on BC's Central Coast.
- The Hecate Strait-Fjords Conservation Unit is the dominant producer with returns ranging between 3.5 to 6.7 million salmon in recent years.
- In recent years, pink salmon have returned below their long-term average though several years in the time series have experienced higher than average returns.

Bar plots above show the number of returning salmon. Total run size (catch and spawners) for pink salmon returning to each of the four regions on BC's NCC (Nass, Skeena, Central Coast, Haida Gwaii) for the period 1954–2016. Spawners is an estimate of the number of fish that return to spawn in a given year, while catch is an estimate of the number of fish intercepted in commercial (US and Canada), recreational, and First Nations fisheries. The percentage displayed on each figure is the percent change between the geometric mean over the entire time series and the geometric mean over the most recent decade, with the shaded area depicting the most recent decade. Note that pink salmon that return in odd-years are genetically distinct from those that return in even-years, and often have very different abundances, which can obscure the patterns shown in estimates of percent change between time periods. These data have been aggregated to help provide a general picture of pink salmon returns in each NCC region over the past ~60 years. Data shown is sourced from the Pacific Salmon Foundation's Pacific Salmon Explorer (*www.salmonexplorer.ca*). For specific details on individual data sources or detailed information on individual salmon Conservation Units, please refer to the Pacific Salmon Explorer. A Conservation Unit is a "group of wild salmon living in an area sufficiently isolated from other groups that, if extirpated, are very unlikely to be recolonized within an acceptable timeframe" (Fisheries and Oceans Canada, 2005).

Coho Salmon

Coho salmon are widely distributed in BC and second only to pink salmon in the diversity of streams that they are known to utilize (Table 6)[1]. However, over the past two decades, reductions in the marine survival of coho salmon have resulted in major conservation actions (particularly for the Interior Fraser Coho, COSEWIC 2016[2]), including an extended period of coho non-retention in all southern BC salmon fisheries. Coho salmon in the BC NCC have also had periods of reduced production, but not for the continuous period observed for the Fraser River and southern BC populations.

This summary of coho salmon will differ from the BC NCC and southern BC (which includes the Fraser River). The NCC data (excluding the Transboundary Rivers and Haida Gwaii) has been incorporated into the Pacific Salmon Explorer (PSE). For southern BC and Fraser River regions, coho abundances have

1 Summary data file provided by D. Dobson, DFO Science Branch (September, 2018).

2 https://www.registrelep-sararegistry.gc.ca/virtual_sara/files/cosewic/sr_Coho%20salmon_2016_e.pdf

TABLE 6. Number of Conservation Units, Population Units, and Management Units for British Columbia Coho. The Transboundary Rivers totals do not include the Alsek or Yukon Rivers.

Geographic Region of BC	Number of Conservation Units	Management Units	Number of Identified Populations
Transboundary Rivers	6	2	16
Skeena / Nass / Portland Canal	6	2	302
North Coastal BC	4	1	280
Central Coast BC	4	1	83
Haida Gwaii	3	1	204
South Coast (Strait of Georgia & Inlets)	8	2	452
West Coast Vancouver Island & Juan de Fuca	3	2	200
Fraser River: Lower Fraser	2	1	133
Fraser River: Interior Fraser	5	1	132
Total	**41**	**13**	**1,802**

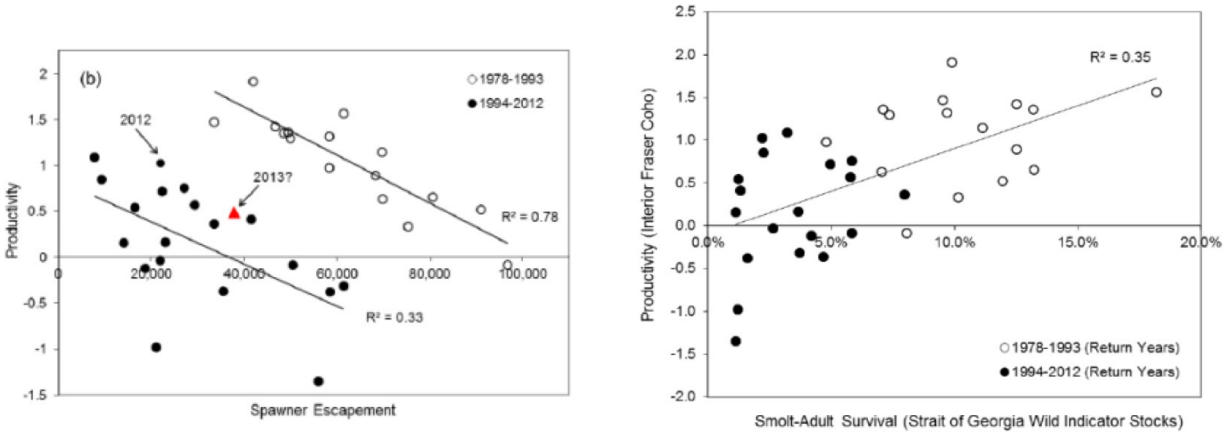


FIGURE COHO-1. Productivity of IFR coho salmon.

left: Decker et al. (2014). Plot of productivity versus aggregate brood escapement for IFR coho salmon for two time periods: 1978–1993 before the decrease in marine survival; and 1994–2012 following the decrease.

right: Decker et al. (2014) Presents strong evidence that the poor productivity is related to the marine survival rate of coho salmon also observed Strait of Georgia coho.

not been incorporated into the PSE however, work is underway to synthesize the available data and integrate this information into the tool. Consequently, the information presented for southern BC and Fraser River coho salmon have been collated from several DFO sources and other publications. There is a focus on the Interior Fraser River coho salmon populations since these have been depressed in production since the mid-1990s and continue under low productivity that is limiting their recovery (Decker et al. 2014; Figure Coho-1). Interior Fraser River coho have also been assessed as Threatened by COSEWIC (2016).

However, while the production of Interior Fraser coho remains depressed (compared to before the mid-1990s), the trend in their production and a modest recovery in recent years (Figure Coho-2) has resulted in DFO (2015) assigning a 'cautious' biological status assessment under the Wild Salmon Policy, but noted a high degree of uncertainty about the assessment since most information is now based on indirect or modeled estimates. The latter includes estimates of fishery exploitation rates since management actions have contributed to the improved state today, but have greatly reduced the coded-wire tag data available for evaluations.

The poor marine survival at the root of the reduced productivity for Interior Fraser coho (Figure Coho-2) also remains an issue for other southern BC coho (Figure Coho-3), but not for west coast Vancouver Island coho (based on Robertson Creek Hatchery assessment). While there is some evidence for improving survival in the latest years of return for the Big Qualicum River, Black Creek, and Inch Creek, most years have experienced ~2% marine survival and would be insufficient for recovery of coho salmon in southern BC. However, outside of the Strait of Georgia in southern BC, coho survival rates have been much better (with a few exceptions).

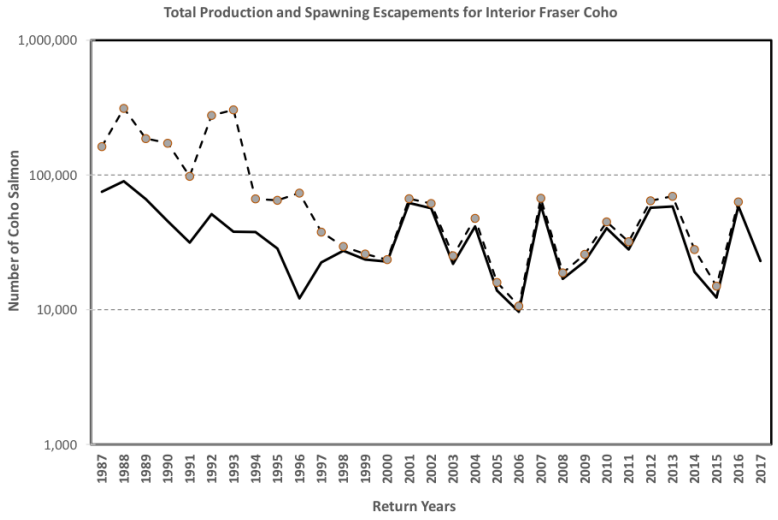


FIGURE COHO-2. Total return of adult coho salmon to the Interior Fraser River (IFR) Conservation Units. Solid line is estimated total escapement and dashed line is the estimated total production of IFR coho salmon based on total exploitation rates.

Management actions to reduce fishing mortality on IFR coho, initiated in 1998, have stabilized the returns to spawning grounds and shows a slow increase in production over time. The vertical axis is expressed in Log10 scale to emphasis the returns within the 10,000 to 100,000 coho abundance. Exploitation on IFR coho salmon is currently set depending on a forecasted abundance but has averaged ~10% total fishing mortality since 1998 (range 4–14% during 1998–2012; Decker et al. 2014). Up-dated data on exploitation rates for 1995–2013 brood years indicates that exploitation rates increased in recent years and now averages 11.7%.

