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Pacific Region

Canadian Science Advisory Secretariat
Science Response 2025/021

WEST COAST OF VANCOUVER ISLAND NATURAL-ORIGIN CHINOOK SALMON (*ONCORHYNCHUS TSHAWYTSCHA*) STOCK ASSESSMENT IN 2024

CONTEXT

The Fisheries Management Branch of Fisheries and Oceans Canada (DFO) has requested that the West Coast Vancouver Island Chinook stock be assessed relative to reference points that are consistent with the DFO Precautionary Approach, provide harvest advice, and inform the rebuilding plan for this stock. In addition, the Ecosystem Management Branch has requested information to evaluate the recovery potential of the stock. This Fisheries Science Response Report is from the April 29-May 3, 2024, regional peer review on the West Coast Vancouver Island Chinook Salmon (*Oncorhynchus tshawytscha*) Stock Assessment in 2024. Additional publications from this meeting will be posted on the (DFO) Science Advisory Schedule as they become available.

SCIENCE ADVICE

Status

Natural-origin Chinook salmon in the West Coast of Vancouver Island (WCVI) Stock Management Unit (SMU) are in the critical zone. This conclusion is based on the following lines of evidence:

- Spawner abundances in populations in the Southwest Vancouver Island Conservation Unit (CU), which have remained largely isolated from hatchery production, have been consistently in the Wild Salmon Policy “red” status zone for roughly 30 years, resulting in status below CU-based Limit Reference Points (LRP).
- Large-scale hatchery Chinook production programs have diminished genetic diversity across WCVI populations, primarily due to interbreeding of hatchery strays with wild fish.
- Declines in size-at-age and age-at-maturity have resulted in fewer and smaller female Chinook returning compared to in previous decades.

Trends

- The aggregate abundance of natural and hatchery Chinook in the SMU increased over the past decade due to improved marine survival. However, some watersheds with low hatchery influence have not increased but rather persist at low levels. This is especially evident in Clayoquot Sound, where several populations are at critical low abundance.
- Genetic diversity continues to decline across natural-origin Chinook populations due to straying, as strays are integrating into both natural spawning and hatchery broodstock populations. Conversely, genetic diversity within large hatchery populations remains stable.

Canada

- Shifts in population demographics, namely declining adult body sizes, age-at-maturity, and fecundity, have been observed over the past three decades.

Ecosystem and Climate Change Considerations

- Natural stock productivity is expected to remain low and natural mortality is expected to remain high until cumulative pressures associated with freshwater and estuarine habitat degradation, an increasing frequency of unfavorable ocean conditions, and other limiting factors are alleviated.
- Climate change effects that are apparent across all phases of the WCVI Chinook life cycle are increasing in frequency and severity, negatively impacting the survival and productivity of natural Chinook populations within the SMU.

Stock Advice

Rebuilding

Balancing conservation of natural-origin Chinook in the SMU with the benefits conferred from hatchery production requires collaborative governance and planning. The highest risk factors implicated in past declines and ongoing low abundances of natural-origin WCVI Chinook span the life cycle and include: demographic changes, interbreeding with hatchery-origin strays, physical habitat perturbations and degradation of rivers and the nearshore marine environment, changes in prey quality and availability, and predation (Table 3). A holistic, ecosystem-focused approach to rebuilding is required.

Current estimates of fishing mortality are below the best estimate of the Removal Reference (RR) but fall within its range of uncertainty (Figure 2c). Harvest rates on larger, older Chinook are increasing, and thereby fishery removals of females and eggs are increasing even though the total exploitation rate is relatively stable. The development of demographically-informed removal reference points (*e.g.*, age-, size-, and/or sex-specific) is recommended to mitigate outsized impacts on female spawners.

Hatchery production provides significant economic, social, and cultural benefits, but increases risks to natural-origin Chinook. Development and implementation of genetic and demographic management plans, with goals of decreasing straying rates and increasing age-at-maturity and size-at-age, should be considered. Broad implementation of hatchery mass-marking, as recommended in Withler et al. (2018), is required to enable visual identification of hatchery fish and to facilitate the use of natural-origin broodstock. Mark-selective harvest could be a tool to limit fishery exploitation on natural-origin fish in mixed-stock fisheries or to remove hatchery-origin fish from nearshore areas where natural populations predominate.

High freshwater risks, including increased mortality of incubating eggs and insufficient rearing habitat, result in ‘carry-over’ effects of increased vulnerability to poor conditions during the early marine phase. Because juvenile Chinook reside in nearshore waters for several months, this early marine phase is the period of highest exposure to key limiting factors such as pathogens, parasites, diseases, poor water quality, lack of food, and predation. This high exposure of young-of-year Chinook within their natal inlets should therefore be a key consideration in managing human activities.

Strategies to mitigate risks associated with limiting factors and to support rebuilding are provided in a later section of this report and include recommendations for harvest, hatchery, ecosystem management, and habitat restoration activities. However, not all limiting factors can easily be mitigated (e.g., restoring hydrological processes in degraded watersheds is a long-term prospect), many are exacerbated by climate change, and trade-offs will often occur (e.g., benefits of increasing production via hatchery supplementation to support rebuilding versus risks of increases in genetic, disease, and ecological consequences to natural spawners). Therefore, further work with resource managers, First Nations, and stakeholders is required to identify specific and localized prescriptions and to evaluate and prioritize those options within a cost-benefit and feasibility framework.

Reference points

Reference points that rely on aggregate abundance at the SMU level do not adequately capture the variability in status or productivity among WCVI Chinook CUs and populations. CU-scale lower benchmarks are provided here (Table 2) to capture distribution of abundances among CUs within the SMU, as reflected in SMU status against the CU-status-based LRP. It is not recommended to assess biological status using aggregate SMU abundances (Holt et al. 2023a). However, aggregate SMU fishery reference points can have utility for management objectives concerning total production and candidate values are therefore included in Table 2. For aggregate abundance reference points, further work is recommended to develop a broader range of criteria, such as distribution among populations within CUs, genetic diversity, and demographics.

Wild Salmon Policy (WSP) rapid status assessment methods were applied based on abundance and trend metrics to designate provisional CU statuses (DFO 2024a). These provisional methods did not include an expert-driven review, nor were important distributional, genetic, and demographic characteristics adequately captured, metrics that reflect the SMU's critical status. Further, both the aggregate reference points and CU status assessments were sensitive to which indicator populations were included.

Also provided in this Science Response are candidate Upper Stock Reference (USR), Removal Reference (RR), and Target Reference Point (TRP) values for the SMU. The candidate USR and RR are based on S_{MSY}(spawner abundance at maximum sustainable yield) and U_{MSY} (exploitation rate at maximum sustainable yield), respectively. The candidate abundance-based TRP is associated with an objective of having at least a 50% probability of all inlets being above their lower WSP status benchmarks. However, relying on abundance alone will be insufficient to achieve rebuilding objectives for the stock and further reference points should therefore be developed in the future.

BASIS FOR ASSESSMENT

Assessment Details

Year Assessment Approach was Approved

Riddell et al. (1996)

Assessment Type

Full Assessment.

Most Recent Assessment Date

Last Full Assessment: COSEWIC (2020)

Last Interim Year Update: Brown (2024)

Assessment Approach

1. Broad category: Multiple approaches used.

2. Specific category: Index-based (including fishery-dependent and fishery-independent indices; Stock-Recruitment Relationship), Other: Wild Salmon Policy Integrated Assessment, Risk Assessment.

Two approaches are generally used for salmon assessments: either index-based estimates of spawner abundance or stock-recruit relationships. Annually, allowable catch, fishing mortality, and fishing effort are determined through surplus to escapement (or spawner) requirements relative to expected abundance (generated through forecasts) and reference points (e.g., either biologically based targets such as benchmarks or LRPs informed by stock-recruit statistics and/or operational control points). The degree of reliance on spawner-index-based versus stock-recruit approaches is a function of data quality and availability. More recently, risk assessments are being used to better understand limiting factors through a life cycle framework and to inform the broader management context (e.g. Irvine et al. 2024).

Stock Structure Assumption

The WCVI Chinook SMU includes three Conservation Units (CUs): West Vancouver Island-North (NWVI), West Vancouver Island-Nootka and Kyuquot (NoKy), and West Vancouver Island-South (SWVI) (Figure 1, Table 1). Across the SMU, 78 rivers are assumed to support Chinook populations. Population sizes range from <100 spawners in small natural systems up to 100 000 spawners in systems with major hatcheries. Twenty rivers have some form of enhancement to supplement natural spawning, including major hatcheries on the Stamp, Conuma, and Nitinat rivers (Table A2). Approximately 15–20% of the Chinook in the WCVI SMU are estimated to be natural-origin.

