COSEWIC
Assessment and Status Report

on the

Chinook Salmon
Oncorhynchus tshawytscha

Okanagan population

in Canada

THREATENED
2006

COSEWIC
COMMITTEE ON THE STATUS OF
ENDANGERED WILDLIFE
IN CANADA

COSEPAC
COMITÉ SUR LA SITUATION
DES ESPÈCES EN PÉRIL
AU CANADA

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

COSEWIC 2006. COSEWIC assessment and status report on the chinook salmon *Oncorhynchus tshawytscha* (Okanagan population) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 41 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

Production note:

COSEWIC acknowledges Brent Phillips, Howie Wright and the Okanagan Nation Alliance Fisheries Department for writing the status report on chinook salmon *Oncorhynchus tshawytscha*, Okanagan population. COSEWIC also gratefully acknowledges the financial support of the Department of Fisheries and Oceans for the preparation of this report. The COSEWIC report review was overseen by Mart Gross, and Paul Bentzen, co-chairs of the COSEWIC Marine Fish Specialist Subcommittee, with input from members of COSEWIC. That review may have resulted in changes and additions to the initial version of the report.

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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur le saumon chinook (*oncorhynchus tshawytscha*) population de l'Okanagan au Canada.

Cover illustration:
Chinook salmon — Photo provided by the Okanagan Nation Alliance.

Catalogue No. CW69-14/469-2006E-PDF
ISBN 0-662-43240-1

Recycled paper

COSEWIC
Assessment Summary

Assessment Summary – April 2006

Common name
Chinook salmon – Okanagan population

Scientific name
Oncorhynchus tshawytscha

Status
Threatened

Reason for designation
The Chinook salmon (Okanagan population) are the only remaining Columbia Basin population of Chinook salmon in Canada, and are geographically, reproductively and genetically distinct from all other Canadian Chinook salmon populations. They consist of anadromous salmon that migrate to and from the Pacific Ocean through the Columbia River, and also individuals that remain in Osoyoos Lake. The Chinook salmon (Okanagan population) was once large enough to support an important food and trade fishery prior to settlement by non-native people. The population used to occupy the area from Osoyoos Lake to Okanagan Lake, but McIntyre Dam has limited access to only the area below the dam and in Osoyoos Lake. As well as this habitat loss, the population was depleted by historic overfishing in the Columbia River and juvenile and adult mortality due to dams downstream on the Columbia River. Fisheries exploitation in the ocean, deterioration in the quality of the remaining Canadian habitat, and new predators and competitors such as non-native fishes also contributed to the current depleted state of the population. Genetic data show evidence of successful reproduction and maturation by individuals in this population, but also that this small population has genetic diversity similar to much larger populations in adjacent areas of the Columbia River basin, and is closely related to those populations. The genetic data, as well as the presence of fish of hatchery origin in the Canadian portion of the Okanagan River, indicate that it is very likely that fish from elsewhere in the upper Columbia River basin have contributed reproductively to the population. With spawning numbers as low as 50 adults, the population is at risk of extinction from habitat loss, exploitation and stochastic factors, but may also be subject to rescue from populations in adjacent areas of the Columbia River basin.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Endangered in an emergency assessment on May 4th, 2005. Status re-examined and designated Threatened in April 2006. Assessment based on a new status report.

COSEWIC
Executive Summary

Chinook Salmon
Oncorhynchus tshawytscha

Okanagan population

Species information

The chinook salmon (*Oncorhynchus tshawytscha* Walbaum) is one of six species of the Pacific salmon (genus *Oncorhynchus*) native to North America. This report assesses the status of the chinook salmon population within the Okanagan River basin in British Columbia as a COSEWIC Designatable Unit (DU).

The case for recognizing Canadian Okanagan chinook salmon as a DU is based on this population's: (1) genetic differentiation from other Canadian chinook salmon populations; (2) geographic and reproductive isolation; and (3) unusual life history characteristics, including evidence of extended freshwater rearing and possible freshwater maturation. This unique population of chinook salmon in Canada will be referred to as "Okanagan chinook."

Distribution

Spawning populations of chinook salmon are found in streams and rivers from northern Hokkaido (Japan) to the Anadyr River (Russia) on the Asian coast, and from central California to at least Kotzebue Sound (Alaska), on the North American coast. The Okanagan chinook appears to exist only in the Okanagan River of Canada (a tributary to the Columbia River). Its current northern limit is the McIntyre Dam (near Oliver, BC), and its southern limit may be the north basin of Osoyoos Lake, immediately north of the BC border with Washington State. In such case the entire breeding population of Okanagan chinook is in Canada, although anadromous individuals will migrate through the U.S. Columbia River to and from the Pacific Ocean.

Habitat

Chinook salmon are born in fresh water and grow in streams, lakes, estuaries, and/or the ocean. Sexually mature or maturing fish migrate to their natal stream to spawn, following which the adults die. They spawn in a broad range of stream flows, water depths, and substrate sizes, but spawn preferentially in areas with intra-gravel water flow. In the ocean, chinook may remain in coastal areas or complete extensive offshore migrations.

Adult anadromous Okanagan chinook migrate from the Pacific Ocean, up the Columbia River (past nine mainstem U.S. dams), and into Osoyoos Lake and the Okanagan River in Canada. The accessible portion of the Okanagan River ends at the McIntyre Dam, and spawning occurs between the dam and Osoyoos Lake. During migration, anadromous adults may hold in the Okanagan River below the Similkameen confluence or Osoyoos Lake until spawning temperatures are favourable. At fry emergence, Okanagan chinook may either rear in the Okanagan River or in Osoyoos Lake for a varying length of time before anadromous individuals migrate as smolts through the Columbia River to the Pacific Ocean. Non-anadromous individuals (residuals/residents) remain in Osoyoos Lake. Available spawning and rearing habitat in Canada could support many times more Okanagan chinook than have been observed for several decades.

Biology

Anadromous Okanagan chinook enter the Okanagan River in June/July and likely hold until spawning in October. Peak spawning occurs generally in the third week of October, when water temperatures are about 10°C-14°C. It is unknown whether spawning also occurs in early July when temperatures are also favourable. Eggs incubate through the winter and fry emerge between January and May.

Fry rear in the Okanagan River and/or Osoyoos Lake for a period ranging from weeks to a year or more. Anadromous migrants exit Osoyoos Lake probably during April/May or in early July. The marine phase of their life history ranges from 1–3 years with adults returning primarily as four- or five-year-olds. Some Okanagan chinook appear not to migrate but instead come to maturity in Osoyoos Lake. Their reproductive success is unknown.

Population sizes and trends

The historic population of anadromous Okanagan chinook was large in size and supported a significant food and commercial/economic trade fishery by the native Okanagan peoples. However, the current population of anadromous individuals (when enumerated) is now only 5-25 adults. In addition, there may be a freshwater maturing segment of the population, but their numbers are hard to estimate and are probably also very low. The Okanagan chinook has been historically persistent, but with such low numbers its future persistence is unlikely.

Limiting factors and threats

Limiting factors include habitat issues and exploitation by various fisheries. Habitat issues include: (1) direct losses of migrating juveniles and adults to injury and predation at the mainstem dams and their impoundments; (2) indirect losses due to migration delays; (3) loss of access to habitat upstream of McIntyre Dam; (4) water quality issues in spawning and rearing habitats; and (5) ecological effects of exotic species including several competitive and predatory fish species, Eurasian milfoil (a plant) and *Mysis relicta* (a planktonic crustacean) in Osoyoos Lake.

Analysis of habitat between Osoyoos Lake and McIntyre Dam indicates that habitat availability does not limit actual spawning activity. While the rate of egg-to-fry survival is unknown, live alevins and fry have been observed in many areas of the spawning grounds. However, there is little suitable river rearing habitat for juveniles due to channel modifications and high summer water temperatures. While juvenile rearing habitat is available in Osoyoos Lake, it may be severely limited in some years due to high water temperatures in the epilimnion and anoxic conditions in the hypolimnion.