The returns resulting from the low marine survival is best represented by the return of adult coho to the Black Creek indicator stream (all natural production) maintained since 1985 (Figure Coho-4). Coho salmon are very difficult to monitor quantitatively without significant effort. Consequently, DFO has invested in a small selection of streams used as 'indicator streams' to enable accurate assessments of adult returns, production of juveniles (smolts emigrating), and coded-wire tagging programs to monitor marine survival, distributions, and fishing exploitation rates. However, as an indicator system, we are assuming that it is representative of other coho salmon populations in that geographic area (frequently we can compare these attributes with hatchery-produced coho in the same area). Given the lack of any trend in adult returns to Black Creek (top, Figure Coho-4) and the poor marine survival (Figure Coho-3), the very low exploitation rates evident in the bottom of Figure Coho-4 has been critical to sustaining the adult escapements to this wild coho salmon indicator stream.

North and Central BC Coho Salmon

The summary plots of species over time for the NCC are very informative of the long-term trends and compare recent abundance trends (2007–2016) to the full time series. The limitation of these roll-ups is an inability to explain changes. Readers should be aware that finer details or explanations are frequently available for specific stocks (e.g., Babine Lake sockeye salmon) or indicator stocks (e.g., Toboggan Creek coho salmon). For example, Figure Coho-5 presents the total return of Toboggan Creek coho salmon since 1988, the marine survival estimated from coded-wire tagging of juveniles, and change in the total exploitation rate over time. These data are comparable to the Black Creek coho salmon indicator stream discussed for southern BC coho salmon assessments.

It should be noted that the NCC data are complete through 2016 salmon returns, but 2017 and 2018

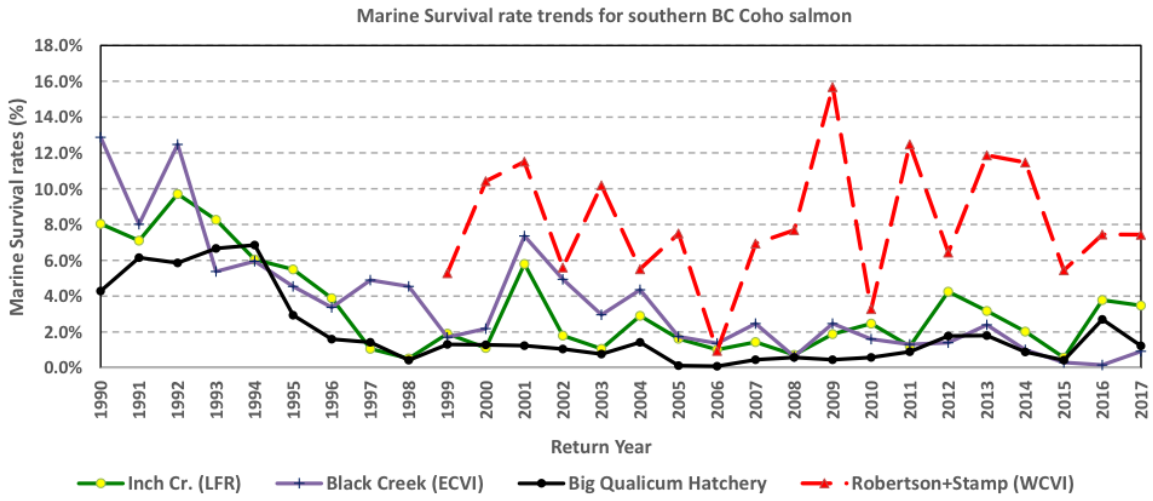


FIGURE COHO-3. Black Creek Coho salmon, a wild stock indicator for the Strait of Georgia.

Trends in marine survival rates (% survival of smolts to pre-fishery recruitment) for four indicator populations in the Strait of Georgia (Big Qualicum Hatchery & Black Creek), the Lower Fraser River (Inch Creek Hatchery), and for the Robertson Creek Hatchery on the west coast of Vancouver Island.

returns have been weaker and need to be incorporated into future considerations.

Transboundary Rivers (Taku & Stikine) Coho Salmon

Coho salmon abundance in these rivers is significant, but conducting monitoring in this region is challenging. Coho monitoring programs are established for the Taku River in conjunction with the Alaskan Department of Fish and Game. Monitoring in the Stikine River has not been fully developed. The current abundance estimates for Taku coho salmon is presented in Figure Coho-6[1]. Returns in 2017 and 2018 are expected to be slightly less than the recent 10-year average of 125,000 coho in the terminal run.

1 Data provided by Ian Boyce and Paul Vecei, DFO Whitehorse, September 12, 2018

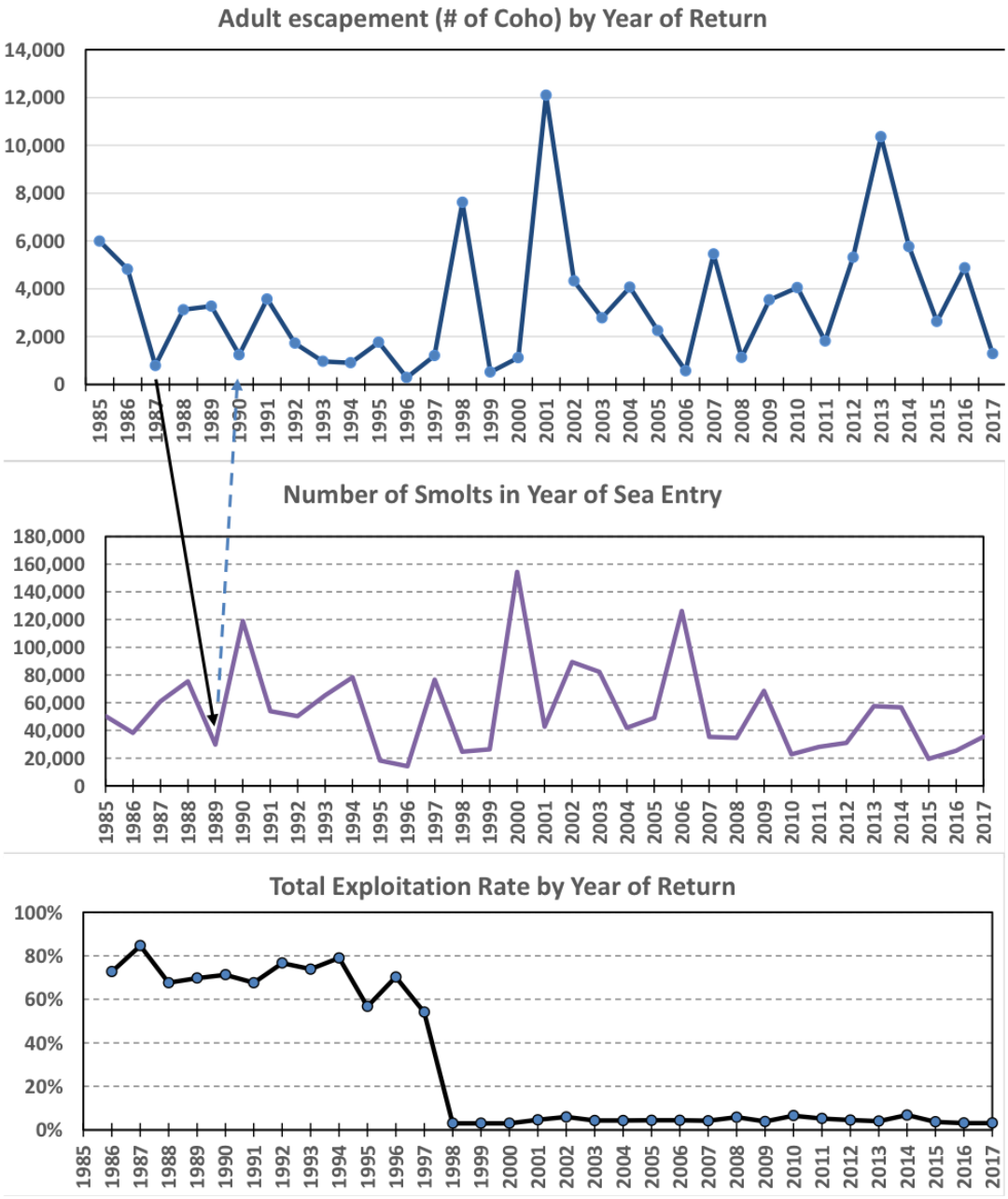


FIGURE COHO-4. Black Creek Indicator stock history.

top: Adult returns to Black Creek enumeration fence by year of return.

middle: Count of smolts leaving Black Creek, also enumerated at fence.

bottom: Fishing mortalities estimated by coded-wire tagging of smolts and subsequent recovery in catches and in adult escapement to Black Creek.