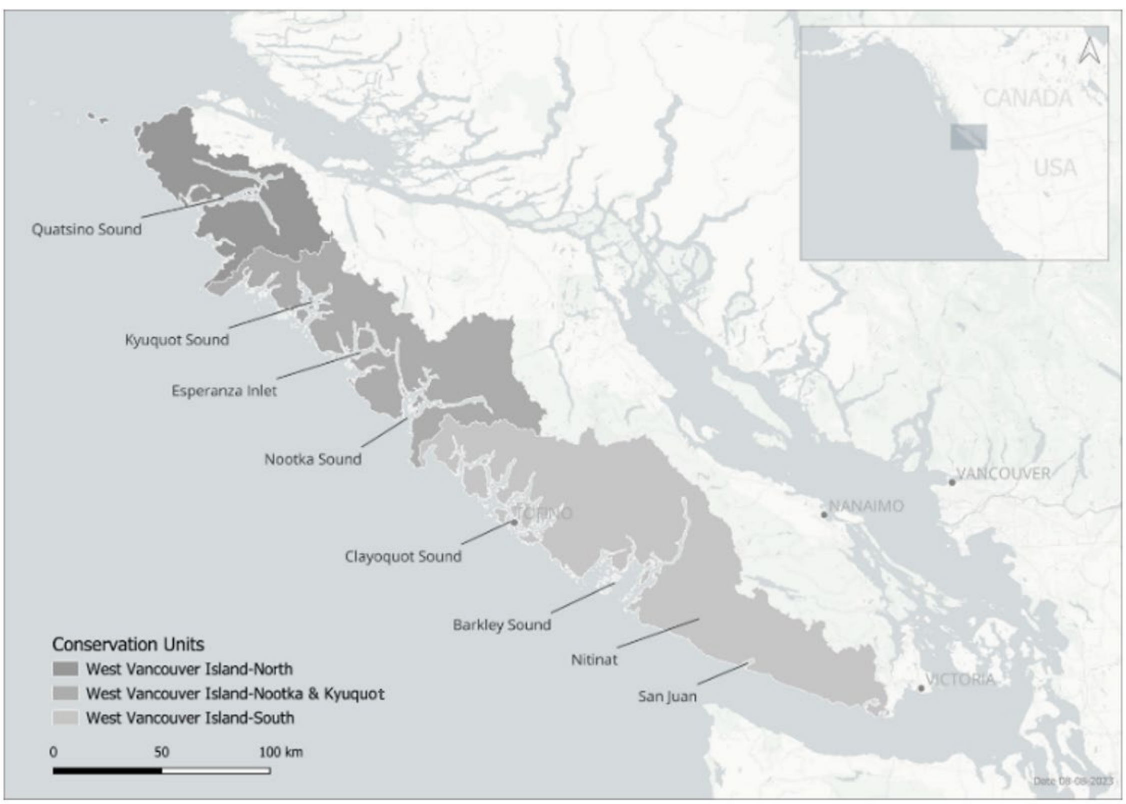

Figure 1. The WCVI Stock Management Unit (SMU) consists of 3 Wild Salmon Policy Conservation Units (CUs) with about 78 rivers, as well as their associated nearshore marine environment, consistently supporting Chinook populations. Adapted from Holt et al. (2022b).

For implementation of the Pacific Salmon Treaty (PST), the SMU is managed and assessed as an aggregate unit. However, 'pre-terminal' Canadian fisheries (i.e. offshore from the WCVI surfline) that are included in PST-defined Aggregate Abundance Based Management (AABM) fisheries are managed domestically to a 10% exploitation rate limit in recognition of low status of WCVI natural-origin Chinook, especially in Clayoquot Sound. Geographically discrete 'terminal' areas, with unique harvest, hatchery, and habitat factors, are managed separately based on the statuses of local natural-origin populations and prevalence of hatchery Chinook (Table A3). Therefore, fishery reference points or operational control points are required for the stock aggregate as well as for terminal areas and, in many cases, specific rivers.

Table 1. Stock structure reference table for the West Coast of Vancouver Island Chinook Stock Management Unit showing CU and DU names or indices and the results of recent status assessments.

Stock Management Unit (SMU)	Conservation Unit (CU) and [index]	Designatable Unit (DU) and [number]	WSP Integrated Status (2016)	COSEWIC designation (2020)	WSP Rapid Status (2023)
WCVI CHINOOK SALMON	West Vancouver Island-Nootka & Kyuquot_FA_0.x [CK-32]	West Vancouver Island-Nootka and Kyuquot, Ocean, Fall [DU 25]	Red	Threatened	Amber
WCVI CHINOOK SALMON	West Vancouver Island-North_FA_0.x [CK-33]	West Vancouver Island-North, Ocean, Fall [DU 26]	Data Deficient	Data Deficient	Green
WCVI CHINOOK SALMON	West Vancouver Island-South_FA_0.x [CK-31]	West Vancouver Island-South, Ocean, Fall [DU 24]	Red	Threatened	Red
WCVI CHINOOK SALMON	Hatchery Stocks [not a CU]	N/A	N/A	N/A	N/A

Assessment Framework

Stock assessments for WCVI Chinook yield data on spawner abundances, fishery catches, and biological characteristics, historically focusing on adult fish but with recent program expansions to cover juvenile life stages. The current assessment framework considers Robertson Creek Hatchery (RCH) Chinook as an indicator of marine survival and exploitation rates for all Chinook in the SMU and considers selected rivers as indicators of natural spawner abundance. Recent assessments have focused on 17 indicator rivers (listed in the following section) with the most consistent and reliable time series of spawner estimates. These 17 indicator rivers constitute approximately 54% of the total Chinook spawning habitat in the SMU (excluding the major hatchery systems—Somass (Robertson Creek hatchery), Nitinat, and Conuma) based on estimates of accessible watershed area. Unmonitored WCVI Chinook populations are assumed to experience similar trends in survival rates, marine distribution patterns, and spawner abundance. Exploitation rates are also assumed similar, except in terminal fisheries, which directly target hatchery surpluses with high harvest rates. Chinook are sampled in fisheries and in river spawning populations for stock identification marks (*i.e.* tissue samples for genetic stock identification, thermally-marked otoliths, adipose fin clips, and coded wire tags [CWTs] for hatchery and brood identification), and also for demographic characteristics (*e.g.,* age, size, fecundity).

Candidate Reference Points

Candidate reference points presented in Table 2 are based primarily on abundance and assume a low productivity of approximately 2.7 recruits per spawner at low population sizes across the SMU. These reference points are based on 17 escapement indicators representing each geographic region of the SMU: the San Juan, Nahmint, Sarita, Bedwell, Megin, Moyeha, Tranquil, Burman, Gold, Leiner, Tahsis, Zeballos, Artlish, Kaouk, Tahsish, Cayeghle, and Marble systems. These candidate reference points do not adequately consider genetic composition, population demographics, and the distribution of spawners among component populations, all of which should be considered equally as important as abundance when assessing status.

Table 2. Candidate reference points for the West Coast of Vancouver Island Chinook Stock Management Unit (SMU). Lower biological benchmarks for component Conservation Units (CUs) are also provided.

Reference Points	Value	Description	*Additional References*
CU-status based LRP	100% of CUs within SMU have WSP status estimates above red.	CU status-based LRPs considering abundances from user-defined selection of populations (17 indicators).	DFO 2022; Holt et al. 2023a,b
CU lower biological benchmarks	SWVI = 2803 spawners No-Ky = 5060 spawners NWVI = 640 spawners	Summed S_{gen} values estimated from integrated watershed-area model using 17 user-defined indicators. No secondary criteria.	Holt et al. 2023a,b
Fishery reference point – Lower	Total S_{gen} = 8503 spawners (sum of CU lower biological benchmarks, above)	See row above	See row above
Upper Stock Reference (USR)	85% S_{MSY} = 16204 spawners	Summation of population S_{MSY} values based on low productivity assumption and does not consider variation in productivities among CUs.	DFO 2016
Target Reference Point (TRP) – example	43900 spawners	Projection-based reference points, associated with 50% probability of all inlets being above lower benchmarks	Holt et al. 2023a,b
Removal Reference (RR)	43% (IQR: 30–54%)	U_{MSY}, based on low productivity assumption. Interquartile range	

Reference Points	Value	Description	*Additional References*
		(IQR) provided to emphasize uncertainty in the estimate.	

Other Reference Points

The development of other stock reference points at appropriate geographic scales is recommended. To inform Rebuilding Targets, reference points should relate to genetic composition, population demographics, and to the distribution of spawners among component populations.

Habitat or ecosystem indicators and reference points that relate directly to salmon productivity and/or natural mortality have not been developed for WCVI Chinook. For *Wild Salmon Policy* (WSP) implementation, indicators and references related to freshwater habitat pressures were developed and assessed (Stalberg et al. 2009).

Stock and Fishery Management

Harvest Decision Rules

WCVI Chinook are harvested in Canadian and USA mixed-stock fisheries and also in terminal fisheries along the WCVI (where most harvest targets WCVI hatchery Chinook stocks).

Harvest limits and USA–Canada allocations are subject to provisions of Chapter 3 of the *Pacific Salmon Treaty*:

- Mixed-stock AABM fisheries are managed with a variable harvest rate strategy. There are 3 AABM fisheries: Southeast Alaska (SEAK), Northern BC (NBC), and West Coast Vancouver Island (WCVI).
- Individual Stock-Based Management (ISBM) fisheries are adaptively managed to achieve national reductions on stock specific exploitation rates, which are specified in the Chinook Chapter.

