OKANAGAN CHINOOK (*ONCORHYNCHUS TSHAWYTSCHA*) STOCK ASSESSMENT 2023

CONTEXT

The Fisheries Management Branch of Fisheries and Oceans Canada (DFO) requested that a limit reference point (LRP) consistent with the DFO Precautionary Approach (DFO 2009) be identified for the Okanagan Chinook stock management unit (Integrated Fisheries Management Plan [IFMP]) and for status against this reference point be assessed. Despite a LRP previously not being formally defined for this stock, it was identified as requiring a rebuilding plan, which was recently developed (approved April 2024), based on its depressed state. The rebuilding plan identified an interim LRP, which will be formally reviewed here. The objective of this process is to assess the status of Okanagan Chinook Salmon and review the interim LRP identified in the Rebuilding Plan.

This Science Response Report results from the regional peer review on April 29–May 3, 2024 on the Okanagan Chinook Salmon (*Oncorhynchus tshawytscha*) Stock Assessment in 2024.

SCIENCE ADVICE

Status

- The population remains in a severely depressed state, with a recently-piloted whole-population abundance estimate of 97 total, or 53 natural-origin, spawners in 2023. The existing index of abundance has ranged from 5–73 natural-origin spawners since 2006, with a most recent estimate of 12 natural-origin spawners in 2023.
- This stock management unit (SMU) is comprised of one Conservation Unit (CU), which has a RED status with high confidence, as of 2023.
- The corresponding Designatable Unit (DU) has most recently been assessed as Endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC; COSEWIC 2017).
- As of 2023, the SMU is below the LRP with high probability, as all available estimates place the number of natural-origin spawners well below 1,000, and the index of abundance shows a declining trend over the last 12 years (2012–2023)—placing the stock in the Critical Zone.

Trends

- Based on the index of natural-origin spawner abundance, the population is decreasing (-7% trend over three generations), with high variability.

Ecosystem and Climate Change Considerations

- In addition to changing oceanic conditions that all Pacific salmon are facing, this population is especially affected by rising freshwater temperatures. Their migration is strongly influenced by freshwater temperatures, and they face two significant thermal barriers to migration; one in-river and one in their holding lake (Osoyoos).

Stock Advice

- The stock is currently in a state of flux with habitat restoration and dam passage improvements dramatically increasing the amount of accessible habitat in recent years, as well as the initiation of a hatchery program and other actions aimed at increasing productivity and abundance. The extent to which the population will be able to recolonize and rebuild given new habitat access and supplementation efforts remains to be seen. The stock's precarious abundance, and its rapidly changing circumstances, warrant continued and/or enhanced monitoring and further consideration of actions that support rebuilding.
- As Canadian Okanagan Chinook Salmon are known to primarily spawn in natural or near-natural rehabilitated portions of the Okanagan River, protecting these habitats, or creating more of them, will be critical for their rebuilding.
- The current United States (US) escapement goal is inadequate for supporting the rebuilding of this stock, since between 1 and 17 Canadian Okanagan Chinook Salmon would be expected at the current escapement goal, assuming their relative proportion compared to the total Upper Columbia Chinook stock aggregate remains within the range observed from 2006–2022.

BASIS FOR ASSESSMENT

Assessment Details

Year Assessment Approach was Approved

N/A

Assessment Type

Full Assessment

Most Recent Assessment Date

1. Last Full Assessment: 2019 Recovery Potential Assessment (Mahoney et al. 2021); 2023 Pacific Salmon Commission (PSC) Okanagan Working Group report (PSC OWG 2023).
2. Last Interim Year Update: N/A

Assessment Approach

1. Broad category: Wild Salmon Policy Status Assessment, habitat capacity model, minimum viable population
2. Specific category: Index-based

   In this assessment, candidate benchmarks from various processes were gathered and compared, and an LRP chosen from these candidates, that seemed most consistent with existing science advice. WSP status was assessed, as well as current status against the LRP.

Stock Structure Assumption

The SMU consists of all Chinook Salmon spawning in the Canadian reaches of the Okanagan watershed (Figure A1). While recent changes in dam passage mean there is the potential for distinct spawning populations to form, the SMU is currently defined as one Conservation Unit under the Wild Salmon Policy (CK-01: Okanagan 1.x), and one SMU (Okanagan Chinook). Traditional Ecological Knowledge (TEK) tells us that there were two distinct runs in the past, a stream-type spring run (referred to as *ntytyix*) and an ocean-type summer/fall run (referred to as *sk'lwis*). Although there is recent evidence of a very small spring run of Canadian Okanagan Chinook Salmon, there currently is not enough information on this component to consider it either in combination with the summer run, or on its own. Further work would be required to determine whether or not the current CU definition would include both summer-run, ocean-type Okanagan Chinook and spring-run, stream-type Okanagan Chinook, but the definition of this CU was flagged in DFO (2016) as needing to be revisited The corresponding designatable unit (DU) under COSEWIC is defined specifically as Summer-run, ocean-type chinook, that spawn in the Okanagan River above Osoyoos Lake (Mahoney et al. 2021). The information gathered here, and in the rebuilding plan, focuses on summer-run, primarily ocean-type Chinook Salmon, since this is the only component for which we have any significant information.

Due to the stock's prolonged history of fish passage being blocked along the Columbia and Okanagan rivers (see more details in "History of Freshwater Habitat Impacts" section below), it is generally assumed that the current population of Canadian Okanagan Chinook Salmon originated from straying US Upper Columbia Chinook Salmon populations, and straying US hatchery fish continue to be found in the system. Genetic analysis in the early 2000s found significant overlap between Canadian Okanagan spawners and Upper Columbia fall/summer run Chinook Salmon populations (Similkameen and Wenatchee river Chinook), although the degree of genetic overlap varied between years (Davis et al. 2007). That same genetic analysis found low genetic diversity, with three families accounting for 40% of the Chinook Salmon sampled (Davis et al. 2007). The Okanagan Nation Alliance (ONA) and DFO are working towards building a genetic baseline for Canadian Okanagan Chinook Salmon, and have taken the first step towards implementing parentage-based-tagging.

Reference Points

A threshold of 1,000 mature individuals is often used by COSEWIC (COSEWIC 2017) to delineate between Endangered (current COSEWIC designation) and Threatened statuses, for small animal populations (COSEWIC 2021, criterion D1). For Pacific salmon, this value has been used as a recovery target (Arbeider et al. 2020; Weir et al. 2022), a metric (among others) to determine stock status under the Wild Salmon Policy (Grant et al. 2020), and is commonly used as an estimate of a minimum viable population size (MVP; Bradford and Wood 2004). When synthesizing genetic evidence for minimum viable population size, Allendorf and Ryman (2002) concluded that a population size of at least 1,000 is necessary to maintain genetic variability. In past Pacific salmon Recovery Potential Assessment processes (see Weir et al. 2022) when a recovery target was found to be below 1,000, a default to the COSEWIC criterion D1 of 1,000 was used to be precautionary.