Arrows above show the adult return by year associated with the smolts produced from those spawning adults but 1.5 years later. The dashed arrow is the link between smolts and the subsequent escapement of adults also about 1.5 years later (assuming all coho mature at 3-years of age). The bottom figure is expressed as the percentage of coho that recruited to fisheries that were subsequently removed by fisheries (i.e., a 50% rate accounts for half of the coho produced).

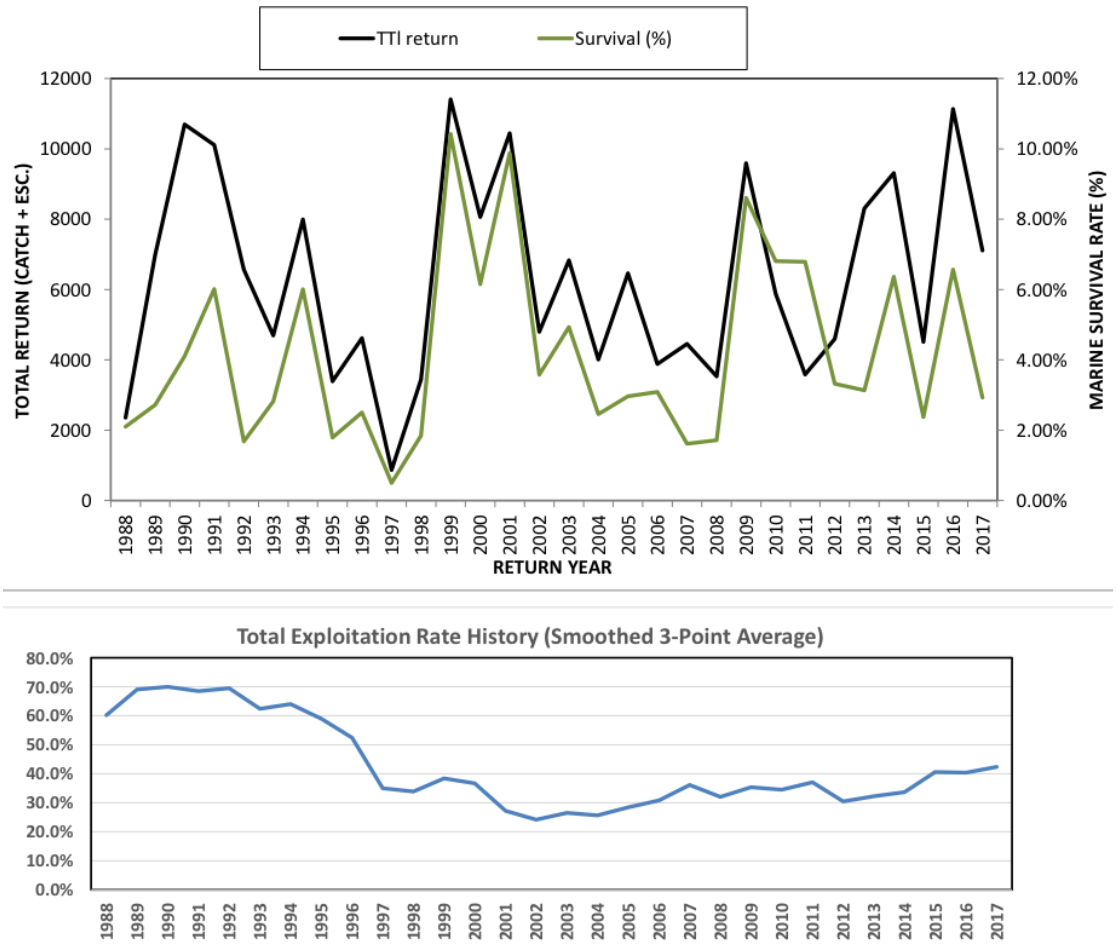


FIGURE COHO-5. Toboggan Creek coho salmon indicator stream, Bulkley Valley, Skeena River.

Top figure matches marine survival rates (% survival) and the estimated total return of Toboggan Creek coho salmon estimated using the annual total exploitation rate determined from coded-wire tagging of Toboggan Creek coho salmon. Change in total exploitation rate in bottom figure, smoothed using a 3-point averaging to emphasize trends. Over the past decade, exploitation rates have been reduce by approximately a third on average.

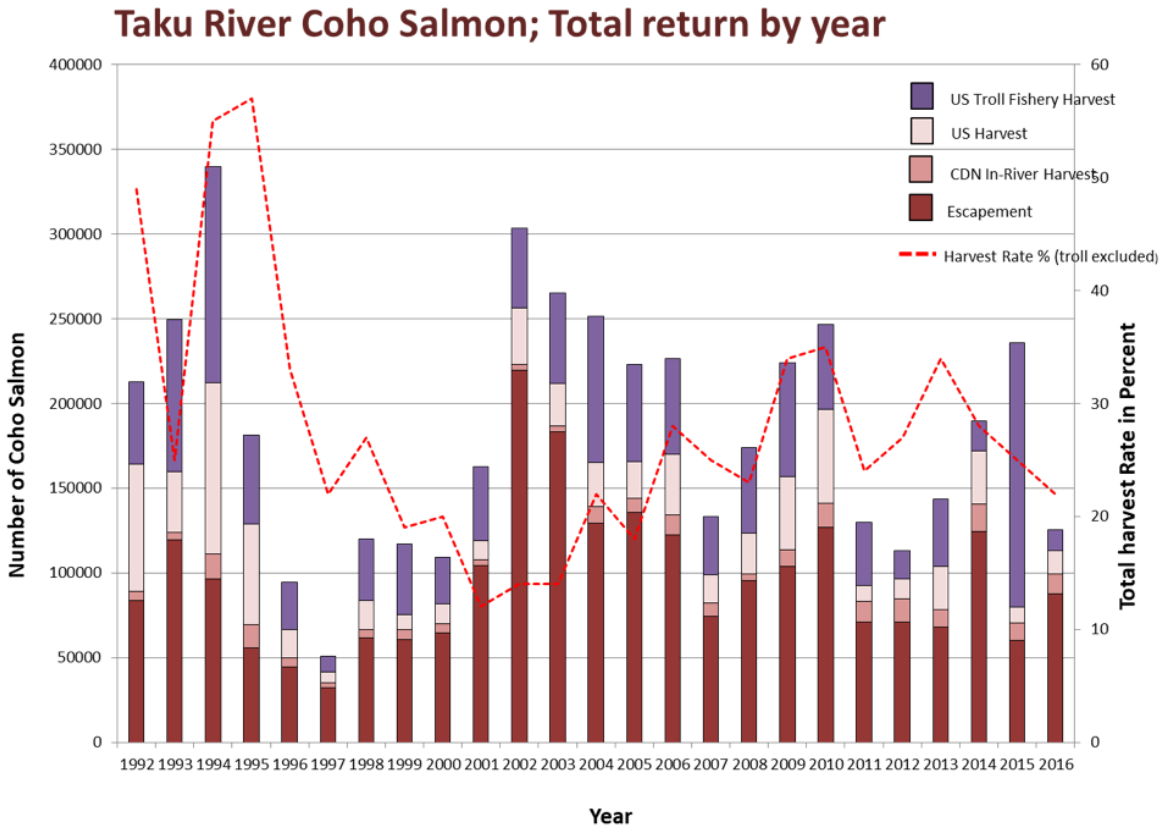


FIGURE COHO-6. Total returns of coho salmon to the Taku River. Cumulative bar plots sums catches and estimated spawning escapement each year. Catches include US Troll fishery harvest, US terminal catches, and catches by Canadians in-river. The annual harvest rate in the terminal areas fisheries (river and inlet) are presented by year (dashed line). Returns in 2017 and 2018 will continue to be slightly below the recent 10-year average abundance of 125,000 coho to the terminal area.

Chinook Salmon

Chinook salmon are widely distributed in BC from the Taku River in the north to the Okanagan River in southeastern BC. Chinook salmon are described geographically in 62 CUs, encompassing 761 spawning populations[1] (see Table 7). Unfortunately, with very few exceptions, the state of Chinook salmon is depressed (or poor) with regards to abundance and productivity. However, reductions in total exploitation rates have sustained spawning in most Chinook populations, but widespread reductions in spawning abundance has continued in the most recent years.

Chinook salmon are produced extensively in hatcheries, but survival rates of hatchery-produced Chinook have also been poor and concerns regarding interactions with wild Chinook are increasing (DFO 2018a[2]). COSEWIC has recently completed a status review of southern BC Chinook salmon CUs (June 2018), but currently the only listed population is Okanagan Chinook (Endangered, COSEWIC 2017; also see Syilx' Okanagan Chinook Reintroduction plan[3]).