Within Canada, additional exploitation rate limits on low status SMUs may be implemented through the Integrated Fishery Management Plan (DFO 2024b), requiring secondary management measures, such as time–area closures, gear limits, etc. Canadian AABM fisheries are thereby limited to a 10% annual exploitation rate on WCVI Chinook, regardless of their total allowable catches (TACs). Within this 10% limit, the Northern BC commercial troll fishery has an annual limit of 3.2% of the annual WCVI Chinook abundance.

In addition, given variation in status among component populations within the SMU and different levels of hatchery contribution, unique harvest control rules are in place for geographically discrete ‘terminal’ areas on the WCVI. Terminal area fishery management considers local conservation objectives as well as First Nation rights and treaty provisions in stipulating harvest control measures. The goal of these measures is to reduce impacts on natural stocks while allowing directed harvest on surplus hatchery fish (Table A3). Local TACs are developed to meet spawner or egg targets for actively managed populations.

Stock Enhancement Plan

Chinook hatchery enhancement in the WCVI SMU has bolstered abundance beyond natural production capacity, particularly given the degraded habitats of many watersheds. However, enhancement has also introduced trade-offs such as reduced genetic diversity in natural populations that receive hatchery strays. DFO’s Salmonid Enhancement Program determines its hatchery production targets through an annual Integrated Production Planning process, which considers: DFO's priorities and mandate, First Nations' priorities, fisher's priorities, and WSP goals for fish health and hatchery-wild interactions. Each hatchery program is guided by specific production objectives: harvest, conservation, rebuilding, assessment, stewardship, and education. These objectives, which include DFO, First Nation, fisher, and other user group priorities, are detailed in Enhancement Plans. Enhancement Plans are forward-looking documents that reflect the aim of adaptively managing hatchery programs through an integrated approach. They also describe context, evaluation methods, production phases and triggers, uncertainties, and prescribe risk mitigation strategies, as applicable. Enhancement Plans are intended to be developed for all enhanced WCVI Chinook systems. Active Enhancement Plans are currently in place for Sarita, Burman, Sooke, and Nahmint Chinook programs. For hatchery-enhanced WCVI systems, the most frequent enhancement objectives are either harvest or rebuilding (Table A2).

Habitat Restoration and Protection Plan

Salmon habitat restoration projects have been implemented to protect, restore, and improve salmon habitat at the local stream and watershed level. DFO habitat restoration biologists, engineers, technicians, and community advisors work with partners to develop, implement, and monitor restoration projects. Several First Nations along the WCVI are also developing and leading Chinook-focused restoration projects within their territories. Restoration activities include supporting rehabilitation of key watershed processes to allow the watershed to naturally restore over time, water use management, and specific projects such as building and reconnecting river side-channels, removing physical barriers to fish migration, and restoring vegetation. Various habitat restoration activities are underway in watersheds and estuaries along the WCVI.

ASSESSMENT

Historical and Recent Stock Trajectory and Trends

Catch

Catch data from ocean fisheries are derived from the exploitation rate in ocean fisheries for the Robertson Creek Hatchery CWT indicator applied to the terminal run reconstruction. The annual ocean fishery catch in Canada and the USA over the recent decade is approximately 100 000 WCVI Chinook (Figure 2a). Approximately 50% is taken in Canadian ocean fisheries. In addition to ocean catch, annual catch in terminal WCVI fisheries since 2015 has averaged 95 000 Chinook, mostly in the approaches to Robertson Creek Hatchery and to Conuma River hatchery. All WCVI Chinook populations are assumed to be similarly vulnerable to ocean fisheries but major WCVI hatchery populations predominate the catch in terminal area fisheries.

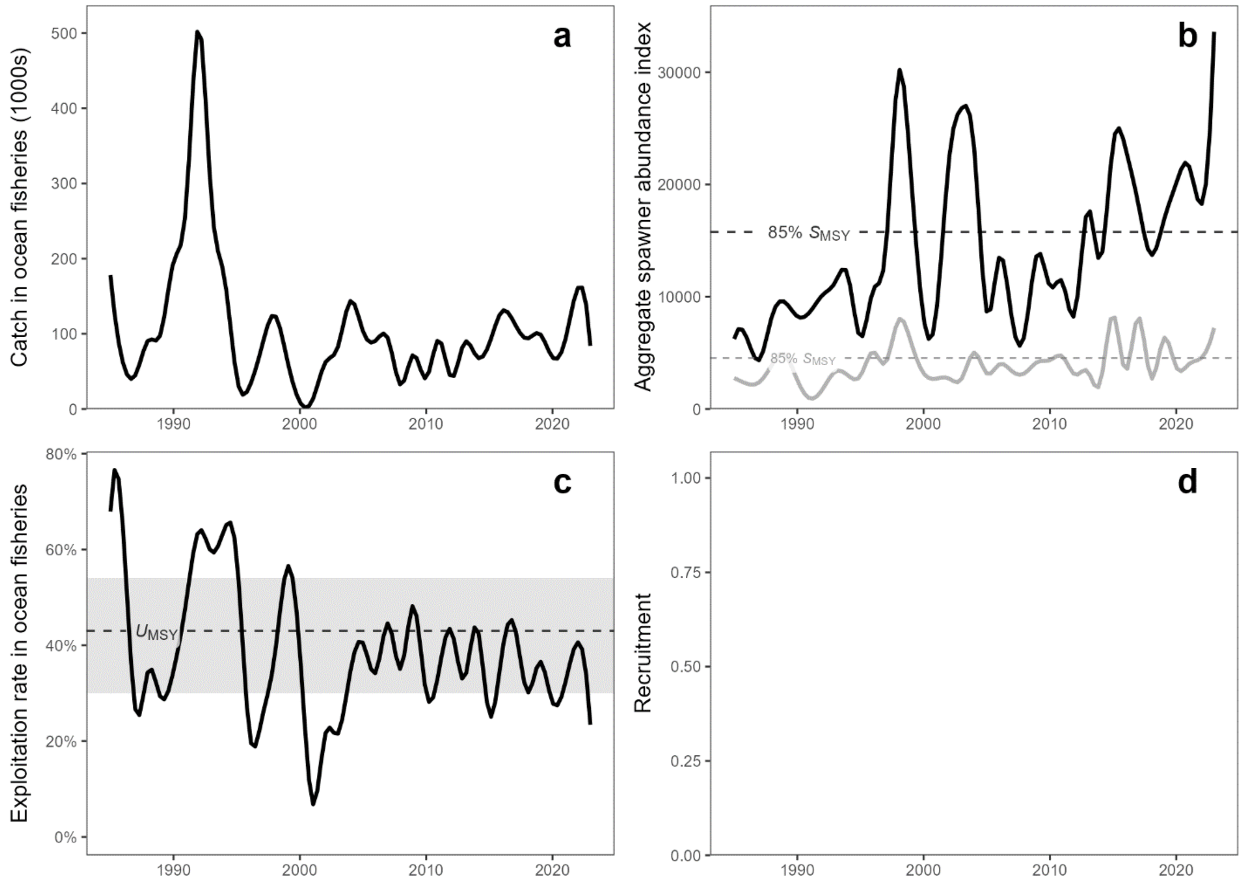

Figure 2. a) Estimated catches of WCVI Chinook in ocean fisheries (including natural and hatchery fish). b) Estimated spawner abundances returning to 17 escapement indicator streams (black line) and to 7 "core" natural-origin escapement indicator streams (grey line) in the SMU. c) Estimated exploitation rate of WCVI Chinook in ocean fisheries, based on Robertson Creek Hatchery Chinook coded-wire tag recoveries. The shaded area shows the interquartile range or 50% confidence interval around U_{MSY}. d) Recruitment—left blank because data are insufficient to estimate natural-origin recruitment in the SMU and hatchery-origin recruitment is not assumed to be representative due to considerable differences in their life histories.

Spawner Abundance

Abundances of Chinook returning to 17 indicator rivers on the WCVI have increased since the 1980's (black line, Figure 2b). However, some of these rivers are supplemented directly with conservation-focused hatchery enhancement while others receive considerable influxes of hatchery-origin strays. A lack of stock composition samples from natural rivers in the historical data makes it very difficult to determine a trend of natural-origin spawners in these 17 indicator populations.

To partially address the uncertainty around natural-origin Chinook abundances in the 17 indicators, the scope of assessment can be narrowed to include only 7 "core" indicators (grey line, Figure 2b), which are assumed to be comprised of mostly natural-origin spawners but represent less than 2% of the Chinook-accessible watershed area within the SMU. These 7 core populations are the most likely to accurately reflect the trend in natural Chinook abundance within the SMU. Three of these core populations are in Clayoquot Sound (SWVI CU) and have persisted below their aggregate S_{gen} since the mid-1990s. Another three of the core populations are in Kyuquot Sound (No-Ky CU); these populations have recently moved above their aggregate S_{gen} and have seen increasing abundances over the last decade, reflecting the general trend shown in Figure 2b. The final of the core populations, Cayeghle Creek, is in the NWVI CU and has consistently exceeded its S_{gen} for over a decade.