Habitat impacts in the U.S. Columbia River can be severe. An estimated 80-85% of anadromous adults survive the upstream migration through dams and impoundments, but only some 43% of anadromous juveniles survive the outward migration.

Anadromous adults are captured in various fisheries, including marine and freshwater. Total fishing mortality for Columbia River summer chinook (Okanagan chinook migrate with these) during the 1990s averaged 31.8%, but increased to a high of 76.4% in 2003 (marine and freshwater). Freshwater fisheries have steadily increased their exploitation of summer chinook, and those that have escaped marine fisheries and lower Columbia River fisheries and enter the upper reaches of the Columbia River, such as the Okanagan chinook, have experienced an expanding fishery from a couple of percent in 2000 to 30% in 2005. The combined mortality resulting from human exploitation and habitat problems such as dams poses a threat to the existence of Okanagan chinook.

The neighbouring chinook salmon populations in the U.S. portion of the Okanagan basin are considered by state fisheries agencies to be “of special concern” (ocean-type) or extirpated (stream-type). The U.S. Colville Confederated Tribes have a hatchery program aimed at reintroducing stream-type chinook into the U.S. portion of the Okanagan basin, and strays from this program could further threaten the integrity of Okanagan chinook.

Special significance of the species

The Okanagan chinook is the only remaining population of Columbia River basin chinook salmon that spawns in Canada. This population shows evidence of extended freshwater rearing, a trait that is uncommon in the chinook salmon of the U.S. portion of the basin. Furthermore, this extended freshwater rearing may include reproduction without migration to the Pacific Ocean, although this has yet to be well documented. Okanagan chinook are also significant for their contributions to First Nations communities, especially as an important food and commercial trade species for aboriginal harvest. There are numerous aboriginal fishing stations along the Okanagan River that are not utilized because of the lack of Okanagan Chinook.

Existing protection or other status designations

In May 2005, COSEWIC assessed the Okanagan chinook as Endangered in an Emergency Assessment. Provincial and federal statutes and policies exist to protect fish and their freshwater and marine habitats.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5th 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2006)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and it is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

Environment Canada — Environnement Canada
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Canada

The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

COSEWIC Status Report

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Chinook Salmon
Oncorhynchus tshawytscha

Okanagan population

in Canada

2006

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SPECIES INFORMATION

Name and Classification

Chinook salmon (Salmonidae: *Oncorhynchus tshawytscha* Walbaum) is one of seven species of the genus *Oncorhynchus* native to North America (Healey 1991). Other common names include spring salmon, king salmon, tyee, and quinnat (Scott and Crossman, 1973). There are two names for chinook salmon in the Okanagan River basin that are used by aboriginal Okanagan peoples: Ntitiyix, meaning “king salmon”, and Sk’elwis, meaning “old king salmon”, which was used to refer to spawners later in the year (Vedan, 2002). The common name in French is saumon chinook.

Morphological Description

Chinook salmon (Figure 1) adults are distinguished from other *Oncorhynchus* species by their large size (up to 45 kg), and by: (1) the presence of small black spots on both lobes of the caudal fin; (2) black gums at the base of the teeth in the lower jaw; and (3) the large number of pyloric caeca (>100) (McPhail and Lindsey, 1970 *cited in* Healey, 1991; McPhail and Carveth, 1994).

Chinook fry and parr are distinguished by the presence of parr marks extending well below the lateral line, the deepest of which are deeper than the vertical eye diameter (McPhail and Carveth, 1994). The adipose fin is normally unpigmented in the centre, but edged with black. The anal fin is usually only slightly falcate, and the leading rays do not reach past the posterior insertion of the fin when folded against the body. The anal fin has a white leading edge, but the adjacent dark line present in coho salmon (*O. kisutch*) is absent. However, juvenile characteristics are highly variable, so proper identification often requires meristic and pyloric caeca counts (Healey, 1991).

Figure 1. Chinook salmon female from the Okanagan River Basin (2002 spawning season).

Genetic Description

The life history of chinook salmon, especially its anadromy and homing to natal streams for reproduction, results in reproductive isolation, genetic differentiation, and the development of local adaptations. Healey (1991) provides a description of chinook life histories, some of which is summarized here.

The chinook salmon life history includes two largely discrete behavioural forms: “stream-type” and “ocean-type”. The stream-type form is typical of Asian populations and of northern and headwater populations in North America (Healey, 1991). In many areas, stream-type chinook are referred to as “spring chinook” because of the timing of their re-entry to freshwater. Stream-type chinook spend one or more years rearing in freshwater as juveniles before migrating to the ocean, where they exhibit extensive offshore migrations for one or more years before re-entering freshwater in the spring or summer (i.e., many months before spawning in their natal habitat). Occasionally some males (and, more rarely, females) of this form do not migrate, but rear entirely in their natal freshwater habitat (Healey, 1991). For the purposes of this document, chinook salmon in the Okanagan River Basin that are the offspring of anadromous parents but rear entirely in their natal freshwater habitat are referred to as “residuals”, whereas those whose parents were not anadromous but reared entirely in their natal freshwater habitat are referred to as “residents”. The ocean-type chinook form is typical of North American populations south of Alaska. Juveniles of this form usually migrate to the ocean during their first year following emergence, normally within the first three months. Ocean-type chinook spend nearly their entire life in the ocean, re-entering freshwater in the summer or fall, a few days or weeks before spawning (Healey, 1991). Depending on the timing of their spawning migration, ocean-type chinook are commonly referred to as “summer chinook” or “fall chinook”, although there is considerable variability and overlap between the migration timing of spring, summer and fall chinook (Chapman *et al*., 1995; Fish and Hanavan, 1948).

The following description of genetic relationships among North American chinook populations is mainly derived from a summary of extensive analyses and discussion presented by Myers *et al*. (1998). Populations in south-central and northwestern Alaska are genetically distinct from populations in southeastern Alaska, which are most similar to stream-type populations in northern B.C. Ocean-type chinook salmon populations from Vancouver Island, the lower Fraser River, and southern B.C. form a genetically distinct, though diverse, group. Populations in Puget Sound and along the Washington Coast also form distinct groups. Within the Columbia River basin there appear to be two large genetic groups: ocean-type and stream-type chinook. All populations south of the Columbia River appear to consist of ocean-type chinook. Genetic groupings in this southern area include the northern Oregon Coast, southern Oregon Coast to the lower Klamath River in northern California, a California coastal group, and the Sacramento and San Joaquin River populations.

Within these broad population groups there may be several sub-groupings based on genetic, geographic, or behavioural considerations. For example, within the Columbia

River basin, the National Marine Fisheries Service (NMFS) has identified seven evolutionarily significant units (ESUs) of chinook: four ocean type and three stream-type (Myers *et al*., 1998). An ESU is a population or group of populations that is substantially reproductively isolated from other populations and represents an important component of the evolutionary legacy of the species (Waples, 1991). The genetic basis for designating ESUs within the U.S. has relied on frequencies of protein variants (allozymes), or of naturally occurring mutations in minisatellite and microsatellite loci and mitochondrial DNA (Myers *et al*., 1998). The degree of reproductive isolation is inferred from an analysis of the pattern of genetic distances between populations (Myers *et al*., 1998). In addition to this research in the U.S., Fisheries and Oceans Canada (DFO 1999a, b) proposed recognizing five or six distinct units of chinook salmon within the Fraser River basin (Candy *et al*., 2002).

Designatable Unit: Okanagan chinook

The case for recognizing Okanagan chinook as a COSEWIC Designatable Unit (DU) is based on this population's: (1) genetic differentiation from other Canadian chinook salmon populations; (2) geographic and reproductive isolation; and (3) unusual life history characteristics. These aspects of the Okanagan chinook population are described in the following paragraphs. This unique population of chinook salmon in Canada will be referred to as "Okanagan chinook."