Chinook salmon production in southern BC has recently been considered in more detail than in northern BC as reductions in production occurred first in southern populations. The initial review of the status and factors for the decline was conducted by an independent panel (Riddell et al. 2013) that includes a concise history of Chinook management and assessment (Riddell et al. 2013; pg. 11-18). Subsequently, DFO conducted an integrated status assessment of Chinook salmon CUs in southern BC under Canada's Wild Salmon Policy (DFO 2016[4]). This status assessment rated southern BC CUs under a 'stop light model' (green, amber, red) or as Data Deficient (DD, not assessed) or TBD (To Be Determined,

1 Diana Dobson, DFO Science, personal communication, 2018.

2 http://www.dfo-mpo.gc.ca/csas-sccs/Publications/SAR-AS/2018/2018_001-eng.pdf

3 https://www.syilx.org/wp/wp-content/uploads/2017/10/2017-FAQ_OK-Chinook-Recovery.pdf

4 http://www.dfo-mpo.gc.ca/csas-sccs/Publications/SAR-AS/2016/2016_042-eng.html

TABLE 7. Number of Conservation Units, Population Units, and Management Units for BC Chinook. In southern BC, Vancouver Island, and West Coast Vancouver Island, four other Conservation Units are excluded due to uncertain population status (includes the Okanagan Chinook), and 3 Conservation Units are excluded as they are predominantly hatchery-based groups.

Geographic region of BC	Number of Conservation Units	Population Units	Management Units
Transboundary Rivers, North and Central BC	32	317	3
Southern BC, Vancouver Island, and West Coast Vancouver Island	30	444	8 (5 in the Fraser River)

due to uncertainties within the population unit, e.g., extent of hatchery production). At present, the CUs in southern BC are rated as: green (2), amber (1), amber/red (1), red (10), DD (9), and TBD (7). This assessment strongly indicates that the present poor state of Chinook salmon (10 of 14 CUs that could be assessed were considered to be at increasing risk of extinction), and the need to for improved assessment capability given that half of the CUs could not be assessed (16 of 30 CUs could not be assessed). These ratings were summarized in a file provided by D. Dobson (DFO Science, personal communication, 2018), but also reported in an important recent report (Table 1, DFO 2018b[1]) . Production of Chinook salmon from CUs in the red zone is presently limited by an insufficient number of spawners, but the factors that have led to the decline in spawning abundance will also have to be addressed for any recovery.

While the integrated status assessment presently provides the most carefully considered assessments of Chinook salmon in southern BC, they don't provide materials to examine trends in Chinook production or explanations for the current state. The recent report (DFO 2018b) does provide data on trends in Chinook escapements, changes in exploitation rates on Chinook, variation in marine survival of Chinook indicator stocks, and changes in biological characteristics of Chinook. In addition, extensive reviews of Chinook spawning escapements, catches, marine survival rates, and exploitation are provided annually by the Chinook Technical Committee of the Pacific Salmon Commission.[2]

To provide the Wild Salmon Advisory Council with advice that has widespread consensus, we summarize information provided in DFO (2018b) and from the Chinook Technical Committee, particularly the most recent report on catch and escapement published by the Pacific Salmon Commission (PSC 2018). Extensive analysis of changes in exploitation rates and marine survival rates are also available from the Pacific Salmon Commission and Chinook Technical Committee reports, but this information will only be briefly summarized in this report (M. Theiss, DFO Science provided up-dated plots, Figure Chinook-3a,3b).

Chinook Figure-1 summarizes regional patterns of change in Chinook spawning escapement expressed as deviations from the average escapements observed between 1975–2017 (a positive deviation indicating a 'better than average' escapement in a given year). In the most recent decade, strong negative deviations are notable for the Transboundary Rivers, Northern BC (Skeena and Nass rivers), Fraser River spring Chinook, and the Fraser Late (Harrison River stock). But, there are few recent positive deviations to note: Northwest Vancouver Island and Lower Georgia Strait in particular. The Fraser Summer 41 stock has a recent period of strong production/escapements, but has been in decline most recently. The average value for this stock is influenced by much smaller escapements during the first half of this time series.

Figure Chinook-2 summarizes patterns of marine survival rates for Canada's primary Chinook indicator stocks (all of which are hatchery-based). Marine survival rates are estimated as the portion of a coded-wire tagged group of Chinook survival until recruitment to fisheries (age-2 for under-yearling smolts or age-3 for yearling smolts). Incomplete returns for the most recent brood year releases are estimated using past age-at-maturity rates within the indicator stock. Figure Chinook-2 is also expressed as deviations from average values over the full time series of data within each indicator stock. Most notable are the large deviations from average and the patterns of good and bad periods of marine survival for these indicators. The decline in escapement for Fraser Summer 4(1)[3] Chinook noted above is associated with the negative deviations apparent in Figure Chinook-2b, Lower Shuswap River indicator stock.

1 http://www.dfo-mpo.gc.ca/csas-sccs/Publications/ScR-RS/2018/2018_035-eng.html

2 https://www.psc.org/publications/technical-reports/technical-committee-reports/chinook/

3 The Fraser Summer 4(1) is a management unit of Chinook Salmon, and is comprised of the Maria Slough and South Thompson summer-run, ocean-type, Conservation Units.

Figure Chinook-3 summarizes the history of fishery exploitation rates for Canada's primary Chinook indicator stocks (all of which are hatchery-based). These figures present the estimated rate (not deviations) of fishing mortality as a proportion of the total production from a brood year. For example, a value of 0.5 would indicate that half of the production that survived to recruit to the fisheries was caught or lost as associated fishing mortalities (hook-release mortality, net drop-off, etc.). The extent of reductions in fishery exploitation rates is apparent comparing the recent three-generation period to the full time series for most of the indicator stocks. In many cases, the reduction from historic levels has been ~50% (for those indicators with data back in to the 1980s). However, the assessment within the past three-generations is not as clear and may reflect changes in terminal fisheries (near-shore marine and/or within rivers), or may have been caused by significant reductions in marine survival rates without sufficient reduction in total fishing mortality to compensate for the loss of productivity.

Trends in spawning escapements are reported annually by the Chinook Technical Committee of the Pacific Salmon Commission.[1] How representative these trends are of changes in production (over time and between regions) will differ depending on the extent of reduction in fishing pressures over time. Reduction of fishing mortality will increase the portion of a stock's production that will return to spawning populations. As evident in Figure Chinook-3, fishing pressures have generally been reduced through the past 20 years and will increase the portion of Chinook production represented by these spawning escapements. But, since spawning escapements are declining in recent years, this implies a substantial reduction in total production and Chinook productivity, likely associated with declines in marine survival rates as shown in Figure Chinook-2. In the DFO publication (DFO 2018b), scientific staff stated:

"Large-scale patterns of environmental change and increased environmental variability have been associated with broad declines in productivity[2] of Chinook salmon across their range in recent decades. Potential effects of recent events, such as the persistence of the warm ocean water 'blob' which formed in the North Pacific in 2014 and moved onshore in 2015, and El Niño conditions in early 2016, have lowered expectations for returns of Chinook salmon in 2018 (PFMC 2018)[3]."

Since the Chinook Technical Committee report includes Canadian and US Chinook stocks, it is a large document. A sampling of charts demonstrating trends in spawning escapement of Canadian stocks are available in a separate file provided for the Wild Salmon Advisory Council's reference (Chinook Appendix figures). These plots show the trends in numerical values (not deviations as in Figure Chinook-1) and demonstrate the variability observed between years.

Declines in recent spawning escapements are pronounced for the more northern Chinook stock groups: Taku, Stikine, Nass, Skeena rivers and for three of five major stock groupings within the Fraser River basin. Of particular concern is the decreased returns in recent years to Canada's previously largest Chinook population (the Harrison River white, fall-run Chinook), in spite of low overall exploitation. Conversely, stronger returns are evident for the Cowichan River and the South Thompson River (summer run-timing).

1 CTC (2018). Annual Report of Catch and Escapements for 2017. Report TCCHINOOK (18)-02. 235 pg. available from www.psc.org/publicaitons.

2 Productivity is the intrinsic rate of growth of a population, estimated from the observed relationship between spawners and adult recruits over time (also referred to as "recruits per spawner").

3 https://www.pcouncil.org/wp-content/uploads/2018/02/Review_of_2017_Ocean_Salmon_Fisheries_18Final.pdf

Concern for the decline in Chinook production and productivity has recently been heightened by Dorner et al. (2018) through an analysis of 24 wild Chinook populations extending from Oregon through Alaska. This assessment provides strong support for a steep decline in productivity starting in the early 2000s for the vast majority of these 24 populations and, importantly, an increased synchrony of changes in Chinook productivity between these populations over time. Increased synchrony has important implications for fisheries. Increased synchronicity may result in greater year-to-year variation in allowable harvests because fewer stock abundances will be high when others are low. In the past, the buffering of good production with bad has offset changes in abundance, but without this buffering coupled with evidence of lower Chinook productivity, we should anticipate further reductions in fishing and potential closures.