Exploitation rate

Pre-terminal annual fishing mortality, which includes southeast Alaska, North and Central BC, and offshore WCVI mixed-stock fisheries, has averaged 35% since 2004 (Figure 2c). Fishing mortality is estimated from CWT recoveries of the Robertson Creek Hatchery indicator stock and includes all age classes and all gear and sector impacts, as well as release mortalities. Age-specific fishing mortalities vary; mortality on older age classes is higher as they recruit to fisheries over multiple years and also may be vulnerable to size-selective gear and/or 'high-grading' of catch. Approximately half of pre-terminal WCVI Chinook catch occurs in Alaskan fisheries.

Recruitment

Brood year specific recruitment has not been estimated for natural-origin Chinook in this SMU. Careful consideration of assumptions about age structure and hatchery contributions are required; further work on this is recommended.

Total stock aggregate production

The catch year total abundance, derived as total catch plus escapement, has an average annual value in the order of 300 000 WCVI Chinook (predominately hatchery-origin) over the most recent decade (Figure 3).

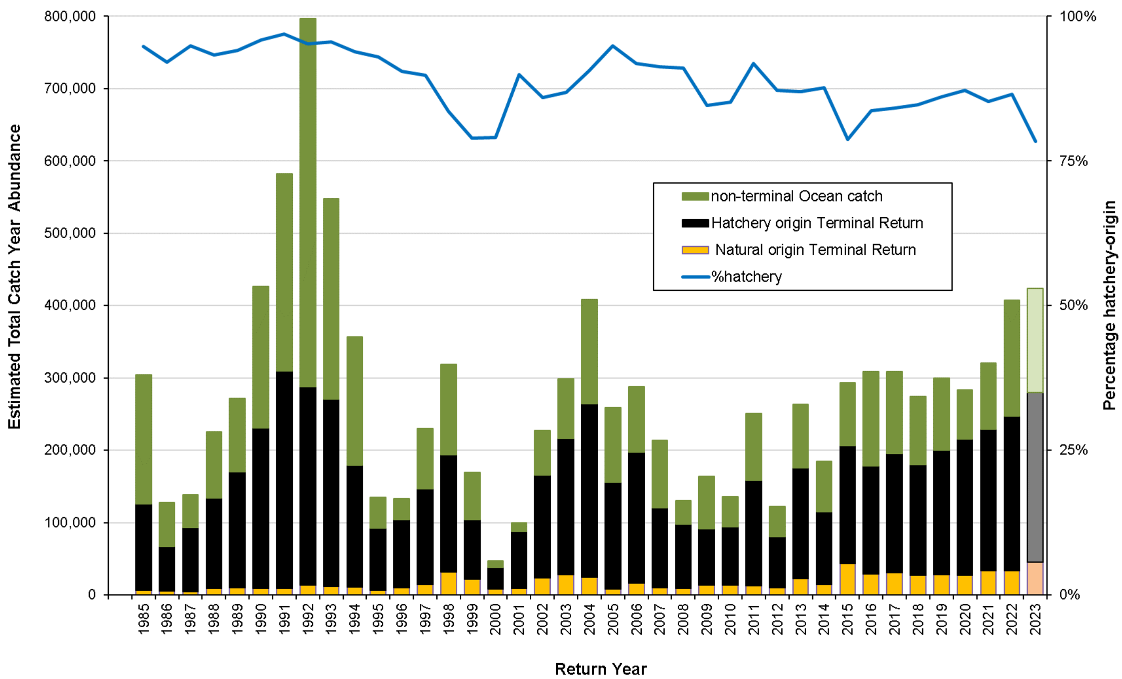

Figure 3. Annual estimates of adult total catch year abundance of WCVI Chinook salmon. Bar segments indicate the proportion of each estimate in ocean fisheries, hatchery-origin terminal return, and natural-origin terminal return. The blue line, with reference to the secondary y-axis, shows the estimated percent hatchery-origin for each year's return (~85% on average). Data for 2023 are preliminary.

Marine Survival Rate

Marine survival (smolt-to-adult) of hatchery Chinook has averaged 1.5% since the 2012 ocean entry year (Figure 4), which corresponds to return years 2015–2023 in Figure 2. As with exploitation rate, survival rate is also estimated from CWT releases and recoveries of the Robertson Creek Hatchery Indicator Stock. Additional work based on run reconstruction data and otolith-thermal-mark-based estimates of natural-origin spawners in the Stamp River produced estimated smolt-to-adult survival rates for natural-origin fish. These data are shown as the dashed line in Figure 4 and suggest survival of natural-origin Chinook is considerably lower than that of hatchery-origin Chinook in the Stamp River.

In addition, LaForge et al. (in press) reviewed data collected from Sarita River Chinook, including the use of otolith microchemistry to assess the survival of out-migrants to adult returns. This analysis reported that over the period 2018–2023 the average smolt-to-adult survival of natural-origin fish was approximately 0.1% compared to 0.6% smolt-to-adult survival of hatchery-origin fish. The natural-origin smolts thus appear to be surviving at a much lower rate than local hatchery-origin smolts.

These low estimated marine survival rates of natural-origin Chinook have important implications for understanding factors limiting natural productivity in the SMU, which informed several key outcomes from the marine risk assessment process (Irvine et al. 2024).

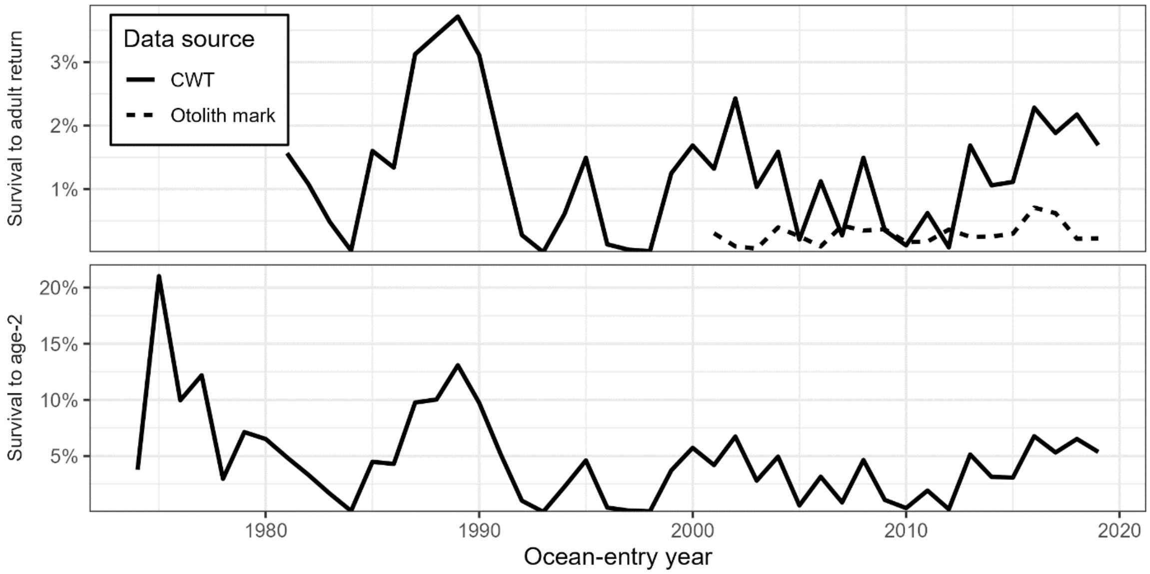

Figure 4. Estimates of Stamp River Chinook smolt survival across two time periods and using two methods. Survival to age-2 is estimated by cohort analysis of Robertson Creek Hatchery CWTs (CTC 2023). Survival to adult return is estimated by reconstructing the terminal return of Robertson Creek Hatchery CWTs, as well as by reconstructing natural spawner abundances from an extensive annual otolith thermal mark sampling program that is conducted in the system. The two lines in the top panel can therefore be considered as distinct survival estimates for hatchery- (solid line) and natural-origin (dashed line) Chinook.

History of Management

History of Hatchery Production

Hatchery production was initiated in the early-1970’s to address low spawner abundances and to restore and maintain harvest opportunities along the WCVI. By the mid-1980’s, 3 major facilities and numerous smaller hatcheries were operating. Current annual hatchery production totals approximately 15 million Chinook smolts (Figure 5), which are released into 20 WCVI rivers (Table A2). Of these releases, about 14 million (90%) are produced by three DFO Major Operations hatcheries and released into the Nitinat, Stamp, Conuma, Hucuktlis, Nahmint, Sarita, Burman, Gold, Sucwoa, and Tlupana watersheds (Table A2). The remaining 1.5 million (10%) are released from either Community Economic Development Program or Public Involvement Program facilities into the Sooke, San Juan, Bedwell, Cypre, Leiner, Tahsis, Zeballos, Marble, Thornton, and Tranquil watersheds (Table A2).