Holt et al. (2018) provide a data-limited method for determining Wild Salmon Policy benchmarks for cases where only escapement data exists. However, these methods are not recommended when harvest is high and productivity is low (which is the case for Okanagan Chinook). If this method was applied, then it would yield a lower benchmark well below 1,000 fish. Similarly, watershed-area-based benchmarks have been applied to Chinook Salmon (Parken et al. 2006), and have been calculated for this SMU (Table 2), but these lower benchmarks also yield results below 1,000 fish.

Table 1. Original, based on Davis et al. (2007) analysis, and updated in 2023 with expanded watershed area estimates, habitat-based benchmarks for Canadian Okanagan Chinook Salmon. Upper benchmark is 85% of S_{MSY}. Lower benchmark is S_{gen}, the number of spawners required to reach S_{MSY} in the absence of fishing, in one generation. These two reference points are often used as lower and upper benchmarks for Wild Salmon Policy status assessments.

Year of Estimate	S_{gen}	85% S_{MSY}
2007	328	2,638
2023	641	4,610

The Okanagan Working Group of the Pacific Salmon Commission suggested a recovery target of a 4-year geometric mean spawner abundance of at least 1,000, paired with a positive population growth trend (PSC OWG 2023). These objectives were used as the recovery target for the Recovery Potential Assessment for this stock (Mahoney et al. 2021). Additionally, 1,000 is also listed as the LRP in the 2023 Integrated Fisheries Management Plan for the stock, which also provides a management target of 3,400 (DFO 2023), based on the estimated S_{MSY} value from Davis et al. (2007). Because the stock is in such a depressed state, and is currently expanding its range, setting a target reference point at this time is premature, as any value chosen likely will not align with the potential size of the stock if it is successful in re-colonizing previously inaccessible habitat. It is suggested that target reference points be revisited if/when the stock's status improves to at least above the LRP.

Recent work by DFO (2022) to create guidelines for defining LRPs for Pacific salmon have suggested that they are based on CU status, and use a "composite metric" approach, consistent with WSP assessments. In most cases, where there are multiple CUs in an SMU, this means that an SMU's status against the LRP can only be defined in binary terms of being above or below the LRP, without a point value associated with the reference point. However, in cases such as Okanagan Chinook, where there is only one CU within an SMU, there is an opportunity to more concretely define an LRP. Based on the points above, an LRP of 1,000 natural-origin spawners (geometric average over one generation/four years), paired with positive population growth over three generations (>0% percent change metric) is recommended. Note a more precautionary benchmark for the percent change metric has been identified, compared to what is included in the rapid status algorithm (DFO 2024; Pestal et al. 2023), because consistent population growth was identified by subject matter experts, and indigenous partners as a critical priority of rebuilding this stock. The LRP (and other reference points) should be revisited once the population shows signs of approaching this very minimum threshold, and/or more consistent data becomes available.

- Limit Reference Point (LRP): 1,000 natural-origin spawners (4-year geometric mean) + positive population growth over three generations (percent change metric > 0 over 12 years).
- Upper Stock Reference (USR): N/A
- Removal Reference (RR): N/A
- Target (TRP): N/A

Harvest Decision Rule

There are no Canadian fisheries targeting this SMU. In the US, it is managed with other Upper Columbia Summer Chinook Salmon stocks, which collectively have an escapement goal of 12,143. Although the abundance of the US portion of this aggregate is highly influenced by hatchery releases, we did find that Canadian Okanagan Chinook Salmon abundance is 69% correlated with the abundance of this aggregate, and has made up between 1/700 and 1/9,000 of the total in the years for which these data are available (2006–2022). At the current escapement goal for Upper Columbia Summer Chinook we expect an index of spawner abundance between 1 and 17 Canadian Okanagan Chinook Salmon, if the proportion stays within the range observed between 2006 and 2022.

Enhancement Plan

The Okanagan Nation Alliance (ONA) operates an enhancement program for Okanagan Chinook Salmon at the kł cp̓əlk̓ stim̓ Hatchery in Penticton. The objective of this program is to increase abundance to have Chinook Salmon recolonize habitats that were previously inaccessible, in order to rebuild the natural population. The first phase of this program includes a hatchery supplementation target of at least 250,000 eggs.

In the US Okanagan, Summer Chinook Salmon hatchery releases began in the Similkameen River in 1989 with an integrated summer/fall program with targets of 800,000 yearling, and 300,000 sub-yearling releases. These fish are 100% adipose fin clipped, and include the application of 200,000 coded wire tags (CWTs). Adipose fin-clipped fish were observed in the Canadian Okanagan watershed prior to hatchery supplementation in Canada, indicating that US hatchery fish can stray to the area, however COSEWIC (2017) concluded that rescue via these nearby populations was unlikely, which was used as the main impetus for changing their status from threatened to endangered.

Habitat Restoration Plan

The PSC Okanagan Working Group (2023) provided a list of recommended restoration measures (PSC OWG 2023, Appendix B). The Okanagan Nation Alliance (ONA) leads a multi-faceted restoration program, the details for which can be found under “Restoration” at: Our Projects – Okanagan Nation Alliance. While a published restoration plan doesn’t exist, a prioritization exercise was conducted by McGrath et al. (2022) to identify off-channel habitats that could be restored. The report informs the Okanagan River Restoration Initiative (ORRI), which is working on implementing a variety of restoration projects.

Data

The current index of abundance (since 2006) represents the majority of spawners from above Osoyoos Lake, as far upstream as Okanagan Lake. Beginning partially in 2019 (although 2019–2022 passage was dependent on high flows) the Okanagan outlet (Penticton) dam fishway was open for Chinook Salmon passage, making all areas of Okanagan Lake accessible for Chinook Salmon (Figure A1). It is uncertain how many fish will migrate beyond the Okanagan Lake dam, and how they will distribute throughout the watershed. Passage into Kalamalka Lake is still partially impeded by a dam at its outlet.