But, in an extensive assessment of Chinook salmon based on 36 coded-wire tagged stocks from Oregon through Alaska (all hatchery-based), Ruff et al. (2017) reports that processes determining marine survival rates are more affected by "sub-basin and even population specific scales" than broader climatic factors, particularly for Chinook populations within the Salish Sea. While these results suggest an opportunity to improve Chinook survival/production through localized mitigation actions, the result may just reflect the greater intensity of human alterations within the Salish Sea than elsewhere along the coast. Regardless, Chinook populations in the Strait of Georgia, mainland inlets, and the Fraser River basin certainly include many important Chinook populations that merit the Wild Salmon Advisory Council's attention and could substantially increase Chinook salmon production with associated benefits to local BC communities.

Additional Considerations Regarding Chinook Salmon

There is increasing concern for changes in the biological characteristics of Chinook salmon including earlier ages at maturity, smaller size at age, and reduced fecundity at maturity. Each of these characteristics will contribute to reduced reproductive potential and their productivity rate.

There are serious deficiencies in assessment capability for important stocks. For example, the lack of tagged indicator stocks for the complex of upper Fraser River spring Chinook groups and similarly for the mainland inlet Chinook populations in the Strait of Georgia. Of particular concern also is the low productivity of hatchery Chinook and the interaction of hatchery with local naturally-produced Chinook.

Assuming ratification of the recently renegotiated Pacific Salmon Treaty, there will be significantly increased pressures for mass-marking of hatchery-reared Chinook salmon and to allow increased catch-and-release fishing for Chinook salmon.

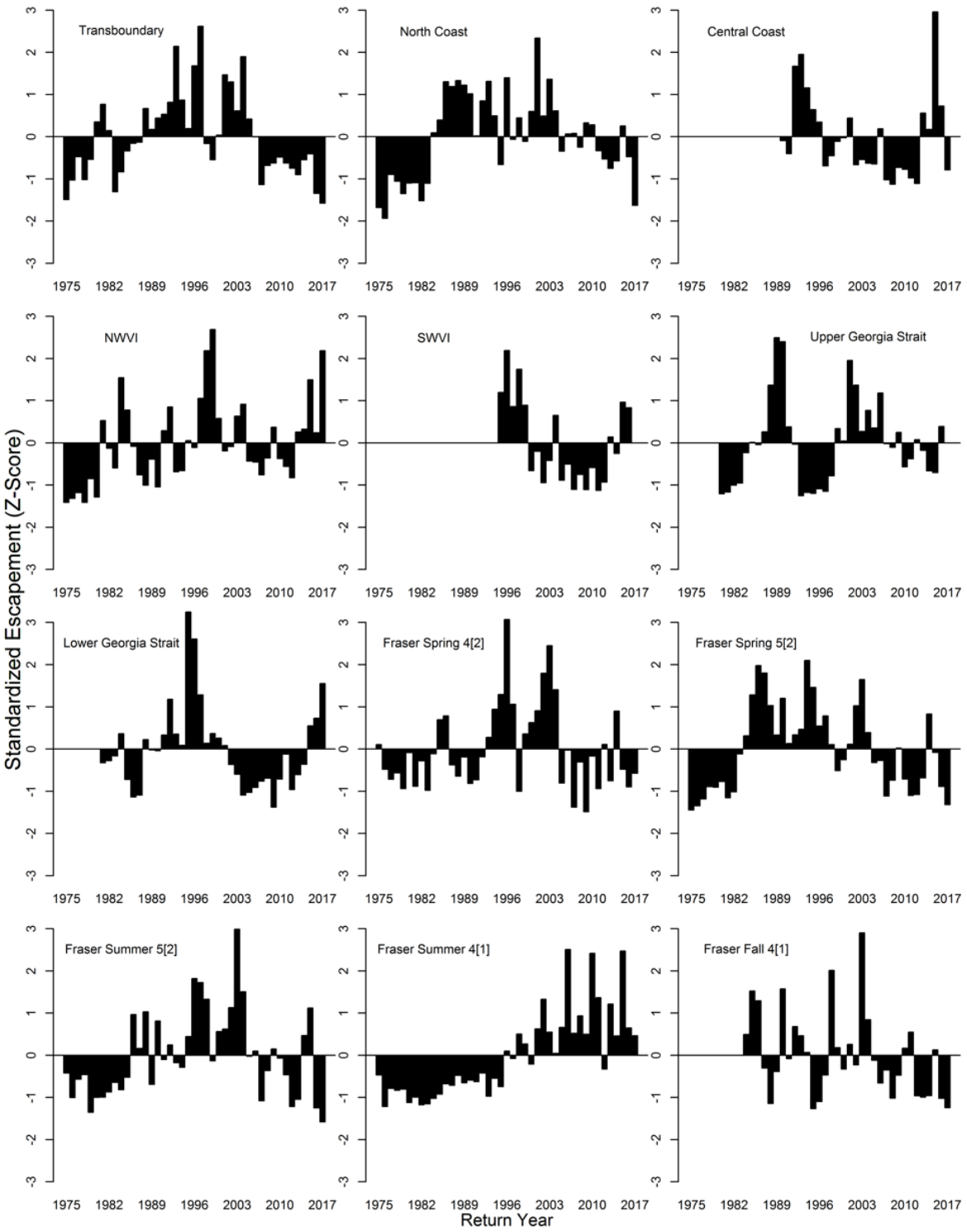


FIGURE CHINOOK-1. Trends in Chinook Spawning Escapements as per DFO (2018b).

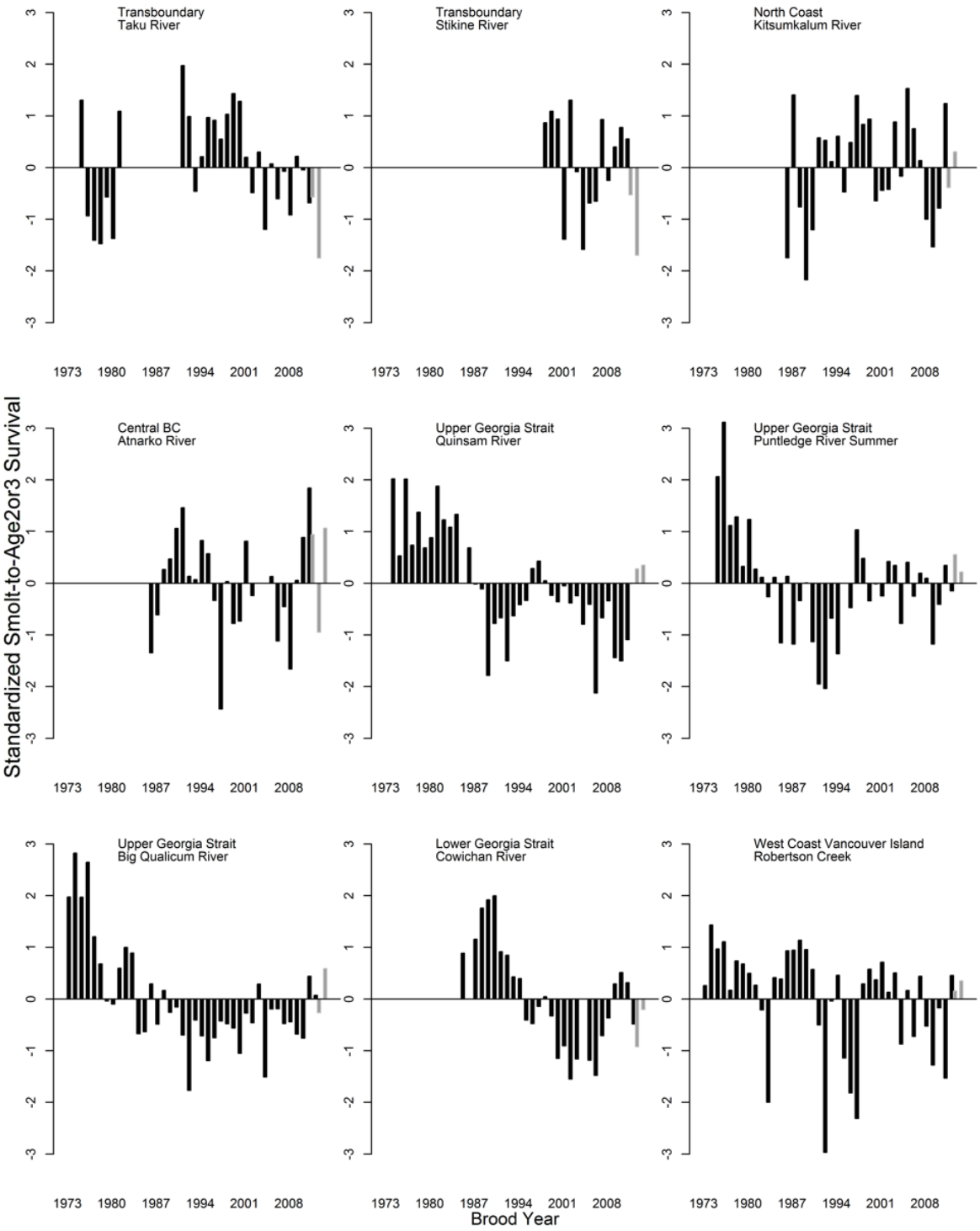


FIGURE CHINOOK-2 (2A). Chinook marine survival rates as per DFO (2018b).