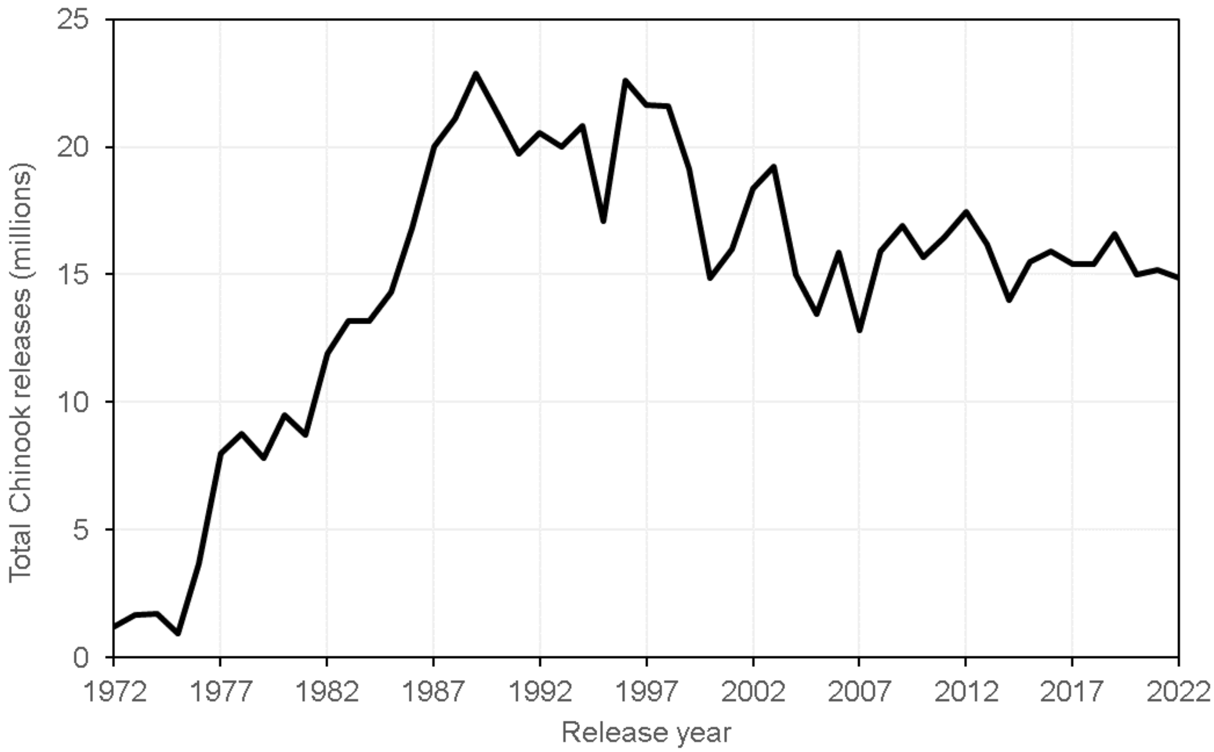

Figure 5. Time series of Chinook smolts released from all WCVI hatcheries.

Hatchery supplementation significantly increased the aggregate abundance of WCVI Chinook. This large hatchery abundance has created significant fishery benefits, but also has had negative consequences. Over time within the WCVI Chinook SMU, there has been a loss of regional genetic diversity across naturally-spawning WCVI populations through hatchery straying into non-natal WCVI rivers. Accordingly, genetic management has been a priority in hatchery operational planning, which continues to incorporate new science and best practices. Genetic management measures have expanded in recent years through the Salmonid Enhancement Program's incorporation of recommendations from the HSRG (2014) and Withler et al.'s (2018) enhanced contribution guidance for Canadian Chinook populations. The Sarita River Chinook enhancement program is a good example as it is managed towards meeting and maintaining specific targets, specifically using the Proportionate Natural Influence (PNI) metric. Table A1 summarizes estimates of PNI for WCVI index systems.

History of Fisheries

WCVI Chinook are harvested in fisheries from Alaska south to the WCVI area. Northern area fisheries harvest WCVI Chinook as both immature fish rearing and feeding in the area and as mature adults during their return migration to their natal stream. Southern fisheries harvest only mature Chinook migrating to their natal stream for spawning. The far northerly distribution of WCVI Chinook limits Canada's ability to unilaterally reduce fishing mortality since a large portion of the catch occurs in Alaska and is subject to terms of the PST.

Chinook fisheries are not selective (*i.e.*, both natural- and hatchery-origin fish are equally vulnerable and harvested at the same rate). Therefore, increased hatchery production (from all hatchery releases, *i.e*. including both USA and Canadian) over the last four decades that was implemented to support larger fisheries has resulted in increased fishing pressure, higher exploitation rates, and thereby higher mortality on natural-origin fish.

Currently, most natural-origin WCVI Chinook are harvested in the AABM fishing areas north of Vancouver Island, including the SEAK fisheries and commercial and recreational fisheries in NBC. Canadian fisheries in southern areas were reduced or adjusted to limit impacts on natural-origin WCVI Chinook as well as other SMUs of concern, with the goal to promote rebuilding. The current level of total fishing mortality is below the best estimate of the RR in most recent years (Figure 2c); however, spawning biomasses have fluctuated above and below the USR over this same time period (Figure 6). The indicator populations in the two northern CUs appeared to respond positively with increasing abundances, while the indicator populations in Clayoquot Sound have not increased and persist at low levels below their S_{gen} values.

The large returns of hatchery-origin WCVI Chinook in the 1980’s and early 1990’s resulted in rapid growth of First Nation, recreational, and commercial fisheries along the WCVI. During this period, local stocks comprised ≥ 90% of the catch. The abundance of hatchery returns resulted in the development of hatchery-directed terminal fisheries in Tlupana Inlet, Alberni Inlet, and the Nitinat Lake area. The combined annual catch of these fisheries averaged 80 000 from 2015–2022.

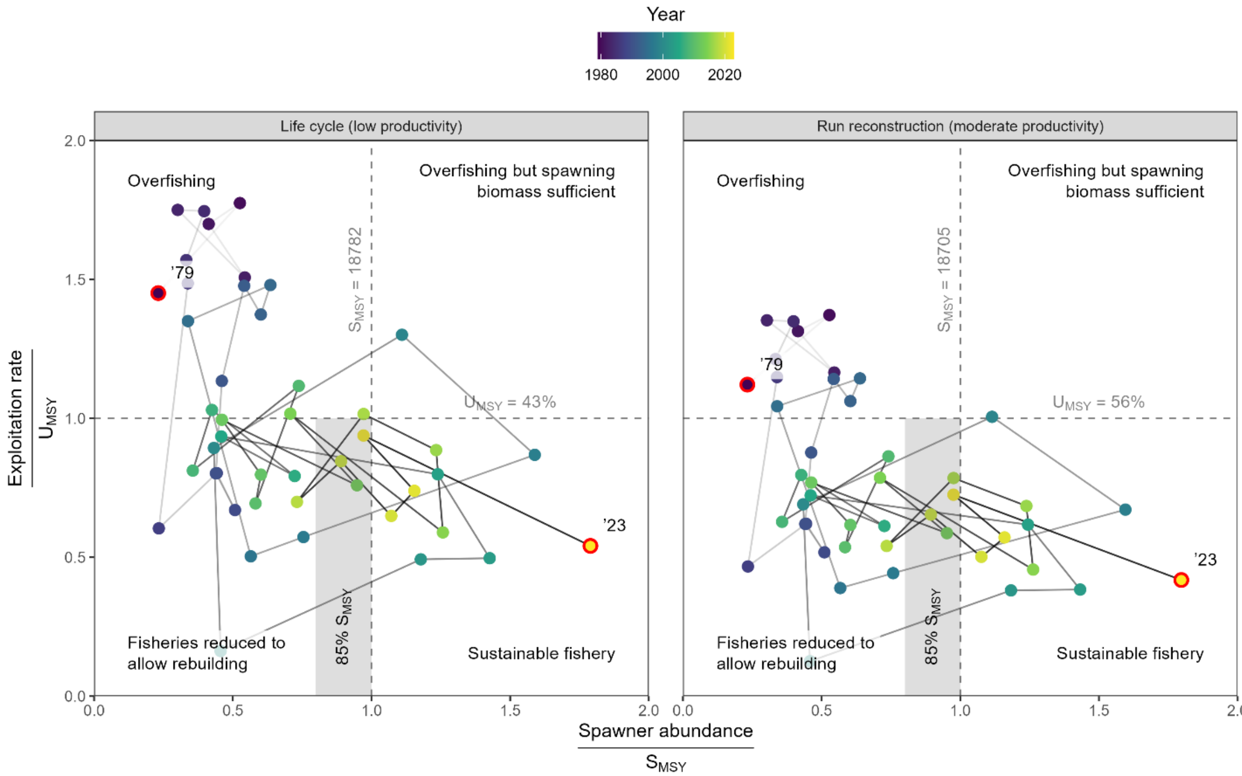

Figure 6. Kobe plots of WCVI Chinook exploitation and spawning escapement, under low and moderate productivity assumptions. The numerator data are the same in both panels—"spawner abundance" is the sum of escapements to the 17 escapement indicators, and "exploitation rate" is the estimated ocean exploitation rate on Robertson Creek Hatchery Chinook. S_{MSY} and U_{MSY} are based on different assumptions in each panel. Under the life cycle model (left panel), U_{MSY} and S_{MSY} assume constant productivity across the SMU. Under the run reconstruction model (right panel), U_{MSY} and S_{MSY} stem from an equilibrium trade-off analysis assuming CU-specific productivity values. The shaded line connects points from adjacent years; the line darkens as years progress toward 2023, the most recent year. The first and last years in the time series (1979 and 2023, respectively) are labelled for clarity. The shaded grey area shows years when spawner abundances exceeded the USR with harvest rates below U_{MSY}.