Escapement estimates are based on stream float/walk counts, and area-under-the-curve analyses, which depend on estimates of survey life in spawning areas and observer efficiency. Since these values have not been measured for this population, survey life estimates are borrowed from other populations, and observer expansions are not used, introducing uncertainty in these estimates that is currently not quantified. These factors make the current abundance estimates uncertain and preclude the use of more robust estimation and modelling methods, such as stock-recruitment analysis, for this population. It is expected that this index is an underestimate due to lack of observer expansion, uncertainty in residence time, and more recently, potential expansion into un-surveyed habitats. Carcasses are also surveyed to determine the proportion of hatchery spawners, and in some years (generally very low abundance years) carcass counts are used instead of AUC estimates, if the carcass count exceeds the AUC estimate. Although improvements could be made to this enumeration approach (eg. by estimating stock-specific survey life, studying observer efficiency) the ONA has opted to maintain the consistency of this index time series, while simultaneously initiating a more robust whole-population enumeration method.

More accurate passive integrated transponder (PIT)-tag based mark-recapture surveys have been recently initiated to develop an estimate of total spawner abundance, including individuals that may be spawning outside of the index area currently surveyed. The first estimate was made in 2020, at 195 individuals (when natural-origin spawners from the stream survey were estimated at 73). Estimates in succeeding years are not available because of Insufficient tagging in those years until 2023, when an estimate of 97 (when natural-original spawners were estimated at 11) was produced so whole-population abundance is likely higher than estimates based on stream floats/walks. However, the proportions of hatchery and natural-origin spawners would not be expected to be consistent among years, as their range, and therefore the proportion of fish captured in the index area, is expected to be in a state of flux.

Calendar-year exploitation rates (CYER), in units of adult equivalents (AEQ) for the US Similkameen indicator stock (referred to as SMK in related documents) act as a proxy for estimating harvest rates on summer/fall run Canadian Okanagan Chinook. Due to differences in run timing, it is unlikely that this CYER index would be a good proxy for harvest rates of an emerging spring-run population. Harvest rates for summer/fall run Canadian Okanagan Chinook remain very high, averaging 52% in the latest 20 years (representing about 5 generations) for which we have catch-year exploitation rate (CYER) data (2002–2021).

ASSESSMENT

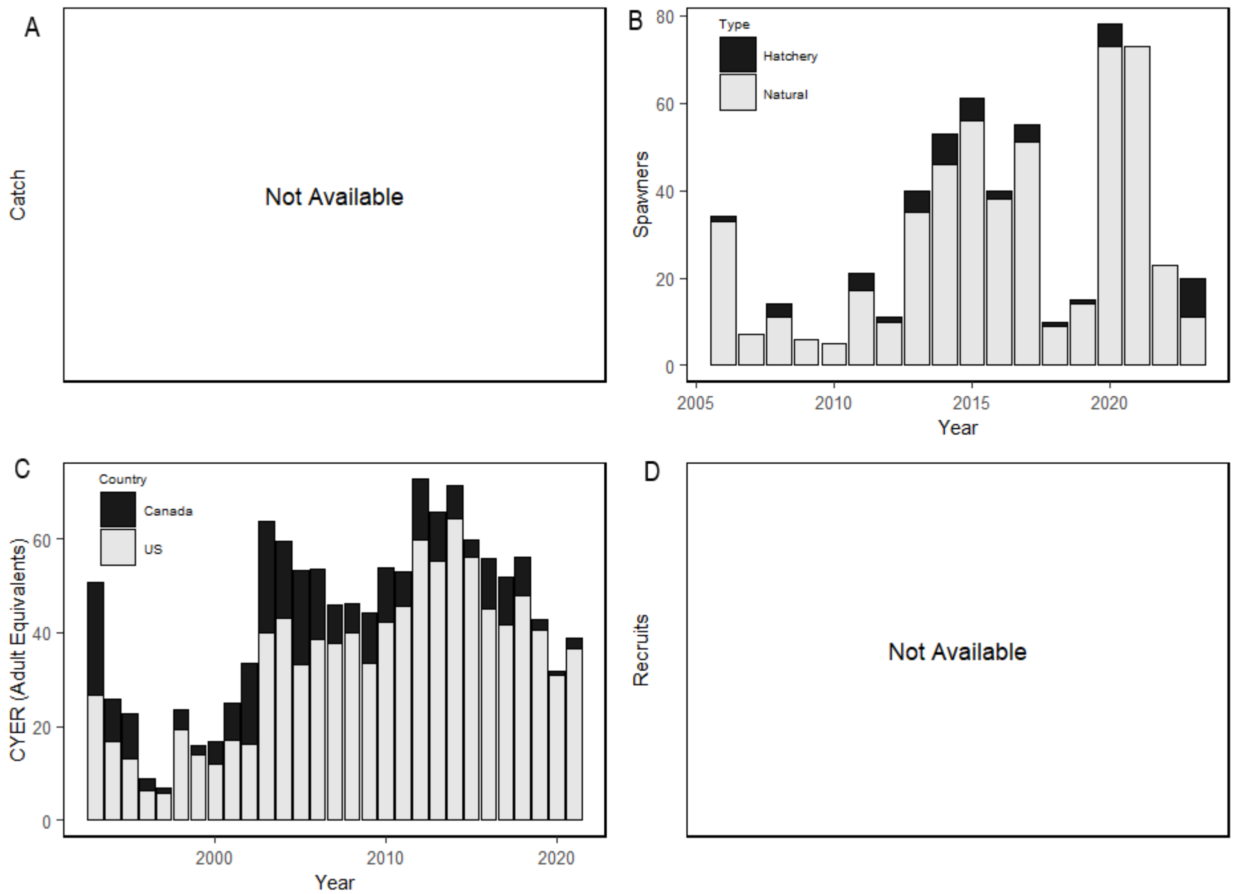

Figure 1. Okanagan Chinook catch, escapement, recruitment and exploitation rate plots. (A) Since we do not have recruitment estimates for this population, we cannot estimate absolute catch. (B) Natural-origin and hatchery-origin escapement index. We did not include our abundance LRP of 1,000 in this figure, since the stock is so far below it. (C) Estimated calendar-year exploitation rates, in units of adult equivalents (AEQ) for the US Similkameen indicator stock (referred to as SMK in related documents). This is our closest proxy for exploitation for Canadian Okanagan Chinook Salmon. There is no removal reference for this stock. (D) Recruitment estimates are not available for this stock.