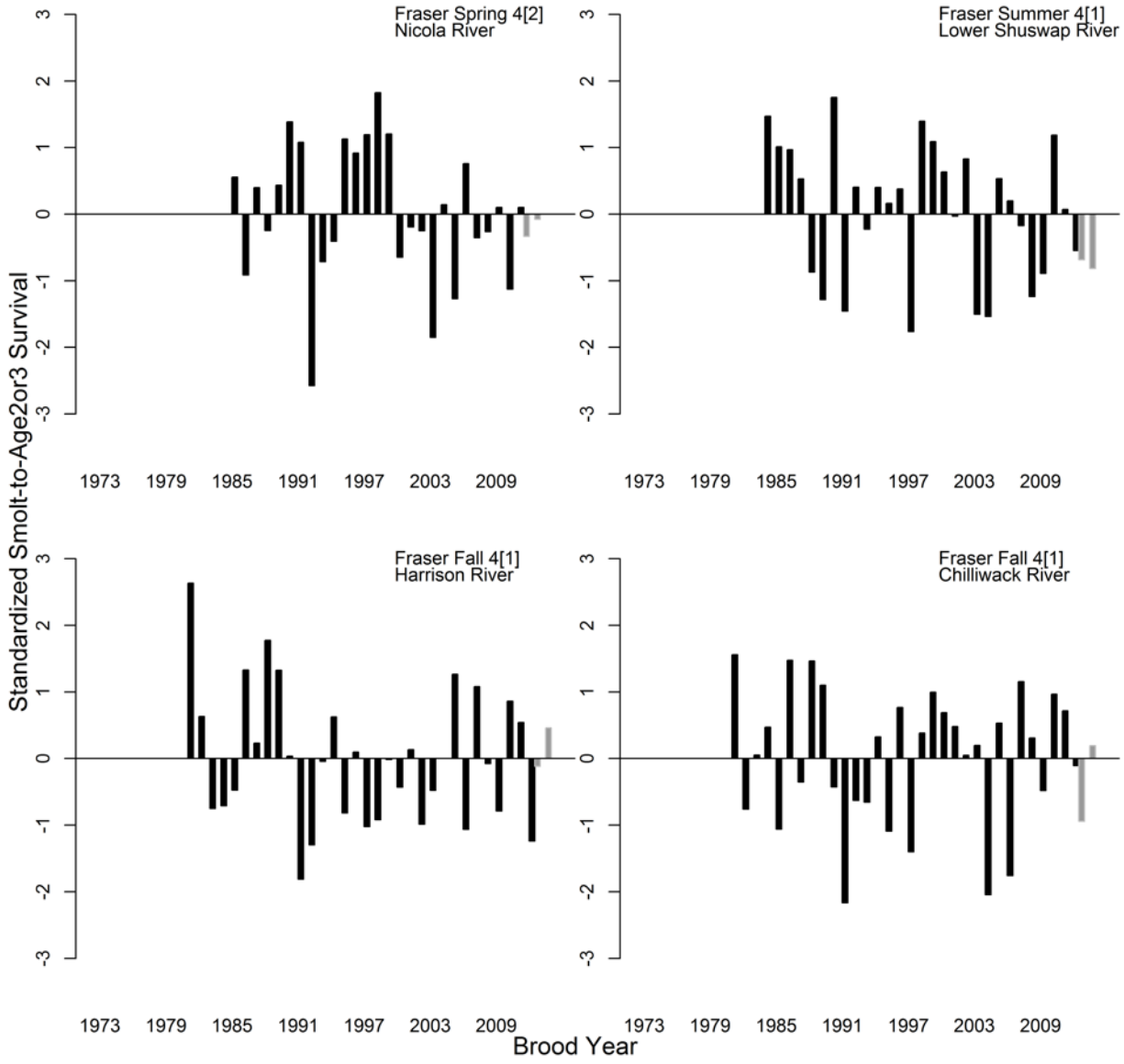


FIGURE CHINOOK-2 (2B). Chinook marine survival rates as per DFO (2018b).

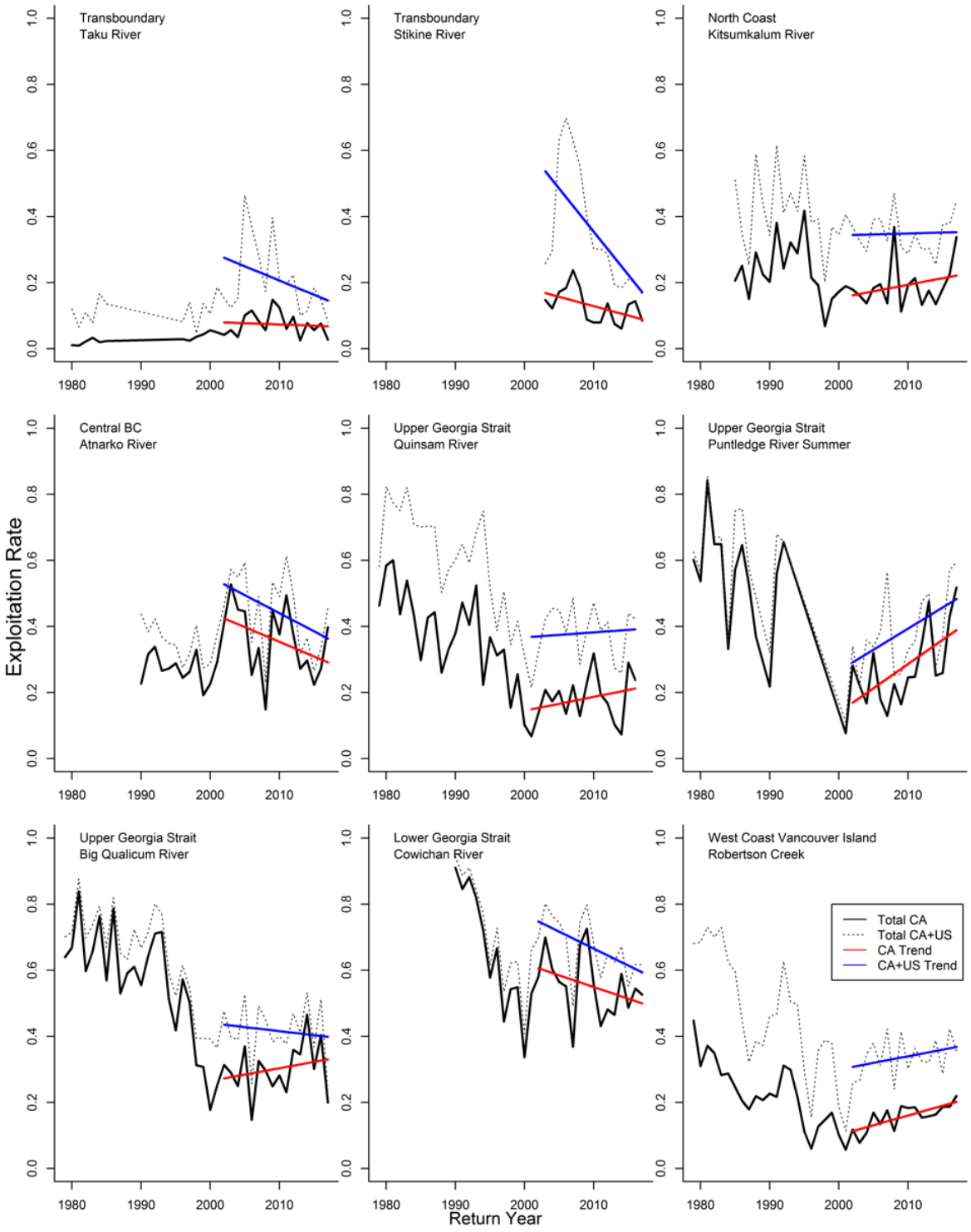
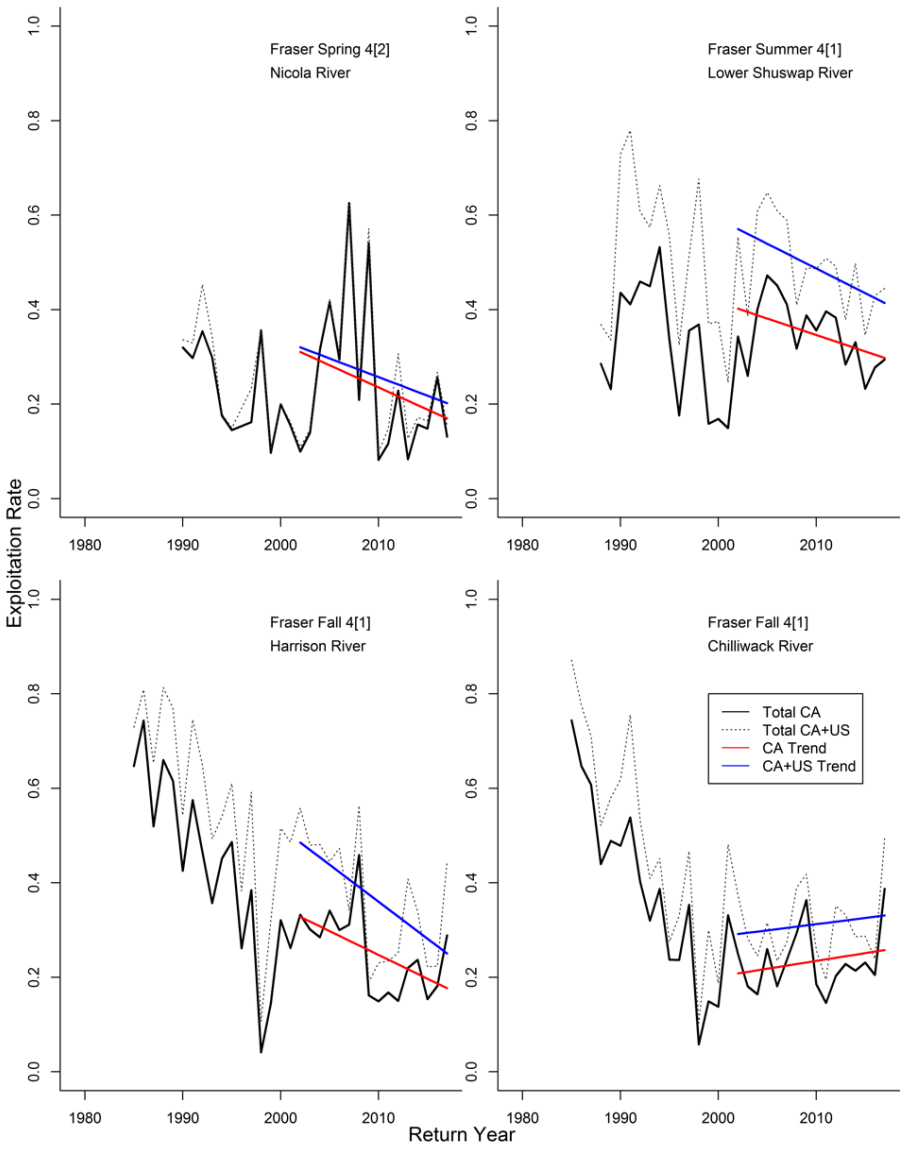