History of Habitat Impacts

Although the WCVI area is remote and generally not urbanized, there is a long history of forestry and mining negatively impacting freshwater salmon habitat. Highest ranked habitat pressures for Chinook include forest disturbance and clear-cut areas, riparian disturbance, and total land cover alteration (Irvine et al. 2024).

Specific factors that likely contributed to declines and ongoing low abundances of natural-origin WCVI Chinook include: loss and degradation of freshwater and estuarine habitat leading to unfavourable discharge, temperature, and trophic conditions that result in higher rates of pre-spawn, egg, and juvenile mortality and lower rates of growth; reduced fitness from hatchery introgression; competition with hatchery fish and other species; increased levels of predation; exposure to pathogens, parasites and contaminants; and effects of past and current fishing mortality. One of the highest freshwater risk factors across the SMU was the increasing magnitude and frequency of high winter discharge causing riverbed scour and sedimentation with resulting mortality of eggs during the incubation phase. The other highest risk was the lack of rearing potential (habitat quantity, quality, and food availability) resulting in early outmigration of small smolts. These small-early migrants were hypothesized to be more vulnerable to poorer nearshore marine ecosystem conditions. This was termed a 'carry-over' effect from the freshwater life cycle phase to the early marine phase.

WCVI coastal rainforests have historically been characterized as ecologically complex 'old-growth' forest systems. However, extensive logging in many WCVI watersheds has greatly reduced the extent of old-growth forests and thereby reduced the complexity and hydrological stability of Chinook spawning and freshwater rearing habitat. Recovery and restoration of watershed hydrological processes and ecosystem function is a long-term prospect but is necessary for natural populations in the SMU to persist into the future.

Ecosystem and Climate Change Considerations

Climate change effects are apparent for all life stages of WCVI Chinook. Recent freshwater and marine risk assessments found that future risk ratings tended to be higher than current, as expected with climate change and increasing anthropogenic activity. Freshwater climate-change effects included increased water temperatures, more extreme hydrological patterns, and extended periods of drought, all of which negatively affect salmon habitat quality. In the marine environment, the frequency of marine heat waves has increased in the last decade, which is causing a range of biological impacts from reduced chlorophyll to shifts in the copepod community, each affecting Chinook salmon via the food chain.

WCVI natural spawning Chinook are affected by the cumulative effects of large-scale changes in ocean conditions, impacts related to fishing mortality, hatchery supplementation, freshwater and estuarine habitat loss, high mortality rates during the early marine life stage, and food limitation and predation in subsequent life stages.

The period of highest marine mortality is likely the early marine life stage in the nearshore waters along the WCVI. There is evidence that young-of-year WCVI Chinook remain in their natal sound for several months, resulting in high exposure to local pressures. Risk is dependent on the exposure and biological impact (mortality) expected from a specific factor. A prolonged exposure period suggests high risk from even modest risk factors. The highest ranked risks during this early marine period were pathogens and parasites, water quality, lack of food, lack of complex habitat, and predation. Our understanding of mortality during the 2–5 years when most WCVI Chinook live in the Gulf of Alaska is limited, although concerns about possible impacts of competition on growth, including by hatchery and wild Pink and Chum salmon, is a concern and was raised as a key knowledge gap.

OTHER MANAGEMENT QUESTIONS

Identification of Reference Points

DFO's Precautionary Approach framework states that "the LRP is based on biological criteria and established by Science through a peer reviewed process" (DFO 2009). The USR, TRP and RR are determined by Resource Management and are science-informed but can include biological, as well as management and socioeconomic considerations (DFO 2009). The best available scientific data and knowledge were assimilated to propose candidate reference points for consideration in future management and decision-making.

Limit reference

DFO (2022) recommended using CU-status LRPs to inform SMU status under the Fish Stocks provisions. Abundance-based reference points were also estimated from the summation of population-level lower benchmarks. In application to the WCVI SMU, any LRP or status assessment based only on abundance will be sensitive to the choice of natural indicators and will not account for variability in productivity among component populations, highlighting the importance of considering a range of spatial scales. Distributional, genetic, and even demographic references should be incorporated as secondary references.

Upper stock reference

A candidate upper stock reference was identified at 85% of S_{MSY} based on the summation of population level S_{MSY} values. This approach does not account for variability in productivity among component CUs, and further consideration of alternative approaches to estimating USRs that consider distribution of productivity is recommended.

Target reference

A candidate Target Reference Point associated with an objective of at least a 50% probability of all inlets being above lower WSP status benchmarks is provided, although other targets that consider social, economic, and cultural objectives could be developed.

Removal reference

Maximum removal references were estimated in two ways, based on equilibrium trade-off analyses accounting for differences in productivity among CUs derived from CU-specific run reconstructions and based on productivity estimates derived from a WCVI Chinook life-cycle model assuming constant (low) productivity among CUs. These methods yielded estimates of SMU-level U_{MSY}, but with high uncertainty. Note that U_{MSY} does not account for demographic effects of size- or age-selective harvest.

Assessment of Stock Status

Stock status was assessed from several perspectives. Abundance and trends in abundance for natural indicator populations were considered for each CU in a Rapid Status Algorithm (DFO 2024a, Figure 7), as were the statuses of genetic diversity and hatchery introgression across the SMU and observed shifts in population demographic diversity. The application of the rapid status algorithm is provided here (see Appendix D in Brown et al. in prep[1] for details).

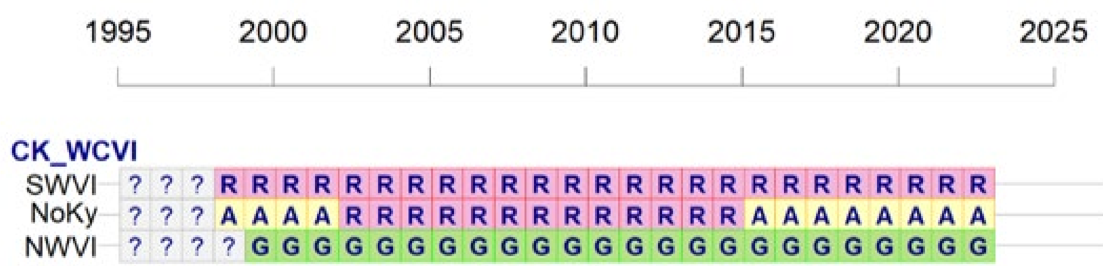

Figure 7. Retrospective status assessments of CUs based on a provisional application of the Rapid Status Algorithm for WSP assessments.

[1] Brown, N., Holt, C., Irvine, J.R., Luedke, W., McHugh, D., Thom, M. In prep. West Coast of Vancouver Island Natural-Origin Chinook Salmon (*Oncorhynchus tshawytscha*) Stock Assessment. Can. Sci. Advis. Sec. Res. Doc.

Life Cycle Assessment and Probable Causes of Decline

Assessment of WCVI Chinook incorporated a life cycle approach to investigate population dynamics, and as a structured means of assessing risks to salmon and the potential benefits of rebuilding at specific life stages (Irvine et al. 2024; Table 3).

Table 3. Summary of highest ranked limiting factors affecting natural-origin WCVI Chinook survival during major life stages as determined through freshwater and marine risk assessment workshops. These limiting factors are provided in addition to principal issues pertaining to hatcheries and harvest that have been discussed in earlier sections.