Stock Status and Trends

Abundance

Indigenous knowledge tells us that Okanagan Chinook Salmon were historically abundant, utilizing all accessible reaches of the Okanagan watershed. Damming of the Columbia and Okanagan rivers in the US and Canada, along with other anthropogenic pressures on the population (channelization, water diversion etc.), led to the population being essentially extirpated around the turn of the 20th century. Through a combination of dam passage improvements, habitat restoration, and hatchery releases, the stock has been slowly re-establishing itself since the late 1980s. The population remains at extremely low abundance, with two absolute abundance estimates of 195 and 97 total spawners for 2020 and 2023, respectively. An index-of-abundance time series exists since 2006, and has ranged from 5 to 73 natural-origin spawners (Figure 1B). The limited data available for this small population, along with its currently uncertain state, due to very recent opportunities at range expansion, precludes from the use of most traditional types of stock assessment for this stock.

Exploitation Rates

Harvest rates for summer/fall run Canadian Okanagan Chinook remain very high, averaging 52% in the latest 20 years (representing about 5 generations) for which we have catch-year exploitation rate (CYER) data (2002–2021; Figure 1C).

Survival

Downstream survival of yearling summer Okanagan Chinook smolts from the kł cp̓əlk̓ stim̓ Hatchery, released into Canadian sections of the Okanagan River, has been assessed since 2019 using PIT tags. Survival from release to Rocky Reach Dam ranged from 4% to 24%, with an average of 16% (PSC OWG 2023). For comparison, survival of US Okanagan summer yearling Chinook released into the Omak Pond and the Similkameen River (feeding into the US Okanogan River) to Rocky Reach Dam averaged 63% (PSC OWG 2023). This difference in survival points to the existence of survival bottlenecks specific to the Okanagan Chinook SMU. These SMU-specific survival bottlenecks would likely occur in the Canadian Okanagan watershed; when passing over dams and flow-control structures, or in Osoyoos Lake due to predation (especially by invasive piscivores), low oxygen, or high temperature. Alternatively, this lower estimated survival could be, at least partially, caused by some juveniles never migrating to the ocean, and opting to stay in freshwater until adulthood, which has been observed (referred to as "residualization"). Despite this low population-specific survival pointing to population-specific factors, downstream dam passage on the mainstem Columbia is well known to have direct and indirect (such as predation in reservoirs) negative effects on survival, depending on dam-specific attributes (PSC OWG 2023). US dams are required to meet dam- and species-specific performance standards; the maintenance of which will be imperative to the rebuilding of Canadian Okanagan Chinook Salmon.

Status Assessments

The Okanagan Chinook DU was first assessed by COSEWIC on an emergency basis in 2005 as Endangered, due to its very small population size and anticipated increased exploitation in Columbia River fisheries (COSEWIC 2005). This DU was re-assessed by COSEWIC in 2006 at a lower status (Threatened), due to rescue potential from populations in adjacent areas of the Columbia River basin (COSEWIC 2006). Most recently, COSEWIC re-assessed Okanagan Chinook as Endangered in 2017, and rescue was deemed unlikely due to the uncertain status of source populations and viability of strays (COSEWIC 2017).

WSP status was determined to be RED in 2012 (DFO 2016), although it was flagged as needing the CU definition revisited. Recent work by DFO (2024; Pestal et al. 2023) has streamlined the Wild Salmon Policy (WSP) assessment process, which up until now has generally been expert-driven (see DFO 2015, 2016; Grant et al. 2020; Grant and Pestal 2013) and has required significant effort to complete. In those assessments, experts are presented with a dashboard of status metrics, and integrate across them to determine status. The rapid status tool uses an algorithm, which employs a set of decision rules that approximate the expert-led decision-making process (DFO 2024; Pestal et al. 2023). The first "bottleneck" in this process is meeting a minimum population size of 1,500 individuals—called the absolute abundance metric. This number was chosen because experts often wanted to employ some caution around the absolute abundance threshold of 1,000 (based on COSEWIC criterion D1)—and generally if a population was below 1,500, it would be designated as "red" by experts, regardless of other metrics. This tool produces dashboards, with a suite of metrics, depending on the data availability of the stock, which are then reviewed by relevant experts in order to determine final status (in this case, the ONA). The dashboard for this stock can be found in Appendix A, and indicates RED status, based on the abundance of the population being below 1,500 (Figures A1, A2). Expert review of this dashboard confirmed that the current WSP status of the CU is RED with high confidence. In fact, retrospective rapid status for all years for which status metrics could be calculated has been red (Figure B1, Panel E; 2009–2023).

The default approach to determining SMU status follows directly from CU status (i.e, if any one CU in an SMU is RED, the SMU is considered below the LRP). However, in this specific case, as we have only one CU in the SMU, we are able to concretely define an LRP against which to assess SMU status. This LRP is straightforward to understand and implement and prioritize the interests of indigenous partners (increase in natural-origin spawners, and population growth), compared to the CU status-based approach. Here, both approaches point to the SMU being below the LRP, as it is RED status following pre-determined WSP approaches, and also below the LRP, which was identified by subject matter experts/indigenous partners at 1,000 generational average natural-origin spawners, and positive percent change metric over last three generations. The most recent generational geometric average number of natural-origin spawners from the time-series of an index of spawner abundance is 35 (2020–2023). However, this index does not capture the entire spawning population, and whole-population mark-recapture estimates are only available for 2020 (181 natural-origin spawners) and 2023 (53 natural-origin spawners). While four consecutive of whole-population estimates are not available to calculate a four-year geometric mean, the abundance is clearly well below 1,000 natural-origin spawners. The percent change metric over the last three generations (2012–2023) applied to the index of spawner abundance is -7%, having declined drastically in recent years after showing positive population growth up until 2022 (Figure B1, Panel D).

History of Management

History of Exploitation

Anadromous salmonids in the Okanagan watershed (Chinook, Sockeye, Coho, and Steelhead Trout) were managed by the Sylix people for thousands of years as one of their Food Chiefs (Sam 2008). Chinook were fished widely throughout the watershed (but especially at Okanagan Falls) and provided for abundant food fisheries and trade (Ernst 2000).

There have been substantial historical fishing impacts (primarily non-Indigenous) on the Okanagan Chinook Salmon population. Historical catch estimates of Columbia River Chinook Salmon numbered in the millions but declined to the thousands by the early 1940s (Matylewich et al. 2019), reflecting the combined effects of fishing and dam construction. Harvest rates in the lower Columbia River during this time could have ranged as high as 90% but were reduced from the 1950s onward until 2008, after which they increased (Matylewich et al. 2019). Prior to the early 2000s, exploitation of this SMU mainly occurred in Southeast Alaskan Aggregate Abundance-Based Management (AABM) fisheries, but as US stocks of Columbia Chinook Salmon rebounded, there was a dramatic shift towards exploitation being dominated by directed US fisheries in the Columbia River. In the US, this SMU is incidentally managed with other Upper Columbia Summer Chinook Salmon stocks. That stock aggregate has consistently exceeded its escapement goal since 1999, and therefore harvest has not been restricted as outlined in the 2019 Agreement for the Pacific Salmon Treaty, and therefore US harvest rates remain high (averaging 52% from 2002–2021). Harvest rates are influenced by US hatchery production levels in the Okanagan and Columbia watersheds which can cause increased fishing pressure on co-migrating wild stocks. PIT-tagged Canadian Okanagan Chinook have also been found in US brood stock collections, and are likely caught incidentally in non-salmon fisheries, so these harvest rates represent a *minimum* value.