<u>Genetics</u>

The Okanagan chinook is genetically differentiated from all other Canadian chinook salmon populations. Chinook populations in North America have been grouped into ESUs (or equivalents) (e.g., Waknitz *et al*., 1995; Myers *et al*., 1998, Teel *et al*., 1999; Candy *et al*., 2002), with the units in the Columbia River basin found to be genetically distinct from those in the Fraser basin (or elsewhere in Canada), likely because of different glacial histories (Myers *et al*., 1998). The Canadian Okanagan chinook population is the only remaining Columbia River basin chinook population in Canada.

Examination of genetic relationships between the Okanagan chinook and other populations in the Columbia River basin has only recently begun. Beginning in 2000, tissue samples have been collected from a total of 36 unclipped (i.e., not hatchery marked) chinook captured in the Okanagan River or Osoyoos Lake. A single fish was sampled in each of 2000, 2002, and 2003, while three were sampled in 2004 and the remaining 28 in 2005. In addition, a tissue sample was collected from one fin-clipped (i.e., hatchery origin) chinook in 2005; although this sample was not included with the unclipped fish when compared to other populations (Anonymous 2006).

As detailed in Anonymous 2006, Okanagan chinook clustered with upper Columbia summer and fall run chinook salmon populations. The longer dendrogram branch length associated with the Okanagan River sample reflects the larger (Cavalli-Sforza Edward chord) distances between it and the other samples in the group (Figure 2).

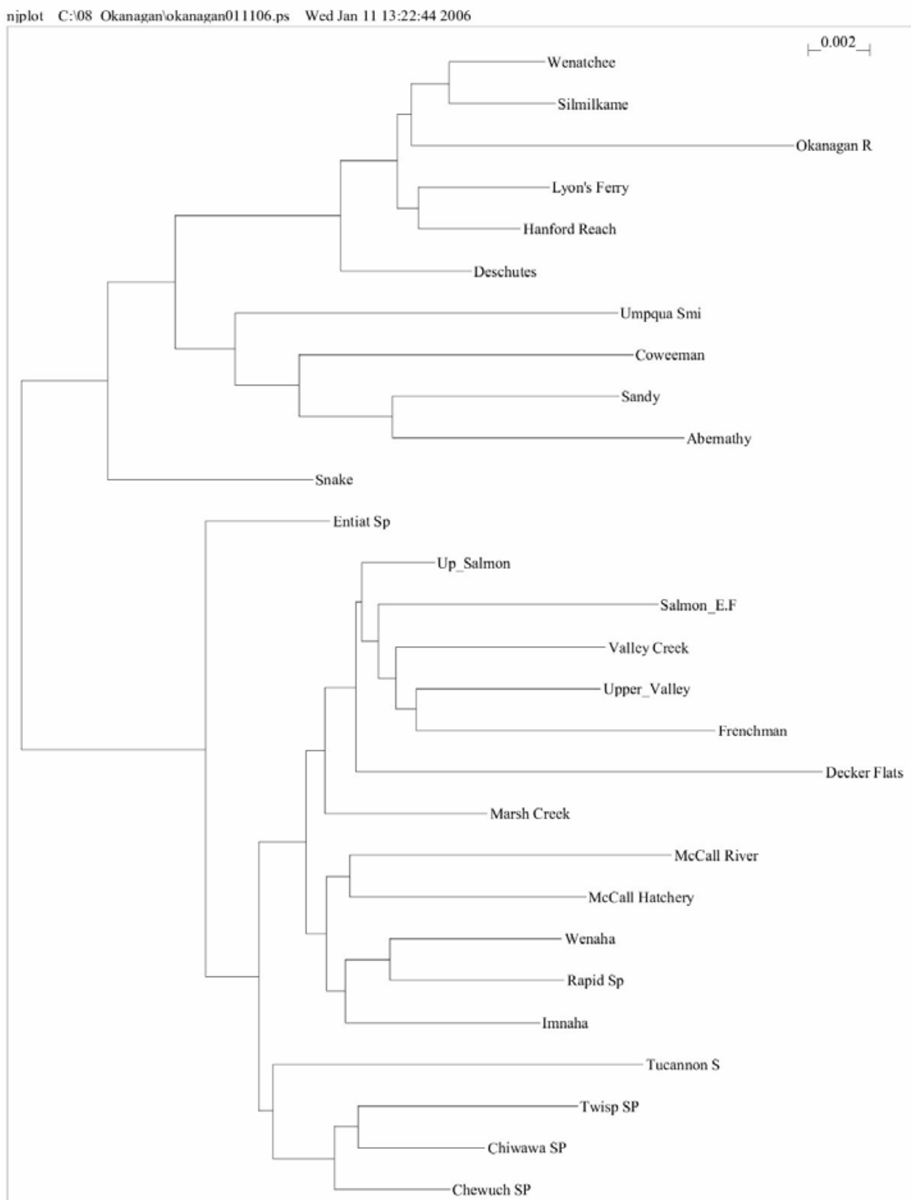


Figure 2. Dendrogram of Cavalli-Sforza and Edwards (1967) chord distances based on 12 microsatellite loci for chinook salmon populations in the Columbia and Okanagan Basins. Reproduced from DFO MGL (2006). See Candy *et al*. (2002) for methods.

However, this distinctiveness of the Okanagan sample is attributable in part to the small sample size relative to both the Similkameen (N= 92) and Wenatchee (N=93) samples, and especially to the close familial relationships between the sampled fish in 2005 (DFO MGL 2006). Of the 28 fish sampled in 2005, 21 were closely related, either full or half siblings, to at least one other fish. The whole group of 28 chinook was the offspring of 11 fish of one sex and 18 fish of the other. Estimates of F_{ST} (a measure of genetic differentiation) between the Okanagan River sample and the Similkameen and Wenatchee Rivers were relatively low (mean F_{ST} = 0.016) despite the fact that the F_{ST} value was likely inflated by the presence of closely related fish in the Okanagan sample. Finally, in spite of the small numbers of spawners observed and their high degree of inter-relatedness in 2005 the allelic richness of the Okanagan sample (A_R = 12.6) was comparable to other, larger populations in the Columbia River basin (mean A_R = 11.9). Collectively, the genetic data indicate that the Okanagan River population is closely related to and likely derived at least in part from stray spawners from other populations in U.S. portions of the upper Columbia River drainage, a conclusion consistent with the presence of adipose-clipped chinook salmon in the river.

Nonetheless, an important implication of the close familial relationship between the chinook sampled on the spawning grounds in 2005 is that it provides strong evidence of successful out-migration, return and survival to spawning of Okanagan-produced chinook.

Geographic/Reproductive Isolation

The Canadian Okanagan chinook population is geographically and reproductively isolated from other Canadian chinook populations. The Okanagan River in British Columbia is the only portion of the Columbia River basin in Canada that is currently accessible to anadromous salmonids. Historically, prior to the construction of Grand Coulee Dam (completed in 1939), large numbers of salmon spawned as far upstream as the outlet to Lake Windermere, British Columbia (Fulton, 1968; Scholz *et al*., 1985; Chapman *et al*., 1995). The spawning grounds for the Canadian Okanagan chinook population are nearly 1000 km from the mouth of the Columbia River, and about 1400 km, by water, from the closest chinook salmon populations along the coast of BC. Although only a few kilometres would have separated the Okanagan and South Thompson (Fraser basin) chinook salmon (prior to the exclusion of chinook salmon from Okanagan Lake), this separation is believed to have existed since late in the last ice age. Presumably straying rates for all Columbia River basin chinook salmon populations (and those elsewhere) are very low, since Columbia River basin chinook salmon are in different ESUs than those in immediately adjacent coastal areas. Hatchery-produced chinook have been observed on the spawning grounds in the Okanagan River so clearly the Okanagan chinook population is influenced by chinook from neighbouring populations.