Life Stage	Limiting Factors and Mechanisms (Interactions with Climate Possible at all Stages)
Adult upstream migration	Climate change leading to low and variable river discharge. Habitat degradation altering channel morphology, limiting or delaying access to spawning grounds.
Adult spawning	Climate change and habitat degradation increase the frequency and intensity of peak flow events, destabilizing spawning gravel and increasing bedload movement, scour, and sedimentation. Reduced spawning success due to unstable conditions for egg incubation. Changing demographics: smaller females dig shallower redds and produce fewer eggs. Genetic input from hatchery fish (particularly stray hatchery fish) reduces genetic and demographic diversity, impacting the fitness of future generations.
Egg incubation and fry emergence	Climate change and habitat degradation exacerbate the frequency and magnitude of peak flow events, disrupting sediment regimes (e.g., surplus sediment, changes in composition, bedload movement). Egg displacement and disruption of fry emergence due to altered sedimentation and scour.
In-river rearing	Degradation of freshwater habitats reduces habitat complexity, variety, and connectivity. Limited rearing space, reduced fish growth, and lower survival rates. Increased reliance on estuarine habitats for rearing.
Estuarine rearing and first marine winter	Carry-over effects from freshwater stages (e.g., smolt size and readiness) impact survival in estuarine and marine environments. Phenological mismatches between prey availability and smolt migration timing. Changes in river discharge patterns increase sediment deposition, reducing habitat complexity. Habitat degradation in the estuary (e.g., loss of salt marsh and eelgrass). Competition with larger hatchery smolts and juveniles for prey. Predation by birds, fish, and seals. Exposure to pathogens, parasites (e.g. sea lice), and toxic contaminants.
Later marine Residence (1–5 years)	Interspecific competition with hatchery salmon and other salmon species for limited prey.

Life Stage	Limiting Factors and Mechanisms (Interactions with Climate Possible at all Stages)
	Demographic declines in size-at-age and age-at-maturity driven by size-selective natural and fishery mortality.
Return migration to WCVI natal rivers	Habitat degradation and climate change can alter holding habitat and behaviour by delaying access to rivers, which increases Chinook vulnerability to predation, primarily by marine mammals such as seals and sea lions that exploit Chinook at key geographical bottlenecks like river mouths.

Rebuilding and Mitigation Strategies

The WCVI SMU extends over a large geographic area with considerable variation in population trends, habitat pressures, anthropogenic activities, and available data. While natural populations in some areas appear to be self-sustaining and rebuilding, other populations remain depressed. Rebuilding will thus require a nuanced approach that is tailored to address regional priorities and local knowledge of limiting factors. Provided here are general strategies and recommendations based on the understanding of limiting factors and key risks that were identified for natural-origin WCVI Chinook across life stages and ecosystems. These broad recommendations will need to be refined through engagement and collaboration with First Nations, local communities, and stakeholders for their eventual application at smaller spatial scales. First Nation leadership will be key to development and implementation of habitat-related mitigation measures in particular. Ongoing review and reassessment of rebuilding objectives is recommended as mitigation measures are implemented.

Hatchery Strategies and Options

- As part of hatchery reform, identify and implement PNI management targets and measures for enhanced WCVI Chinook populations, including greater implementation of other genetic management measures more broadly (e.g. cessation of out-of-CU transplants, genetic screening of broodstock, dedicated stray removal programs, and improvements to hatchery production imprinting).
- Expand Chinook mass marking to the Robertson Creek Hatchery (Stamp River) and Nitinat River Hatchery production populations, while maintaining it at Conuma Hatchery, to facilitate stray management and assessment. Additionally, extend mass marking to community facilities and other federal hatchery programs, prioritizing populations where mass marking is critical for supporting PNI designation goals, where the capacity to effectively use mass marking as a tool exists (e.g. via mark-selective broodstock and/or in-river stray removals programs). Moreover, where appropriate, extend mass marking programs to facilitate mark-selective fisheries, as identified by Fisheries Management and associated consultation processes, that would be expected to result in net benefits (increases in natural-origin Chinook escapement abundances) to WCVI natural-origin Chinook populations.
- Manage hatchery program size to a level that best meets stated objectives while managing and mitigating risks (e.g. minimize surplus production to program requirements), as identified by enhancement plans. Additionally, prioritize addressing straying issues at the source population (e.g. through production reductions) rather than solely at the recipient population level.
- Enhance hatchery science, research, and experimentation (e.g. the development of updated hatchery spawning guidelines that promote natural selection processes), with ongoing integration of the latest best scientific advice and practices where applicable and supported.

- WCVI Chinook populations with persistent low abundances face an increasing risk of genetic diversity loss and depensatory pressures (e.g. predation), heightening their vulnerability to extinction. To mitigate these risks, hatchery programs with appropriate genetic management measures should be considered as possible critical, strategic conservation tools for these endangered populations. However, hatchery enhancement alone is unlikely to support long-term rebuilding of depressed populations until factors limiting productivity are also addressed.

Harvest Strategies and Options

- Reduce fishery related mortality of large natural-origin Chinook that are over-represented by large and old females to improve egg deposition rates and mitigate artificial selection for small body sizes and earlier maturation.
- Leverage existing or expanded mass marking programs, consider and evaluate the use of appropriate mark-selective fisheries to reduce direct harvest mortality on unmarked, natural-origin Chinook, in concert with appropriate consultation, comprehensive baseline data, and fishery monitoring.
- Account for unreported catch, including bycatch in trawl and other non-salmon fisheries.
- Expand the reporting area of CWT catch by stock to fisheries outside the current PST area, most notably western Alaska. Determine stock compositions using genetics from samples of Chinook salmon from multiple locations other than WCVI.

Predation Strategies and Options

- Gather information on pinniped population sizes across the WCVI and use this information to identify areas where small, vulnerable Chinook populations are likely exposed to high predation pressure.
- Following the guidance set forth by the Washington State Academy of Science (WSAS 2022), consider implementing localized pinniped deterrence and removal programs, focusing on seals and sea lions in areas where they pose the highest predation risk to vulnerable Chinook populations. Engage with First Nations to incorporate indigenous knowledge regarding predation management, recognizing historical practices and insights. Ultimately, experimental approaches must change pinniped populations at spatial and temporal scales that can meaningfully impact the ecosystem.
- Monitor and evaluate interventions: establish robust monitoring programs to assess the effectiveness of predator deterrence and removal measures and their impacts on Chinook population recovery. Other approaches (e.g. modelling) to studying this ecosystem dynamic are not expected to yield fundamentally new insights (WSAS 2022).

Freshwater Habitat and Ecosystem Strategies and Options

- Use risk assessment results, life cycle assessments, and other sources of data and knowledge to identify important habitats for salmon. Incorporate these into local planning processes such as land use, water use, etc. and protect as much spawning habitat as possible from sources of human disturbance.
- Use the same information and tools as above to develop watershed restoration strategies and plans that protect and restore Chinook habitat on WCVI.
- Implement habitat protection measures to preserve existing high value salmon habitats from threats such as logging, mining, urban development, or other anthropogenic disturbances.

- Develop and implement a prioritized list of short-term freshwater habitat restoration projects that address high risk limiting factors that will provide immediate benefit to WCVI Chinook, in conjunction with longer term process-based restoration programs.
- Engage in multi-jurisdictional processes to ensure salmon habitat is a key consideration during land, water, and resource use planning.

Estuarine and Near-shore Marine Habitat Strategies and Options

- Establish protected areas in estuaries and nearshore habitats that are critical nursery grounds for juvenile WCVI Chinook.
- Restore estuarine and nearshore marine habitat complexity, e.g. work on sedge grass, eel grass, and kelp forest habitats that have been impacted and degraded.
- Consider migration corridors and key habitats for juvenile WCVI Chinook in aquaculture siting and marine use planning processes.
- Adjust aquaculture operations to reduce exposure of local juveniles to parasites and pathogens.

Ocean Ecosystem Strategies and Options

- Retrospectively evaluate potentially useful ocean ecosystem indices relevant to natural-origin WCVI Chinook marine life stages to better understand and ultimately predict interannual patterns of survival and growth for WCVI Chinook.
- Studies evaluating density dependent effects of competition by hatchery-origin and other salmon on WCVI Chinook growth and survival.
- Step up strategies to combat global climate change, which is negatively impacting marine food web productivity.

Improved Collaboration

- Maintain collaboration and integration with local knowledge holders including WCVI First Nations to coordinate and provide strategic guidance in support of WCVI Chinook rebuilding.

SOURCES OF UNCERTAINTY

The most significant source of uncertainty in providing science guidance for the WCVI Chinook SMU is the inability to separate hatchery from natural fish in the historical data. The entanglement of hatchery with natural fish has confounded assessments of fishery catch and total abundance of natural-origin Chinook in the SMU. A second important source of uncertainty is the dearth of historical age data from natural spawner populations. A stock-recruit analysis for the SMU was not conducted due to high uncertainty in population-specific age compositions, and therefore an understanding of stock productivity was entirely based on summary data and expert opinion.

Research Recommendations

1. Incorporate tools to differentiate spawner abundance by hatchery- versus natural-origin.
2. Improve integrated monitoring and assessment of the fish and ecosystem through the life cycle framework.
3. Investigate climate-related interactions in factors limiting WCVI Chinook productivity.

4. Investigate and improve understanding of WCVI Chinook responses to habitat disturbances and land use impacts in WCVI streams.
5. Improve biological sampling of adult returns in natural systems.
6. Identify additional quantitative reference points on population characteristics beyond aggregate abundances (e.g. demographic diversity, distribution of abundance, degree of hatchery influences).
7. Improve collaboration and information gathering and integration of data from outside DFO sources and knowledge holders.
8. Increase hatchery science, research, and experimentation.