Due to the low population size, there are no directed Canadian fisheries on Okanagan Chinook Salmon. However, Okanagan Chinook Salmon are caught in the ocean AABM fisheries that target Chinook Salmon, but harvests are incidental to other, more abundant stocks. Canadian incidental exploitation rates have fluctuated over time, but have been very low in recent years (0.6–2.3% from 2019 to 2021). A detailed overview of fishery mortality can be found in the recent Pacific Salmon Commission Okanagan Working Group report (PSC OWG 2023).

History of Hatchery and Supplementation

Hatchery releases of Okanagan Summer Chinook Salmon into the Canadian Okanagan River began in 2017 with eggs obtained from US Okanagan broodstock and reared at the kł cp̓əlk̓ stim̓ Hatchery in Penticton, BC. Spawner abundances in Canada are usually too low to collect broodstock, but a few fish (no more than 8) were collected in 2017, 2020, 2022 and 2023. When Canadian brood stock aren't available, Chief Joseph Hatchery, in Washington state, provides eggs when they can. Fry release numbers have ranged from 0 to 42,000 (Table 1).

Table 2. Chinook Salmon releases from the ONA kł cp̓əlk̓ stim̓ Hatchery. Source: Okanagan Nation Alliance.

Brood Year	Release Timing	Total Release	PIT Release	Age	Brood/Egg Source
2016	June 2017	10,396	3,417	subyearling	Chief Joseph Hatchery
2017	June 2018	3,383[a]	0	subyearling	Chief Joseph Hatchery
2017	April 2019	8,229	8,220	yearling	Chief Joseph Hatchery
2018	-	0[b]	0	-	-
2019	Nov. 2020	20,390	4,728	large subyearling	Chief Joseph Hatchery
2019	April 2021	21,847	17,225	yearling	Chief Joseph Hatchery
2020	April 2021	6,137	0	subyearling	Okanagan River (Canada)
2020	Jan. 2022	22,550	22,550	yearling	Chief Joseph Hatchery
2021	May 2022	364[c]	0	subyearling	Chief Joseph Hatchery
2022	May 2023	2,066	2,011	subyearling	Okanagan River (Canada)
2022	May 2023	9,842	9,580	subyearling	Chief Joseph Hatchery

a all coded wire tagged
b Brood stock collection was not possible in 2018 due to extremely low escapement (10 total spawners) and brood stock from U.S. hatchery collections were not available
c 296 acoustic tagged and all thermal marked

History of Freshwater Habitat Impacts

In the late 1800s fishing practices (using fish fences) on the US side of the Okanagan River likely entirely blocked passage for Canadian Okanagan Chinook during some years (Department of Fisheries 1888). Throughout the 20th century, the Columbia and Okanagan rivers have been dammed in at least 13 locations (Mahony et al. 2021). From 1939 to at least 1943 the Grand Coulee Fish Maintenance program transported Columbia River summer Chinook Salmon over the Rock Island Dam to US tributaries for spawning, or to hatcheries, with no record of releases of Chinook into the Okanagan (Fish and Hanavan 1948). This program likely eliminated the genetic distinctiveness of the historic Okanagan Summer Chinook Salmon population by eliminating five consecutive brood years (Matylewich et al. 2019). Fish passage at Rock Island Dam was re-established in 1943.

Many adaptations have been made to the dams obstructing the Okanagan and Columbia rivers in recent decades. In 2009 a gate retrofit of McIntyre Dam was completed which enabled Chinook to access Skaha Lake, 7 km of Okanagan River mainstem habitat, Vaseux Lake, and one tributary. In 2014, activation of the fish ladder at Skaha Lake outlet dam enabled Chinook access up to the outlet of Okanagan Lake, 6 km of mainstem river habitat upstream, and two tributaries. Partial fish passage was restored at the Okanagan Lake outlet dam, giving access to most of their historic range beginning in 2019, although passage was improved again in 2022, so that it is less flow-dependent.

In addition to a long history of fish passage issues, this stock has been profoundly impacted by human development affecting freshwater habitats. The Okanagan River between Osoyoos and Okanagan lakes was a historically meandering river with active floodplains. Settlement in the area led to diking, narrowing, and channelization of the river in the 1950s, which decreased its length by 50%. Seventeen vertical drop structures were installed to compensate for the increased gradient of the river, hindering free access to fish between reaches. In addition, three dams were built, which blocked fish access upstream of McIntyre Dam, meaning they only had access to Osoyoos Lake, and the mostly channelized river north of it, and not the three additional lakes upstream of that point (Vaseux, Skaha, and Okanagan). Channelized sections have relatively little suitable habitat for spawning. Although access to the three previously blocked lakes has been recently granted to anadromous fish, and substantial habitat restoration projects have been undertaken, only about 16% of the river in Canada remains in a natural or semi-natural state (Bull 1999). Several restoration projects have already been conducted along the Okanagan River with the goal of returning portions of the channelized river to more natural conditions in order to create more complex and diverse habitats. The Fish Water Management Tool improved the management of water within the Okanagan watershed for the benefit of fish, by stabilizing flows during the spawning and incubation period (Machin et al. 2018).

Projections

Due to data limitations, projections are not feasible for this stock. In order for projections to be feasible, estimates of productivity and accurate estimates of escapement by age would be required to estimate the recruitment for each cohort of fish. The first steps towards producing projections is age-estimation, which would allow for brood tables to be compiled for naturally-produced Chinook. A population viability analysis (PVA) was developed and reported in COSEWIC (2006), and Mahoney et al. (2021) but due to lack of data for this specific SMU the analysis included many assumptions. For example, productivity of the population was estimated based on a US proxy population, and habitat capacity was estimated based on old (smaller) watershed area values. Due to the assumptions and limitations of this analysis, we chose not to focus on it, or update it. Results of that PVA showed that substantial hatchery supplementation and/or complete cessation of harvest would be required to rebuild the SMU (COSEWIC 2006; Mahoney et al. 2021).