Life History Characteristics

The Okanagan chinook exhibits unusual life history characteristics when compared to chinook salmon in the U.S. portion of the Okanagan basin (Similkameen). The principal difference is the extended period of freshwater rearing by juveniles, with the additional possibility of freshwater maturation. The evidence of freshwater maturation is that: (1) seven young (mostly aged 1+) chinook captured in Osoyoos Lake in September 2003 were resorbing scales, consistent with scale resorption prior to reproduction in older anadromous salmon (ONAFD, *unpublished data*, 2005): (2) the stomach samples of six of these seven chinook contained sockeye fry, indicating piscivory (an adult characteristic), and the six also exhibited additional internal features of sexual maturation (ONAFD, *unpublished data*, 2005); and (3) in the 2005 Okanagan River samples, 4 of 17 female chinook were fully reproductively mature at three years of age, earlier than known for anadromous females.

Additional field assessment is required to determine whether these freshwater-rearing chinook salmon spawn in the Okanagan River. If they do spawn, these residuals/residents may have retained some of the population's historic genetic lineage, bridging the period when the Grand Coulee Fish Maintenance Program (GCFMP) excluded anadromous fish from the Okanagan River. Under the GCFMP, most upstream migrating anadromous fish from the Upper Columbia River were captured in the fishway at Rock Island Dam for five years (1939-1943). The fish were then used as hatchery broodstock or were transported to major rivers upstream of Rock Island Dam (excluding the Okanagan) to spawn naturally. Hatchery out-plants were also released into selected rivers upstream of Rock Island Dam, with sockeye being the only anadromous salmon released directly into the Okanagan River. By 1944, it is possible that many of the returning runs of chinook to the Upper Columbia were the progeny of the mixed-stock hatchery and relocated stocks (Fish and Hanavan, 1948); however, some wild 6-year-old chinook may have returned to their natal streams in 1944 (Mullan, 1987) and continued existing lineages. It is also not known if any Okanagan chinook that were released upstream of the dam found their way to the Okanagan River.

DISTRIBUTION

Global Range

Spawning populations of chinook salmon are distributed from northern Hokkaido (Japan) to the Anadyr River (Russia) on the Asian coast, and from central California to Kotzebue Sound (Alaska) on the North American coast (Figure 3). Spawning occurs from near tidewater to over 3,200 km upstream in the headwaters of the Yukon River (Major *et al*., 1978 *cited in* Healey, 1991). Spawning stream-type and ocean-type chinook populations are geographically separated to a considerable degree: whereas Asian and Alaskan chinook populations are mainly stream-type, those in the remainder of the North American populations are predominantly ocean-type (Healey, 1983, Healey, 1991). Where stream- and ocean-type populations are found in the same river, stream-type fish tend to be found in headwater spawning areas and ocean-type in downstream spawning areas (Myers *et al*., 1998; Healey and Jordan, 1982), although these behavioural "types" may simply be a continuum of temperature-driven behaviour (Brannon *et al*. 2004). While ocean-type chinook tend not to disperse more than 1,000 km from their natal river or far from shore (Healey, 1983), stream-type chinook tend to disperse more broadly and further offshore (Healey, 1991).

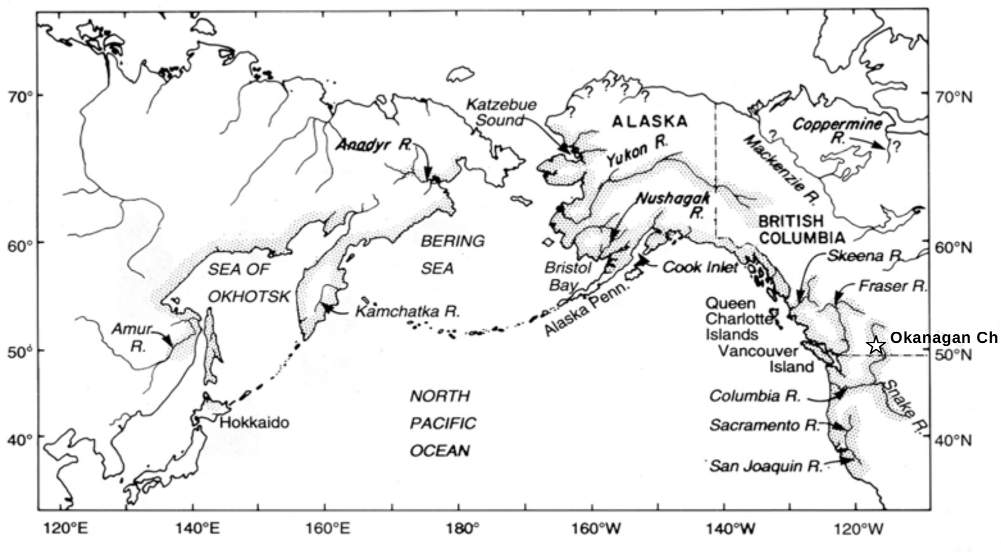


Figure 3. Map of the North Pacific Ocean and Bering Sea, showing the distribution of chinook spawning populations (stippled) (Used with permission from M.C. Healey, Fisheries and Oceans Canada).

Canadian Range

Chinook salmon are native to rivers along the entire west coast of Canada, and may also be found in rivers on the Arctic coast (Healey, 1983). In addition, naturally spawning populations may have become established from transplants in the Laurentian Great Lakes (Carl, 1984).

In the Okanagan Basin (Figure 4), First Nations have reported that chinook were once heavily fished at Okanagan Falls (i.e., outlet of Skaha Lake), and that chinook were able to reach both Skaha and Okanagan Lakes (Ernst, 1999; Ernst and Vedan, 2000). Corroboration of these claims is found in the reports of Clemens *et al*. (1939), Gartrell (DFO, *unpublished files*, December 1919 and April 1920), and Kelowna Fish and Game Association (DFO, *unpublished files*, August 1924). Chinook cannot currently reach either Okanagan Falls or any of the lakes upstream of Osoyoos Lake due to the presence of McIntyre dam at the outlet of Vaseaux Lake.