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APPENDIX

Table A1. Adapted from Weil et al. (2024). Mean escapement, hatchery contribution and proportionate natural influence (PNI) for recipient rivers in the WCVI region between 1998–2021. Mean proportions of local hatchery-origin spawners ($pHOS_{local}$), strayed hatchery-origin spawners ($pHOS_{stray}$), strayed hatchery-origin spawners originating from outside the CU ($pHOS_{stray,OCU}$), proportionate natural influence (PNI), and PNI from local-only spawners (PNI_{local}) are described for each river. Mean PNI values are colour-coded based on benchmarks from Withler et al. (2018): Integrated Wild (IW) = Green; Integrated-Transition (IT) = Orange; Integrated-Hatchery (IH) = Red. Data are presented by Conservation Unit (CU), and the data type used in the estimate is indicated (CWT = coded-wire tag, TM = [otolith] thermal mark).

CU	Recipient River	Region	Data	ESCAPEMENT	$pHOS_{local}$	$pHOS_{stray}$	$pHOS_{stray,OCU}$	pHOS	PNI_{local}	PNI	Designation
CK-033	Marble R	Quatsino Sound	TM	3028	0.06	0.00	0.00	0.06	0.91	0.91	IW
CK-032	Artlish R	Kyuquot Sound	TM	333	0.00	0.39	0.01	0.39	--	--	–
CK-032	[1]Kaouk River	Kyuquot Sound	TM	429	0.00	0.04	0.00	0.24	--	--	–
CK-032	[1]Kauwinch River	Kyuquot Sound	TM	104	0.00	0.60	0.00	0.60	--	--	–
CK-032	Tahsish River	Kyuquot Sound	TM	648	0.00	0.52	0.00	0.52	--	--	–
CK-032	Conuma R	Nootka Sound	TM	21916	0.96	0.01	0.00	0.97	0.03	0.03	IH
CK-032	Burman R	Nootka Sound	TM	2630	0.63	0.16	0.02	0.79	0.29	0.25	IH
CK-032	Gold R	Nootka Sound	TM	2397	0.17	0.61	0.59	0.78	0.62	0.26	IH

CU	Recipient River	Region	Data	ESCAPEMENT	$pHOS_{local}$	$pHOS_{stray}$	$pHOS_{stray,OCU}$	pHOS	PNI_{local}	PNI	Designation
CK-032	Leiner R	Nootka Sound	TM	691	0.30	0.30	0.01	0.60	0.69	0.47	IH
CK-032	Sucwoa R	Nootka Sound	TM	96	0.01	0.86	0.04	0.87	0.83	0.17	IH
CK-032	Tahsis R	Nootka Sound	TM	739	0.29	0.26	0.01	0.55	0.76	0.58	IT
CK-032	Tlupana R	Nootka Sound	TM	379	0.15	0.79	0.01	0.94	0.45	0.07	IH
CK-032	Zeballos River	Nootka Sound	TM	248	0.50	0.10	0.06	0.60	--	--	–
CK-031	Bedwell R	Clayoquot Sound	TM	222	0.00	0.15	0.09	0.15	1.00	0.85	IW
CK-031	Cypre R	Clayoquot Sound	TM	780	0.00	0.03	0.03	0.03	--	--	–
CK-031	[1]Megin River	Clayoquot Sound	TM	74	0.00	0.58	0.58	0.58	--	--	–
CK-031	[1]Moyeha River	Clayoquot Sound	TM	124	0.00	0.18	0.18	0.18	--	--	–
CK-031	[2]Tranquil Cr	Clayoquot Sound	TM	543	0.00	0.04	0.00	0.04	1.00	1.00	[2]IW
CK-031	Robertson Cr	Barkley Sound	TM	41965	0.91	0.00	0.00	0.91	0.01	0.01	IH

CU	Recipient River	Region	Data	ESCAPEMENT	$pHOS_{local}$	$pHOS_{stray}$	$pHOS_{stray,OCU}$	pHOS	PNI_{local}	PNI	Designation
CK-031	Nahmint R	Barkley Sound	TM	519	0.28	0.11	0.01	0.40	0.61	0.57	IT
CK-031	Sarita R	Barkley Sound	TM	2022	0.77	0.03	0.00	0.80	0.15	0.14	IH
CK-031	Toquaht R	Barkley Sound	TM	290	0.00	0.06	0.06	0.06	1.00	0.95	IW
CK-031	Nitinat R	Nitinat - Sooke	TM	21151	0.89	0.00	0.00	0.89	0.09	0.09	IH
CK-031	San Juan R	Nitinat - Sooke	TM	1831	0.32	0.05	0.03	0.37	0.59	0.58	IT
CK-031	Sooke R	Nitinat - Sooke	TM	770	0.48	0.05	0.00	0.53	0.48	0.48	–

[1]These systems had ≤ 20 samples taken in any year of the analysis.
[2]Tranquil Creek receives releases of up to 65000 smolts in many years (Table A2). Because these hatchery-origin fish have historically not been marked in any way, they have been incorrectly identified as “natural-origin” in the analysis. Accordingly, Tranquil has likely been Integrated-transition throughout the last three decades.

Table A2. Annual release targets of Chinook for WCVI enhancement facilities. "Ad" = adipose fin clipped; "AdCWT" = adipose fin clipped and implanted with a CWT; "Thermal" = thermally-marked otoliths; "PBT" = parentage-based tag (a genetically-based method).

System	Release Objective	Release Strategy	Mark Strategy	Release Target
Bedwell R	Rebuilding	Seapen 0+	AdCWT, PBT	85000
Burman R	Rebuilding	Seapen 0+	Thermal, PBT	200000
Conuma R	Harvest	Fed Fry Seapen 0+	Ad, Thermal, PBT Ad, Thermal, PBT	500000 2200000
Cypre R	Rebuilding	Seapen 0+	PBT	160000
Gold R	Harvest	Smolt 0+	Ad, Thermal, PBT	500000
Goodspeed R	Stewardship	Smolt 0+	PBT	32000
Hucuktlis	Rebuilding	Smolt 0+	AdCWT, Thermal, PBT	100000
Kennedy R	Rebuilding	Smolt 0+	PBT	200000
Leiner R	Rebuilding	Seapen 0+	Ad, Thermal, PBT	150000
Marble R	Harvest	Smolt 0+ Seapen 0+	Thermal, PBT Thermal, PBT	910000 90000
Nahmint R	Rebuilding	Smolt 0+ Smolt 1+	AdCWT, PBT AdCWT, PBT	75000 10000
Nitinat R	Harvest	Fed Fry Seapen 0+	Thermal, PBT Thermal, PBT	2000000 1500000
Robertson Cr	Assessment / Harvest	Seapen 0+	AdCWT, Ad, Thermal, PBT	6400000
San Juan R	Rebuilding Harvest	Smolt 0+ Seapen 0+	Ad, Thermal, PBT AdCWT, Thermal, PBT	440000 40000
Sarita R	Harvest	Fed Fry Smolt 0+	AdCWT, Ad, Thermal, PBT AdCWT, Ad, Thermal, PBT	250000 250000
Sooke R	Rebuilding	Smolt 0+	Thermal, PBT	437500

System	Release Objective	Release Strategy	Mark Strategy	Release Target
	Harvest	Seapen 0+	AdCWT, Thermal, PBT	500000
Tahsis R	Rebuilding	Seapen 0+	Ad, Thermal, PBT	150000
Thornton Cr	Harvest	Smolt 0+	PBT	100000
Toquaht R	Rebuilding	Fed Fry	AdCWT, PBT	210000
Tranquil Cr	Rebuilding	Seapen 0+	PBT	65000

Table A3. Terminal area harvest controls for WCVI Chinook fisheries.

Terminal Area	Harvest Controls
Kyuquot Sound	Area-wide salmon retention time and area closure during periods of local Chinook population return migration (i.e. starting July 15).
Nootka Sound (outer)	Targeted gear restrictions, bag limits and time and area closures in place to limit impacts on natural spawning stocks.
Tlupana Inlet	Conuma Hatchery directed fishery on abundances surplus to egg targets. Additional time and area closures in place to limit impacts on non-target chinook stocks.
Matchlee Inlet	Enhanced-stock directed fishery with a variable harvest rate strategy for abundances surplus to egg-targets.
Clayoquot Sound	Targeted gear restrictions, bag limits and time and area closures in place to limit impacts on natural spawning stocks.
Barkley Sound	Targeted gear restrictions, bag limits and time and area closures in place to limit impacts on natural spawning stocks.
Sarita River	Terminal First Nations fishery based on mark selective fishery with objective to manage PNI by removing hatchery fish from the river spawning population.
Alberni Inlet	Robertson Creek Hatchery directed fishery managing to spawner egg target. Time and area closures in place to limit impacts on non-target chinook stocks.
Nitinat Lake	Nitinat directed fishery for abundances surplus to egg targets.
Port Renfrew	Targeted gear restrictions, bag limits and time and area closures in place to limit impacts on natural spawning stocks.

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