FIGURE CHINOOK-3 (3A, *this page*; 3B, *next page*).
Exploitation rates (total fishing mortality expressed as portion of the production from a brood year) for indicator stocks for BC Chinook, and a linear trend analysis for the past 3 generations. The full history of exploitation rates for both total (US + Canada) and Canada only are also provided to place the current exploitation rates within the context of past exploitation rates. Figure 3a includes the 9 non-Fraser River indicators and Figure 3b the four Fraser River indicators.


Fraser Spring 4[2]
Nicola River
Fraser Summer 4[1]
Lower Shuswap River
Fraser Fall 4[1]
Harrison River
Fraser Fall 4[1]
Chilliwack River
Total CA
Total CA+US
CA Trend
CA+US Trend
Exploitation Rate
Return Year
0.0
0.2
0.4
0.6
0.8
1.0
1980
1990
2000
2010

Steelhead Trout

The vast majority of the estimated 423 steelhead populations in BC belong to three major genetic groups defined by ancestral lineages and post glacial recolonization. In addition, there are two transition groups that reflect genetic mixing of the major groups.[1]

Steelhead population status within the North Coast, which spans an area over the northern half of the steelhead range contained within BC, is informed mainly by the state of Skeena steelhead which appears to be stable over the past 20-years fluctuating near or above biological reference points intended to sustain steelhead production (Figure Steelhead-1). All North Coast summer-run populations that encounter salmon gillnet and purse seine fisheries lack data regarding mortality or removals in those fisheries. Steelhead in the Transboundary Rivers between BC and Southeast Alaska are among the least understood with respect to spawning abundances, mortality or removals in salmon fisheries, and conservation status.

Steelhead status within the Northern Transition group, a relatively small area in mid-latitudes of the BC coast, is informed by Dean and Bella Coola steelhead. Dean steelhead may have undergone a decline to about the mid-2000s while Bella Coola steelhead have

1 British Columbia Steelhead Stock Status Review 2018. Robert Bison - BC Ministry of Forests, Lands and Natural Resource Operations, 1259 Dalhousie Drive, Kamloops, BC V2C 5Z5 Robert.Bison@gov.bc.ca. http://www.psmfc.org/steelhead/past-2018.html

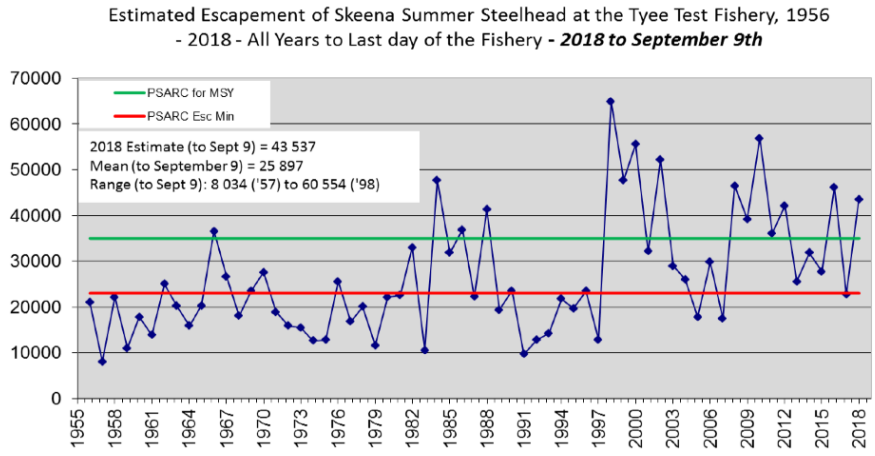


FIGURE STEELHEAD-1. Historical returns of Summer Steelhead in the Skeena River (Tyee Test fishery). Horizontal green line = target index for production objectives. Horizontal red line = recommended minimum escapement target. Many of the large index values are related to reductions in ocean net fisheries. Graph produced by M.Beere, FLNRO Smithers, BC. (September 10, 2018)

clearly declined and remain in a state of relatively low abundance. Status is again limited by a lack of information on commercial fishery impacts for the Dean and both commercial and First Nation harvest impacts for the Bella Coola.

Steelhead population status in southern BC involves three groups (South Coast, South Interior, and the Southern Transition), each of which is in a state of decline. The South Interior group is assessed by COSEWIC as containing two Designatable Units (Thompson and Chilcotin) and both have been classified as Endangered and at imminent risk of extinction (COSEWIC 2018[1], e.g., Figure Steelhead-2). In the South Coast, there is also evidence of wide spatial scale declines in recruitment capacity, most dramatically among winter-run populations. Most recently, a decline in Gold River steelhead is particularly noteworthy given its history as a premier BC steelhead stream. The two major hatchery streams in this group are also exhibiting abundance declines within the last six- to eight-years. Within the South Coast, pinniped predation, extreme climate events and climate trends, along with forestry-related stream degradation are among the main conservation and management concerns. In the South Interior and the Southern Transition, pinniped predation, climate change, offshore competition, and bycatch in salmon fisheries are among the main conservation and management concerns.