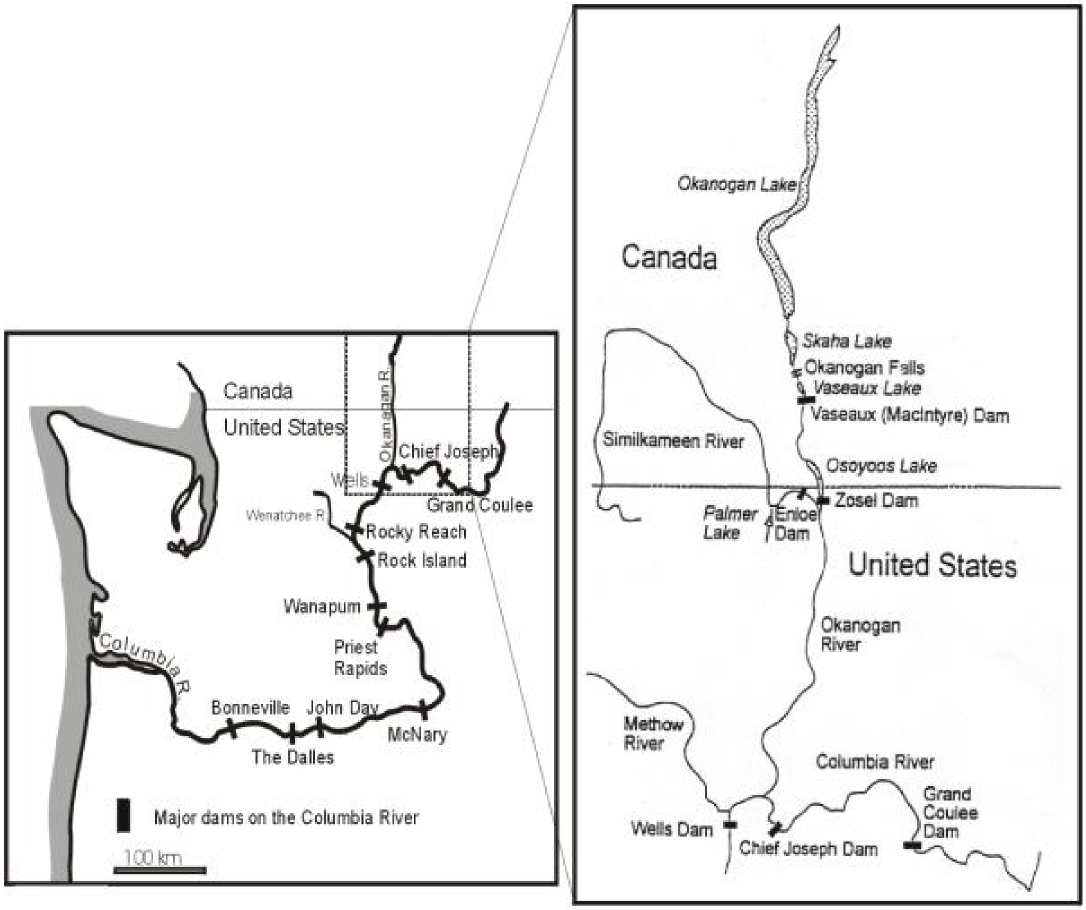


Figure 4. Map of Okanagan Basin in relation to British Columbia and Washington State. Map reprinted with permission of Paul Rankin, DFO.

HABITAT

Habitat Requirements

Chinook salmon rearing occurs in streams, as well as lakes, estuaries, and the ocean. Maturing adults migrate to spawn in their natal streams, whereupon the adults die. However, precociously maturing fish, especially sub-yearling males, may be able to recover from spawning and spawn again in a subsequent year (Mullan *et al*., 1992).

While chinook spawning habitat includes a broad range of water depths, water velocities, and substrates (e.g., Scott and Crossman, 1973; Healey, 1991), it is often patchily distributed within apparently uniform habitats, suggesting that other factors, such as intra-gravel flow, may be most critical (M. Healey, personal communication, 2004). In some cases, however, water velocity and substrate have been found to be useful predictors of preferred chinook spawning habitat (Gallagher and Gard, 1999). Spawning habitat characteristics for Okanagan chinook, based on measurements taken at 18 redds in 2002 and 2003, have been documented (Table 1; Phillips and Wright 2005).

Table 1. Chinook spawning habitat characteristics in the Okanagan River.

	Depth (m)	Mean Velocity (m/s)	Substrate Size D_{90} (m)	Substrate Size D_{50} (m)
Mean	*0.49*	*0.65*	*0.10*	*0.05*
Std Dev.	0.16	0.19	0.03	0.02
Minimum	0.20	0.34	0.05	0.03
Maximum	0.75	1.14	0.14	0.10

Phillips and Wright (2005) estimated that there could be spawning habitat for between 1,260 and 4,340 spawning pairs of Okanagan chinook between Osoyoos Lake and McIntyre Dam. The upper end of the habitat availability range is based on the above factors and is a likely over-estimate; however, the lower end of the range also considers areas of groundwater inflow in the river and observed redd associations with instream bars and islands.

Estimates of the area of the Okanagan River and Osoyoos Lake that are available for spawning and juvenile rearing suggest that the geographic extent of occurrence (EO) of Okanagan chinook is roughly 16 km^2, and that the area of occupancy (AO) is only slightly less at perhaps 15 km^2 in Canadian freshwaters. Anadromous individuals also use the Columbia River as a migration corridor, and the Pacific Ocean for growth to adulthood (neither of which are included in calculations of EO and AO).

Habitat Trends

<u>Stream Habitat</u>

As in the United States, chinook salmon in Canada have been adversely affected by numerous factors, including water withdrawals, construction of dams (for power generation or water diversion) that limit fish passage or entrain/harm migrating fish, and degradation of habitat through industrial, agricultural and urban usage (Raymond, 1988; Myers *et al*., 1998). Habitat loss/degradation might be inferred, in part, from the historical decline in chinook salmon abundance in the Upper Columbia River (i.e., hundreds of thousands of chinook salmon in the Upper Columbia River in the mid-1800s vs. about 58,000 in the same area in recent years; Myers *et al*., 1998).

Loss of habitat (or access to habitat) for spawning, rearing and holding has had an unknown impact on the Okanagan chinook population. Had access been restricted while the run was still strong, the impacts would likely have been profound. However, the run was probably already depressed, possibly by factors outside the basin, by the time the mainstem dams in Canada were constructed. Historical reports and Okanagan traditional knowledge indicate that chinook had originally had access to Okanagan Lake (Clemens *et al*. 1939, Ernst 1999, Vedan 2002).

The long history of major mainstem channel modifications in the Canadian Okanagan basin began in about 1910, with modifications to the outlet of Okanagan Lake (Symonds, 2000). Since that time, dams have been constructed at the outlets to Okanagan Lake

(Penticton Dam), Skaha Lake (Okanagan Falls Dam), Vaseaux Lake (McIntyre Dam), and Osoyoos Lake (Zosel Dam in the U.S.). Only Zosel Dam at the outlet to Osoyoos Lake is regularly passable to upstream migrating fish. While McIntyre Dam can be managed to permit passage of adult salmonids at some times of year (Summit and ONFC, 2002), this is not the usual practice. At present, all anadromous salmonids spawn downstream of McIntyre Dam, unless a few are permitted to pass the dam.

In addition to loss of access to habitat, there have been major direct losses of spawning and rearing habitat in the Canadian Okanagan River. Most of the river between Okanagan and Osoyoos Lakes has been straightened and channeled (Symonds, 2000). Where there once was over 10 km of channel (about 80,000 m^2) between Okanagan and Skaha Lakes that was suitable for use by spawning sockeye (and presumably chinook), there is now only about 3 km of channel suitable for spawning (Anonymous, 1909; Summit, 2003). Similar or greater habitat losses have occurred throughout the mainstem Okanagan River in Canada wherever the river has been channeled (Hourston 1954): one estimate puts the loss of natural accessible river channel at 91% (Bull 1999). However, this does not necessarily mean that there has been an equivalent reduction in suitable habitat for spawning salmonids. The amount of summer rearing habitat in the river (i.e., groundwater-fed side channels) that has been lost is unknown. However, it is likely that little usable summer habitat remains in the dyked sections of channel due to the absence of side channels and other areas where groundwater inflow may have a significant temperature-moderating effect.

At present, the Okanagan River is used by spawning Okanagan chinook and may be used by rearing juveniles for a period ranging from days to months or longer. High water temperatures in the river limit the period when mature Okanagan chinook can enter the river, both for migration and spawning, and limit the area available for rearing juveniles. During the summer months, water temperatures in the river are often in the lethal range for chinook salmon, except in groundwater-fed side channels (ONA, 2003). Juvenile salmonids have been observed in side channels of the river when temperatures in the rest of the river were 24°C (Alexis *et al*. 2003). Water temperatures in the river prior to construction of the mainstem dams and other channel modifications are not known.

Following the last major channel modifications in the 1950s, fish habitat in the river has remained relatively unchanged until the past five years. Stream channel habitat conditions do not appear to have degenerated in the past 50 years. In fact, water quality in the river has probably improved in the past 20 years in response to widespread improvements to sewage treatment in upstream areas. Other habitat improvements include the addition of fish screens to many water intakes on the river and the experimental addition of rock riffles (to increase habitat diversity and improve fish passage) in a channeled section of river. Another major improvement is a water management initiative directed at improving decision-making for the benefit of fish in the mainstem river and lakes (COBTWG, 2004). The water management initiative is expected to significantly improve sockeye—and presumably chinook—smolt production (COBTWG, 2004). Lastly, there are conceptual plans to re-naturalize the Okanagan River to its fullest extent, with measures including re-oxbowing, set-back dyking, riparian restoration, and construction of instream riffles (Gaboury *et al*.