Ecosystem and Climate Change Considerations

The vast habitat range of Okanagan Chinook Salmon makes them vulnerable to environmental change at multiple life stages. Likely the most critical limiting or threatening climatic factor is increasing water temperature which could render certain habitats unusable, and further hinder migration. The Okanagan watershed is susceptible to increasing stream temperatures due to low gradient, hot summer climate, and water extraction, which is further exacerbated by extensive habitat alterations. During their upstream migration, this stock faces two substantial thermal barriers—the first occurring at the confluence of the Okanagan and Columbia rivers, which causes a portion of the population to hold in Wells pool in the Columbia River for one to six weeks (Pearl et al. 2022), where they are vulnerable to US fisheries. Often, the second thermal barrier, in Osoyoos Lake, has already established during this time and fish must hold in the cooler Similkameen River, a tributary to the US portion of the Okanagan River (PSC OWG 2023). The thermal barrier in Osoyoos Lake typically begins earlier and lasts longer than that in the US Okanagan River. Average surface water temperatures in Osoyoos Lake, where Okanagan Chinook Salmon hold prior to spawning, often exceed 22°C throughout the summer months. Furthermore, in the late summer, the central and southern basins of Osoyoos Lake often experience a phenomenon where low-oxygen conditions spread upwards, and warm surface temperatures spread downwards, causing what is referred to as a “temperature-oxygen squeeze”. This reduces lake habitat for migrating fish to the deeper North Basin, which experiences temperature-oxygen squeezes less frequently. The Okanagan River mainstem above Osoyoos Lake typically exceeds 22°C from mid-July to the third week of August. Thus, cool water holding habitats are limited to the North Basin of Osoyoos Lake, Skaha and Okanagan lakes, and potentially some deep pools in the natural reach of the Okanagan River between Skaha Lake and Osoyoos Lake. Climate change related increases in air temperature are projected to increase the frequency and duration of time that these thermal barriers are in place, potentially further delaying or preventing migration.

As described previously, juvenile survival for this SMU is known to be quite low, potentially driven by many different environmental and anthropogenic (namely, dam passage) factors. Invasive species have been identified as a substantial threat to this SMU’s recovery, primarily via juvenile predation. Invasive Walleye, Bass, and Pike are likely predating on juveniles in the Okanagan watershed and mainstem Columbia. Invasive Eurasian Watermilfoil have indirect impacts on Chinook Salmon by creating prime habitat for these predators. Continued monitoring for and control of invasive species spread will be required to reduce these impacts.

BYCATCH

Since there are no Canadian directed fisheries on this stock, all Canadian catch would be considered bycatch. See section above for estimates of Canadian bycatch in salmon fisheries. Due to their migration timing, Okanagan Chinook Salmon are also likely caught as bycatch in groundfish trawl fisheries. An enhanced monitoring and sampling program is being implemented in order to estimate the magnitude of these incidental catches.

SOURCES OF UNCERTAINTY

While the SMU’s status is not particularly uncertain, as its abundance is well below any conceivable LRP, the SMU is relatively data-limited, and both its ecology and data are in a state of flux. As described above, in recent years the SMU has gained access to large areas of previously inaccessible habitat, including the large Okanagan Lake and its tributaries. In addition, significant habitat restoration and water control efforts have been underway for at least a decade, improving the quality of accessible habitat. Simultaneously, supplementation efforts are building up, but their feasibility remain uncertain, as there often are not enough spawners for adequate broodstock, necessitating transplants from US hatcheries.

In terms of data, the escapement time series that currently exists is relatively short (beginning in 2006) and may be uncertain due to proxies being used in area-under-the-curve estimates (see

Data section). In the past, it was reasonably assumed that this escapement index captured the majority of spawners, but this assumption may become more uncertain as more potential habitat becomes available, if these habitats are not surveyed. The establishment of a whole-SMU mark-recapture estimate is currently underway, but has been hampered by low abundance, not allowing for adequate tagging and recapture rates. Recruitment estimates are not yet available for this stock, as aging has not been carried out sufficiently to estimate the escapement for each cohort of fish, and exploitation rates are not measured directly for this SMU. As the current exploitation rate estimates are based on catch rates of a proxy hatchery-origin population, they may not adequately represent the effects of fisheries on natural-origin fish, all of which are required to generate stock and recruitment estimates by cohort. Exploitation rate estimates provided here are based on the most similar US Chinook salmon CWT indicator stock (SMK), which is nearby and has most fish spawning within tens of kilometers downstream of Osoyoos Lake.

Research Recommendations

The PSC Okanagan Working Group's recent report (2023) includes a comprehensive list of potential recovery actions and projects (many of which are research projects) to aid in rebuilding (PSC OWG 2023, Appendix B). The list includes improved biological and habitat monitoring, life-stage specific survival estimates, water management scenario analyses, predator and invasive species monitoring. It also lists building population dynamics models that could be used to test scenarios and management strategies, however, these types of models are not likely to be useful at such low abundance and given ongoing changes to enumeration methods, ongoing range expansion, and high uncertainty in existing data Given the potential for range expansion and changes occurring in enumeration methods, close-kin-mark-recapture could be explored as an option for estimating abundance of this SMU.

Further research is required to determine if there is an established spring run of Okanagan Chinook, and whether this warrants the creation of a new Conservation Unit and/or Stock Management Unit. The presence of a spring run of Okanagan Chinook will become especially relevant if the Enloe Dam is removed, allowing access to the Canadian portion of the Similkameen River (part of the Okanagan watershed), which is suspected to have the potential to provide excellent habitat for spring Chinook Salmon. Bond et al. (2023) estimated spawner capacity of 72,600 Chinook Salmon for the Similkameen watershed.