1 https://www.registrelep-sararegistry.gc.ca/virtual_sara/files/cosewic/Ea-SteelheadTrout-voo-2018Feb-Eng.pdf

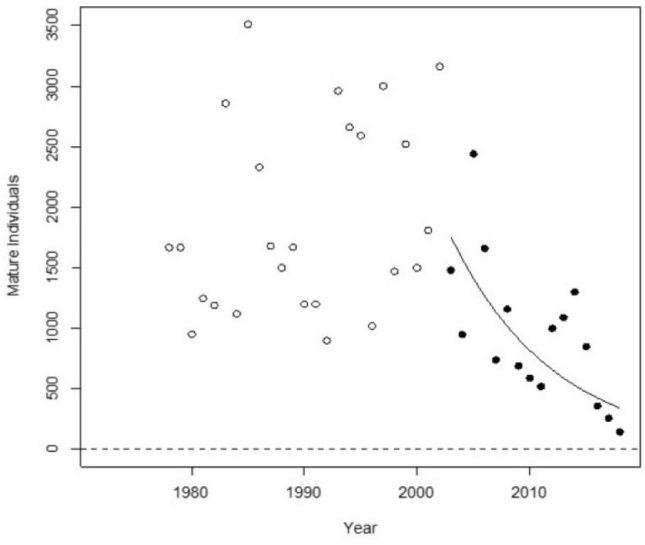


FIGURE STEELHEAD-2. Trend in the number of mature individuals in the Thompson River Steelhead Trout DU, 1978-2018, and the fitted log-linear regression through the last 3 generations (5 year generation time). The solid data points were used in the decline estimate of 79%. Data obtained from R. Bison, November 6, 2017. Note that fish entering fresh water in the fall of 2017 will spawn in the spring of 2018. (Source: https://www.fraserbasin.bc.ca/_Library/TR_2018/cosewic_report_steelhead_feb_2018.pdf)

References

Bocking, R. C., Link, M. R., Baxter, B., Nass, B., and Jantz, L. 2002. Meziadin Lake Biological Escapement Goal and Considerations for Increasing Yield of Sockeye Salmon (*Oncorhynchus nerka*). DFO Canadian Science Advisory Secretariat, Research Doc. 2002/124.

Connors, B. M. and Atnarko Sockeye recovery planning committee. 2016. Atnarko Sockeye recovery plan. 62 pp.

COSEWIC. 2016. COSEWIC assessment and status report on the Coho Salmon *Oncorhynchus kisutch*, Interior Fraser population, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xi + 50 pp. http://www.registrelep-sararegistry.gc.ca/default.asp?lang=en&n=24F7211B-1

COSEWIC. 2018. Technical summaries and supporting information for Emergency Assessments. Steelhead Trout *Oncorhynchus mykiss* (Thompson River and Chilcotin River populations). Available for: https://www.registrelep-sararegistry.gc.ca/virtual_sara/files/cosewic/Ea-SteelheadTrout-voo-2018Feb-Eng.pdf

COSEWIC. 2017. COSEWIC assessment and status report on the Chinook Salmon *Oncorhynchus tshawytscha*, Okanagan population, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xii + 62 pp. http://www.registrelepsararegistry.gc.ca/default.asp?lang=en&n=24F7211B-1

Decker, A. S., Hawkshaw, M. A., Patten, B. A, Sawada, J, A. L. Jantz I. 2014. Assessment of the Interior Fraser Coho Salmon (*Oncorhynchus kisutch*) Management Unit Relative to the 2006 Conservation Strategy Recovery Objectives. DFO Canadian Science Advisory Secretariat, Research Doc. 2014/086. xi + 64 p. http://publications.gc.ca/collections/collection_2014/mpo-dfo/Fs70-5-2014-086-eng.pdf

Dorner, B., M. J. Catalano, and R. M. Peterman. 2018. Spatial and temporal patterns of covariation in productivity of Chinook salmon populations of the northeast Pacific Ocean. Canadian Journal of Fisheries and Aquatic Science 75:1082–1095. Dx.doi.org/10.1139/cjfas-2017-0197

English, K. K., Peacock, D., Challenger, W., and Mochizuki, T. 2016. North and central coast escapement, catch, run size and exploitation rate estimates for each conservation unit for 1954–2014. Report prepared by LGL Ltd., Sidney, BC. 102 pp.

English, K. K. 2016. Review of Escapement Indicator Streams for the North and Central Coast Salmon Monitoring Program. Report prepared by LGL Ltd., Sidney, BC. 55 pp.

Fisheries and Oceans Canada (DFO). 2005. Canada's Policy for Conservation of Wild Pacific Salmon. Fisheries and Oceans Canada, 401 Burrard Street, Vancouver, BC, V6C 3S4. 49 pp. ISBN 0-662-40538-2.

Fisheries and Oceans Canada (DFO). 2009. Framework for characterizing Conservation Units of Pacific salmon (*Oncorhynchus spp.*) for implementing the Wild Salmon Policy. DFO Canadian Science Advisory Secretariat, Research Doc. 2008/052. http://publications.gc.ca/collections/collection_2011/mpo-dfo/Fs70-6-2008-052-eng.pdf

Fisheries and Oceans Canada (DFO). 2015. Wild salmon policy biological status assessment for Conservation Units of interior Fraser River Coho Salmon (*Oncorhynchus kisutch*). DFO Canadian Science Advisory Secretariat, Science Advisory Report 2015/022. http://www.dfo-mpo.gc.ca/csas-sccs/Publications/SAR-AS/2015/2015_022-eng.html

Fisheries and Oceans Canada (DFO). 2016. Integrated Biological Status of Southern British Columbia Chinook Salmon (*Oncorhynchus tshawytscha*) Under the Wild Salmon Policy. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2016/042.

Fisheries and Oceans Canada (DFO). 2018a. Integrated Fisheries Management Plan: June 1, 2018 – May 31, 2019. Salmon, Northern BC. 434 pp.

Fisheries and Oceans Canada (DFO). 2018a. Review of genetically based targets for enhanced contributions to Canadian pacific Chinook salmon populations. DFO Can. Sci. Advisory Secretariat, Science Advisory Report 2018/001. 11 pp.

Fisheries and Oceans Canada (DFO). 2018b. Pre-season run size forecasts for Fraser River sockeye (*Oncorhynchus nerka*) in 2018. DFO Canadian Science Advisory Secretariat, Science Response 2018/034.

Fisheries and Oceans Canada (DFO). 2018b. Science information to support consultations on BC Chinook Salmon fishery management measures in 2018. DFO Canadian Science Advisory Secretariat, Science Response 2018/035. 26 pp.

Fisheries and Oceans Canada (DFO). 2018c. Integrated Fisheries Management Plan: June 1, 2018 – May 31, 2019. Salmon, Southern BC. 559 pp.

Holtby, B. and Finnegan, B. 1997. A biological assessment of the coho salmon of the Skeena river, British Columbia, and recommendations for fisheries in 1998. DFO Canadian Science Advisory Secretariat, Research Document 1997/138.

Ogden, A. D., J. R. Irvine, M. O'Brien, N. Komick, G. Brown, and A. Tompkins. 2014. Canadian commercial catches and escapements of Chinook and coho salmon separated into hatchery- and wild-origin fish. NPAFC Doc. 1531. 19 pp. (Available at http://www.npafc.org).

Pacific Salmon Commission (PSC) Joint Chinook Technical Committee Report. 2018. Annual report of catch and escapements for 2017. Report TCCHINOOK (18)-02. 235 p. https://www.psc.org/download/35/chinook-technical-committee/11280/tcchinook-18-2.pdf

Peterman, R. M., and Dorner, B. 2012. A widespread decrease in productivity of sockeye salmon (*Oncorhynchus nerka*) populations in western North America. Canadian Journal of Fisheries and Aquatic Sciences, 69(8), 1255–1260.

Riddell, B., M. Bradford, R. Carmichael, D. Hankin, R. Peterman, and A. Wertheimer. 2013. Assessment of Status and Factors for Decline of Southern BC Chinook Salmon: Independent Panel's Report. Prepared with the assistance of D. R. Marmorek and A. W. Hall, ESSA Technologies Ltd., Vancouver, BC. for Fisheries and Oceans Canada (Vancouver. BC) and Fraser River Aboriginal Fisheries Secretariat (Merritt, BC). xxix + 165 pp. + Appendices. https://www.psc.org/publications/workshop-reports/southern-bc-chinook-expert-panel-workshop/

Routledge, R. and Wilson, K. 1999. Coast-Wide Coho. Pacific Fisheries Resource Conservation Council. Available through PSF's Salmon Watershed Program.

Ruff, C. P., (+ ten authors). 2017. Salish Sea Chinook salmon exhibit weaker coherence in early marine survival trends than coastal populations. Fisheries Oceanography 2017:1–13.

Ruggerone, G. T., and Irvine, J. R. 2018. Numbers and Biomass of Natural and Hatchery Origin Pink Salmon, Chum Salmon, and Sockeye Salmon in the North Pacific Ocean, 1925–2015. Marine and Coastal Fisheries, 10(2):152–168.

Salmon Watersheds Program. 2016. Pacific Salmon Explorer: a data-driven look at salmon habitat and populations. Retrieved online from http://salmonexplorer.ca

created September 26, 2018
assembled into this format March 1, 2020

PACIFIC SALMON FOUNDATION

SALMON WATERSHEDS PROGRAM