2000). Implementation of this concept has begun with an area along the Okanagan River purchased and identified for set-back dyke restoration.

Lake Habitat

Due to historical dam construction and current dam management practices Osoyoos Lake provides the only lake-rearing habitat available to anadromous salmon in the Okanagan basin. Adult Okanagan chinook hold in the lake for weeks or months prior to spawning, and juveniles rear in the lake for a period ranging from weeks to years. Most of the detailed observations on rearing conditions in Osoyoos Lake have been focused on sockeye salmon, but much of this information also applies to Okanagan chinook.

Osoyoos Lake consists of a series of three basins, with the southern-most basin spanning the Canada-United States international boundary. The lake has a mean depth of 15 m and a water residency time of about 0.7 years (Pinsent *et al*. 1974). It is classified as a mesotrophic lake, with phosphorus as a limiting nutrient (Wright 2002). There has been no paleolimnological work conducted on Osoyoos Lake, so historical information is lacking. However, phosphorus reduction measures were implemented (as in the other mainstem Okanagan lakes) in the early 1970s due to water quality issues (Pinsent *et al*. 1974). Jensen and Epp (2001) note that water quality has improved in terms of phosphorus reduction: where spring phosphorus loading in the early 1970s was about 25-30 μg/L, today it averages 15-20 μg/L.

Osoyoos Lake has a high percentage of littoral area (23%) compared to Skaha and Okanagan Lakes (15%) (Wright, 2002). However, high epilimnetic water temperatures likely limit littoral habitat usage by chinook during the growing season (April to November). In addition, exotic Eurasian milfoil (*Myriophyllum spicatum*) has spread rapidly in Okanagan littoral areas and would provide additional habitat for exotic "ambush" predator species such as largemouth bass (Wright *et al*. 2002). Beach seining for sockeye in the north basin of Osoyoos Lake in 2002 found that fry were present in low abundance in littoral areas until water temperatures exceeded 17°C (mid-June), at which time they move offshore (ONAFD, unpublished data, 2005). In addition, rearing habitat in the lake may be further constrained in late summer and fall by high water temperatures in the epilimnion and low dissolved oxygen levels in the hypolimnion (Wright 2002; Wright and Lawrence 2003). This habitat squeeze between high water temperatures in the epilimnion and low dissolved oxygen levels in the hypolimnion is particularly severe in the two southern basins of the lake, such that all sockeye (and likely Okanagan chinook) production in Osoyoos Lake is from the northern basin (Hyatt & Rankin, 1999). However, in spite of habitat limitations, sockeye smolts in Osoyoos Lake are among the largest in the world (Hyatt & Rankin 1999), testament to the abundance of food in the lake. Okanagan chinook rearing in the lake may exhibit similarly high growth rates, which may contribute to the anomalous extended freshwater rearing (Brannon *et al*. 2004).

An additional constraint of unknown severity results from the introduction of an exotic shrimp, *Mysis relicta*, into the Okanagan basin. *M. relicta* has been present in the lake since at least 1998 (Hyatt and Rankin 1999), having invaded from upstream lakes where it is well established. There is usually a downward trend in limnetic fish populations after *M. relicta* invasion (Lasenby *et al*. 1986), and this has already been documented for kokanee salmon populations in Okanagan Lake. While chinook are more often found in littoral areas and feed less on zooplankton (i.e., less competition with mysids), this behaviour has not been established for Osoyoos Lake, where the littoral zone is likely inaccessible through much of the growing season due to high water temperatures (ONAFD, *unpublished data* 2005).

In summary, high water temperatures in the Okanagan River constrain the timing of Okanagan chinook adult migration and spawning, and restrict juvenile rearing habitat to groundwater-fed side channels during much of the summer. Construction of dams has reduced accessible Okanagan chinook habitat to a fraction of its former size, eliminating access to the mainstem river, lakes and tributaries upstream of McIntyre dam (i.e., the outlet of Vaseaux Lake). In addition, approximately 90% of the mainstem Okanagan River in Canada has been modified, resulting in a major loss of spawning and rearing habitat. Salmon rearing habitat in Osoyoos Lake is largely limited to the north basin. Okanagan chinook may rear in littoral areas early in the growing season, but are soon constrained by high epilimnetic water temperatures. Rearing habitat is further constrained by low hypolimnetic dissolved oxygen levels in the late summer and fall. In addition, Okanagan chinook rearing in the lake may have to compete with mysids for food (at least until they become piscivorous), especially when littoral areas are inaccessible, and may be subject to predation by exotic species when rearing in littoral areas. However, in spite of these constraints, Osoyoos Lake does provide a productive environment for salmon rearing, as evidenced by the growth rate and smolt sizes of sockeye salmon.

Habitat Protection and Ownership

The main chinook spawning area in the Okanagan River is between Oliver and McIntyre Dam. Nearly the entire accessible spawning area in Canada is dyked, and thus the channel is either actively managed by the B.C. Ministry of Water, Land and Air Protection or is within the boundaries of Osoyoos Indian Band reserve lands. There is very little development along the river channel where it passes through the Indian Reserve.

In the Canadian portion of the Okanagan and Similkameen watersheds, provincial parks account for 14.5% of land ownership. Indian Reserve lands comprise an additional 4%, and 50.2% is municipal or privately owned land. The remaining land base (approximately 30%) is designated as Crown lands. In addition, 31.8% of the land base (distributed throughout these designations) is held in the Agricultural Land Reserve.