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APPENDIX A: THE COLUMBIA AND OKANAGAN WATERSHEDS

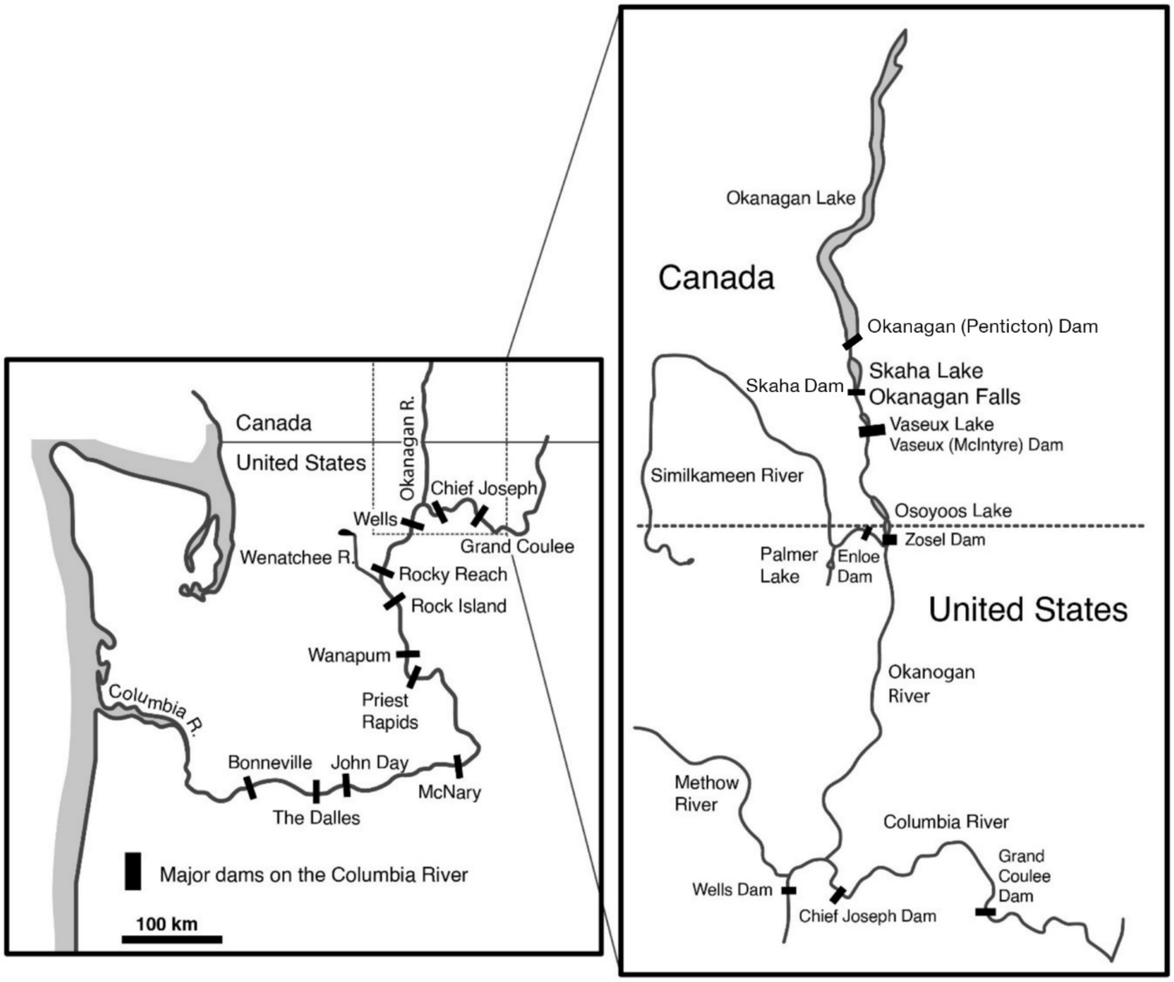

Figure A1. Maps of the Columbia and Okanagan watersheds, with dams labelled. Fish passage on the Columbia River currently ends at Chief Joseph Dam, blocking access to the upper Columbia. In the Okanagan watershed, fish passage is now possible up to Okanagan Lake, but the Enloe Dam blocks access to other potential Canadian habitat in the Similkameen River.

APPENDIX B: WSP RAPID STATUS SUMMARY FOR OKANAGAN CHINOOK STOCK MANAGEMENT UNIT

CU No#	CU name	Populations
CK-01	**Okanagan_1.x**	**Okanagan River** (Pop ID 48442)

Data: The Okanagan Chinook SMU is comprised of one CU (Okanagan-1.x (CK-1)) with one population. Rapid status assessment for most Southern BC Chinook CUs currently use time series generated using the approach from Brown et al. (2020), but DFO area staff provided an alternative data set for Okanagan Chinook. Annual estimates of natural-origin spawners, starting in 2006, were developed by the Okanagan Nation Alliance (ONA) based on an area-under-the-curve (AUC) estimate of visual survey observations. Since this population is so small, and because no expansion is applied to account for observer efficiency, in some years, more carcasses are counted than the AUC estimate (which is based on live counts) and in these cases the carcass count is used instead.

Future work: As this current index of abundance is known to be biased low, and does not meet Pacific Salmon Commission Chinook Technical Committee (PSC-CTC) data standards, a test survey using PIT mark-recapture program has been implemented to produce whole-population estimates. Enough fish were recovered in 2020 and 2023 to produce estimates, of 195 and 97 total spawners (wild + hatchery) respectively. Additional mark-recapture surveys are planned, and in a few years a recalibrated time series may be possible. Until then, rapid status assessments will use the current index of abundance, which, up until recent years, is expected to capture the vast majority of spawners fish.

Forewords: Based on traditional ecology and Indigenous knowledge, it is known that this population had high abundance, and provided an abundant source for food and trade. Its current low abundance is reflective of environmental degradation (specifically damming, water diversion, channelization), heavy exploitation (average catch-year exploitation rate >50% 2014–2023), and rising temperatures causing thermal barriers to migration. One key impact was the translocation of the entire population to other watersheds as part of the Grand Coulee Fish Maintenance Program in the late 1930s. Despite the entire available time series showing very low abundance, this should not be considered a naturally small population.

WSP rapid statuses: A detailed decision tree that interprets how four standard WSP status metrics interact to give an overall status (Figure B2). This decision tree was selected among candidate trees, because it best approximates the rationale and status designations developed during expert workshops held from 2012 to 2014 (DFO 2024; Pestal et al. 2023).

Table B1. Rapid Status summary for Okanagan Chinook.

CU #	CU Name	WSP Rapid Status	WSP Rapid Status Details
CK-01	Okanagan_1.x	**RED, HIGH CONFIDENCE**	The current year's WSP rapid status (2023) is *Red* with *High* confidence. The current generational average is well below 1,500 spawners, the lower benchmark for the *absolute abundance* metric (Node 3; Figures B1–B2). This *Red* status has been consistent throughout the time series from 2009 to 2023 (Figure B1). The 2012 WSP rapid status of *Red* matches the WSP integrated status (DFO 2016). Although not used to assess status for this CU, given the low absolute abundances, the *percent change* (short-term trends) for this CU indicates green, despite the metric being below zero (indicating population decline; Figure B1).