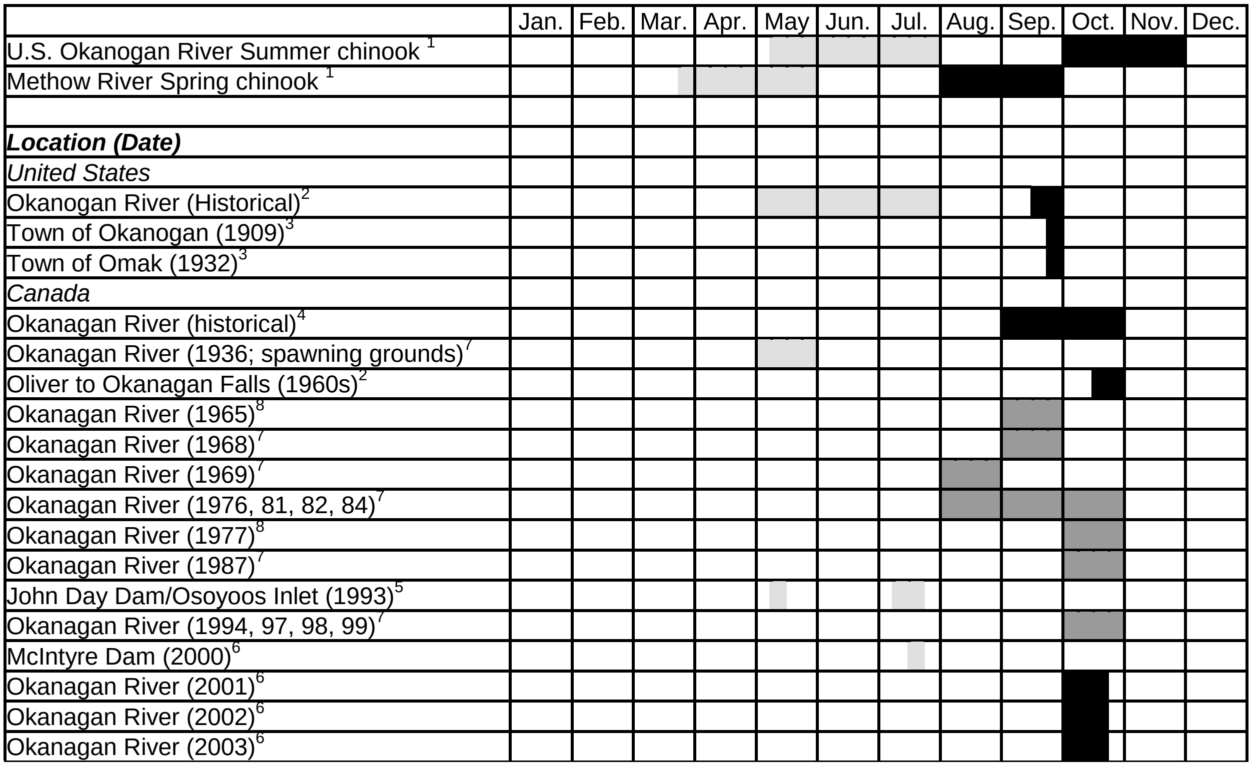
BIOLOGY

The general biology of chinook salmon has been well documented in North America. The following sections draw heavily from Healey (1991) and Myers *et al*. (1998). The characteristics of the Okanagan chinook population have only recently begun to be documented, apart from traditional ecological knowledge and sporadic past observations. The main source of current information on this population is a compilation of observations collected by the Okanagan Nation Alliance Fisheries Department (Wright and Long, 2005).

Life Cycle and Reproduction

Based on both traditional ecological knowledge (Ernst and Vedan, 2000) and recent observations on run timing (Wright and Long, 2005), Okanagan chinook spawn in the fall. Since there are accounts of chinook arriving in the river upstream of Osoyoos Lake in spring/early summer, there may have been a second population spawning in late-June/early July prior to elevation in river temperatures; alternatively, these early arrivals may be an early migrating segment of the same fall-spawning population. Historical Indian fisheries conducted in May, June and early July were likely for spring (stream-type) chinook (Moore *et al*., 2004). In addition, Canadian biologist Gartrell noted 100-300 spring chinook present on the spawning grounds upstream of Osoyoos Lake in May of 1936 (DFO unpublished files, 1936 Salmon Escapement Data Set file). Data on run timing have been collected for the U.S. Upper Columbia River chinook salmon ESU, including both ocean-type (U.S. Okanogan River) and stream-type (Methow River) chinook, and a summary of observed run times in the Okanagan River basin has been compiled (Figure 5). Recently, spawning by chinook upstream of Osoyoos Lake is observed in October, which is typical of ocean-type populations in the Upper Columbia River basin. Spawning is likely initiated by a reduction in temperatures to below 16°C (Healey, 1991), which occurs in the Okanagan River in late September or early October (Hyatt and Rankin, 1999). While this spawn timing is typical of ocean-type chinook, conditions in the lake may permit a stream-type population to thermoregulate and delay spawning through to October, such as occurs elsewhere in the Columbia basin (Myers *et al*., 1998).

There is little information on the age distribution of spawners in the Canadian Okanagan River. However, assessments of the stock in the U.S. portion of the basin have identified approximately 21% as three-year-old males (i.e., jacks), 44% as four-year-olds, and 34% as five-year-olds (Howell *et al*., 1985, Chapman *et al*., 1994). (Age is measured from egg deposition.) No two-year-old (i.e., age 1+) spawners were recorded in the U.S. Okanogan basin, and only one percent of spawners were six-year-olds. In the Canadian Okanagan basin most of the small chinook that have been caught in Osoyoos Lake have been identified as two-year-olds (i.e., 1+) (ONAFD, unpublished dat*a*, 2005). Prior to 2005, seven full-sized chinook from the Canadian Okanagan basin were aged; one was a four-year-old (sex unknown), while the other six (three males and three females) were at least five years old (Wright and Long, 2005). For 2005, a total of 23 chinook were aged (DFO aging lab) in the Canadian Okanagan basin (ONAFD, unpublished data, 2005). The sex ratio was 43.5% males to 56.5% females. For 2005, 43.5% were three-year-olds (5 males and 5 females), 47.8% four-year-olds (4 males, 7 females), and 8.7% five-year-olds (1 male, 1 female).



[1]Myers *et al*. 1998, [2]Smith 2002 (chinook spawning described as being near the end of sockeye spawning), [3]Smith 2003b, [4]Vedan 2002 (chinook fishery described as being in the fall, but prior to the chum salmon fishery in November), [5]MOE 1993, [6]Wright and Long 2005, [7]DFO SEDS unpublished files, [8]DFO SEDS correspondence files.

Adult Freshwater Migration = Spawning = Present – unknown if migration or spawning

Figure 5. Summary of historical and recent chinook salmon observations in the Canadian Okanagan basin and selected historical observations in the U.S. portion of the basin.

There are no fecundity data reported for Okanagan chinook. However, upper Columbia River chinook captured at Wells Dam, the nearest dam downstream of the Okanagan River confluence, showed a mean fecundity of 5041 eggs per female, with fish averaging 90.4 cm long (Hymer *et al*., 1992; Myers *et al*., 1998). Larger fish tend to produce more and larger eggs, but the relationship is non-linear (Myers *et al*., 1998). A variety of additional factors influence both the number and size of eggs including fish age, life history strategy, migration distance, and latitude (Myers *et al*., 1998).

Egg to fry survival in chinook is highly variable, but Healey (1991) placed an upper limit of 30% on eggs deposited and incubated under natural conditions. Egg survival can be relatively high where intra-gravel percolation is good and redds are not impacted by scour, desiccation, or deposition of fine particles (Healey, 1991). Where the density of spawners is high, established redds are often disturbed by subsequent spawners with a resultant loss of eggs.

Predation

Predators are commonly implicated as the principal agent of mortality among young juvenile chinook (Healey, 1991). Piscivorous birds and fish consume juvenile chinook in freshwater, estuarine, and marine environments. In addition, invertebrate predators have been observed to kill or injure juvenile salmon, but predation by invertebrate predators outside of hatchery conditions is not well documented (Healey, 1991). Mortality rates of 70%-90% among young juvenile Pacific salmon have been recorded in several river systems (Healey, 1991).

Among the piscivorous fish that likely prey on Okanagan chinook are numerous exotic species, 13 of which have been reported (Wright *et al*. 2002). Exotic species comprise 84% of the littoral fish population in Osoyoos Lake and are also found in the mainstem Okanagan River (Wright *et al*. 2002). Juvenile chinook in Osoyoos Lake may be preyed upon by bluegill (*Lepomis macrochirus*), black crappie (*Pomoxis nigromaculatus*), smallmouth bass (*Micropterus dolomieui*), yellow perch (*Perca flavescens*), and largemouth bass (*Micropterus salmoides*).

Predation mortality during downstream smolt migration has most likely increased in the Columbia River due to mainstem dams (Myers *et al*. 1998). This is evidenced by the fact that predator control measures have been conducted on the Columbia as a means of improving downstream smolt survival for salmon populations (Zimmerman 1999, Zimmerman and Ward 1999a, b).

Based on a review of several studies of mortality rates in ocean-rearing chinook salmon, Healey (1991) concluded that the marine mortality rate is likely less than 35% per year and probably closer to 20% per year. In addition, he concluded that mortality rates are likely higher during the first year or two at sea, and higher in coastal areas, which would result in relatively higher mortality rates for ocean-type chinook relative to stream-type chinook (which often complete extensive offshore migrations; Healey, 1983). Sources of mortality for chinook in the larger size classes include commercial and recreational fisheries, predation by large fish and mammals, disease, and adverse marine conditions in some years.

Physiology

The upper and lower temperatures for 50% pre-hatch mortality of chinook are 16°C and 2.5-3.0°C, respectively (Alderdice and Velsen, 1978 cited in Healey, 1991). The same authors identified the time to 50% hatch as about 159 days at 3°C and 32 days at 16°C, and concluded that a simple thermal sum model (development time = 468.7/T; where T is the average temperature during incubation) is adequate for predicting time to hatching.