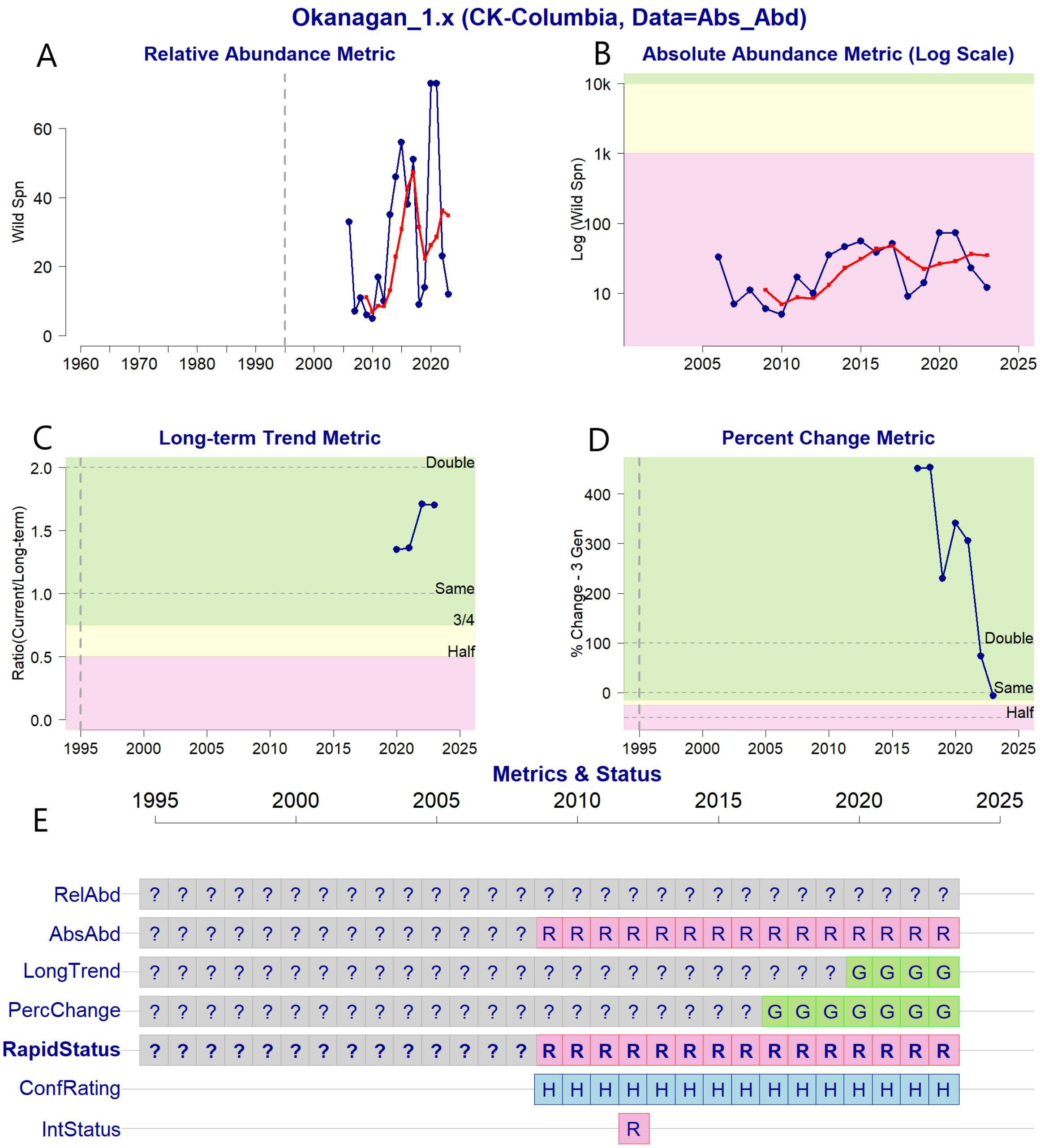

Figure B1. Metrics and status for Okanagan_1.x (CK-01, Okanagan). Top panels show the four standard WSP metrics, calculated based on the time series of spawner abundances. Bottom panel summarizes the status for each individual metric by year and shows the resulting rapid status for the CU with a confidence rating. Past integrated WSP status assessments are shown on the last row (IntStatus). The relative abundance metric is currently not available, because there are no defined benchmarks on the scale of the spawner index. The absolute abundance metric is available, because the spawner index was categorized as capturing most of the CU abundance. The absolute abundance metric, which drives status in this case, uses generational averages, so the first rapid status designation is available for 2009, four years after the start of the time series. Metric definitions and rapid status algorithm are documented in Appendix A of Pestal et al. (2023).

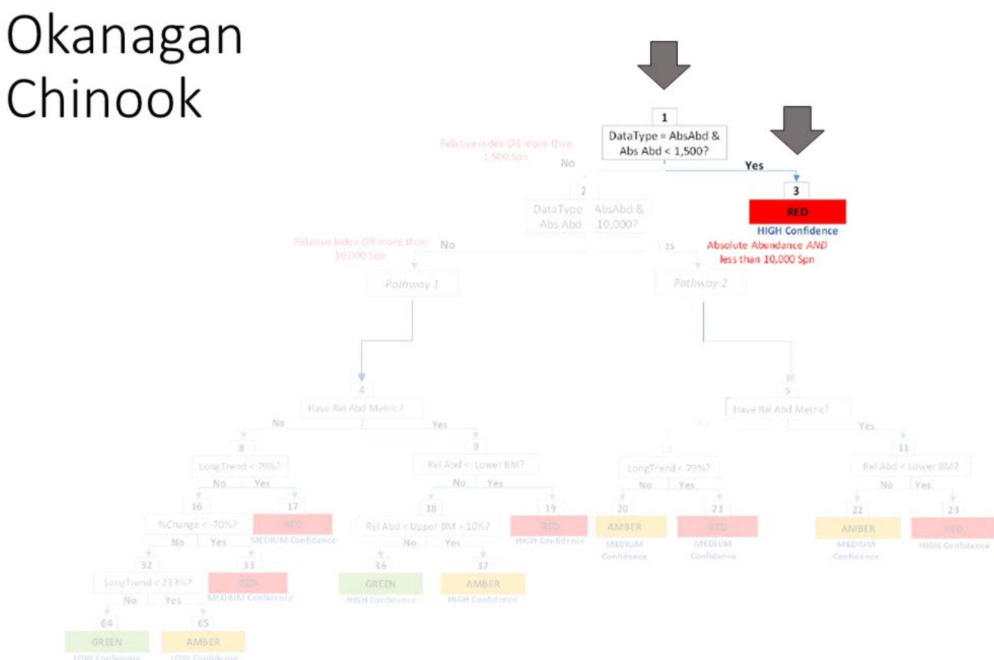

Figure B2. Algorithm pathway taken to assess status for Okanagan Chinook in 2023. The recent generational average falls below the absolute abundance lower (1,500) threshold (node 3).

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