Water percolation through spawning gravels is essential for egg and alevin survival, a requirement that can be severely compromised by siltation of spawning beds (Healey, 1991). Shelton (1955, *cited in* Healey, 1991) concluded that survival to hatching was greater than 97% at percolation rates of at least 0.03 cm/s, but that emergence was 13% or less from small gravel when percolation rates were less than 0.06 cm/s. Much higher emergence rates (87%) were recorded for chinook in large gravel with adequate intra-gravel flow.

Adults stop migration and seek temperature refuges when water temperatures exceed 22°C (Alexander *et al*., 1998). The preferred temperature for chinook fry is 12-14°C with the upper lethal temperature being 25.1°C (Scott and Crossman, 1973).

Dispersal/Migration

Upstream migration of mature Okanagan chinook occurs mainly during daylight hours with few fish migrating upstream at night (Healey, 1991). Conversely, downstream movement of fry occurs mainly at night, generally concentrated around midnight, although small numbers of fry may move during the day (Healey, 1991). As presented in Figure 5, the timing of upstream migration into the Okanagan River corresponds with that in the U.S. portion of the basin.

The only observations of Okanagan chinook leaving Osoyoos Lake were obtained in a rotary screw trap set 300 m downstream of Zosel Dam (i.e., at the outlet of Osoyoos Lake) (Hansen, 1996a and b). Okanagan chinook were recorded as an incidental observation to the target species (sockeye smolts), and little information is provided other than that chinook fry (newly emerged) were captured in a majority of sampling sessions between April 17 and May 31. The chinook fry observed may not have been from spawning areas upstream of the lake, but rather from redds between the trap and Zosel Dam, where suitable spawning habitat is present but spawning has not been confirmed (C. Fisher, personal communication, 2005). Newly emerged fry were also captured upstream of Osoyoos Lake in April and May (Wright and Long, 2005). There are no records of Okanagan chinook smolts leaving Osoyoos Lake.

As previously mentioned, stream-type chinook from the Columbia basin perform extensive offshore migrations in the ocean before returning to spawn, while ocean-type chinook are more commonly found in nearshore waters along the coast of North America. The ocean behaviour of Okanagan chinook has not been studied.

Okanagan chinook returning to spawn in the Okanagan basin must either enter the Okanagan River before river temperatures are too high or wait in the Columbia River for temperatures to decrease to tolerable levels. If they enter the Okanagan Basin before temperatures are high, they may briefly hold in the river upstream of Osoyoos Lake before falling back to the lake as temperatures rise. Tagging studies have shown that summer-run (ocean-type) chinook enter the Okanagan River from the Columbia River through July until the Okanagan River water temperature reaches 22°C, with the peak of Okanagan chinook migration into the Okanagan River occurring immediately after temperatures drop below this level in late-August (Alexander *et al*., 1998).

Interspecific Interactions

Predation on Okanagan chinook juveniles and adults has been discussed above and will not be covered in this section.

Okanagan chinook fry in freshwater feed on terrestrial insects, crustacea, chironomids, corixids, caddisflies, mites, spiders, aphids, corethra larvae, and ants (Scott and Crossman, 1973; Healey, 1991). The macrozooplankton community in Osoyoos Lake, upon which rearing Okanagan chinook feed in part, is dominated by cyclopoids and diaptomids, with substantial populations of *Daphnia* and *Bosmina* (Wright 2002). Okanagan chinook have also recently been found to be piscivorous, feeding on sockeye salmon fry (ONAFD, unpublished data, 2005). The degree of competition for food between cohabiting species of salmon rearing in freshwater is not known, but is presumably influenced by the degree of habitat segregation among species (Healey, 1991).

Young chinook salmon in the marine environment eat mainly fish, particularly herring, with invertebrates like squids, amphipods, shrimp, euphausiids, and crab larvae comprising the remainder of their diet (Scott and Crossman, 1973; Healey, 1991). The relative abundance of fish in the stomach contents of commercially caught chinook salmon increases with the size of the fish. In general, invertebrate taxa form a relatively small component of the diet of adult chinook salmon in the ocean, although there is considerable seasonal and regional variation in diet composition (Healey, 1991). The peak feeding periods for chinook salmon in the ocean appear to be spring and summer, with spring being the best period in the southern part of their North American range and summer the best period along the coast of Canada (Healey, 1991).

Adaptability

Chinook salmon exhibit a high degree of life history variation, as evidenced by the high degree of variability in the duration of freshwater and saltwater rearing stages, age at maturation, spawning habitat requirements, and rearing habitat requirements. The existence of this degree of variation suggests a high degree of adaptability in the species (Healey, 1991).

Chinook salmon have been produced in hatcheries in North America for more than a century, with hatchery outplants introduced to a wide range of rivers with and without native chinook salmon populations (Myers *et al*., 1998). The species has also been successfully introduced into highly novel environments, including the Laurentian Great Lakes system and New Zealand rivers. However, there is currently considerable concern about the apparently low fitness of many hatchery outplants and the impacts this may have on naturally spawning populations (Berejikian and Ford, 2003).

POPULATION SIZES AND TRENDS

Search Effort

The Washington Department of Fish and Wildlife has been conducting spawning ground surveys in the U.S. portion of the Okanagan basin for the Okanogan summer chinook population since 1956 (Miller 2004). These spawning ground surveys were conducted through aerial redd counts, plus float/walk surveys in some years (yearly since 1991 and sporadically prior to that). It is unknown if the methodology for the aerial surveys has changed throughout the survey years.

The Okanagan Nation Alliance Fisheries Department has enumerated spawning chinook during their Okanagan sockeye programs (when feasible) in the Okanagan River in each year since 2001 (Wright and Long, 2005; Long, 2002), and seined adult anadromous chinook in the river in 2003, 2004 (Wright and Long, 2005), and recently in 2005 (ONAFD unpublished files 2005). However, there are few formal records of Okanagan chinook observations in the river prior to this time. The best records are historic accounts of the major chinook fishery at Okanagan Falls (Ernst, 1999; Ernst and Vedan, 2000), the Gartrell observation of spawning chinook in May (DFO, unpublished SEDS files, 1936), chinook identified as present in correspondence files of DFO region 1920's to 1999 (DFO, unpublished correspondence files, Kamloops, B.C.), seining of juveniles in Osoyoos Lake in 1971 (Northcote *et al*., 1972), and annual observations of spawners in the river during sockeye enumeration survey(s) from 1968-1999 (DFO, unpublished SEDS files).

Abundance, Fluctuations and Trends

The historic Okanagan chinook population in the Okanagan River was large enough to support an important food and commercial/economic trade fishery prior to non-native human settlement (Ernst and Vedan, 2000). However, by 1874 it was estimated that over one-half of the salmon run returning to the Upper Columbia (including the Okanagan) was harvested in the downstream commercial fishery. By the 1890s the runs to the Upper Columbia River basin were almost completely decimated (Moore *et al*., 2004), presumably including the Okanagan River.

Chinook have been sporadically documented as being present in the system since 1965 as a result of incidental observations made during monitoring of sockeye salmon escapement (Figure 6). Estimates of chinook escapement, based on counts of peak numbers of live and dead chinook adjusted by a standard expansion factor used by DFO, are shown for years for which the necessary data are available (Bailey 2004, personal communication). It appears that when studies have occurred in the system, chinook have been documented as present (Northcote *et al*. 1972, Wright and Long 2005). The only evidence of discontinuity in the presence of Okanagan chinook in the basin has been their absence from gillnetting samples in Osoyoos Lake in 1972 (Allen and Meekin, 1980). By contrast, Okanagan chinook were captured in gillnet sampling of Osoyoos Lake in 1971 by Northcote *et al*. (1972).

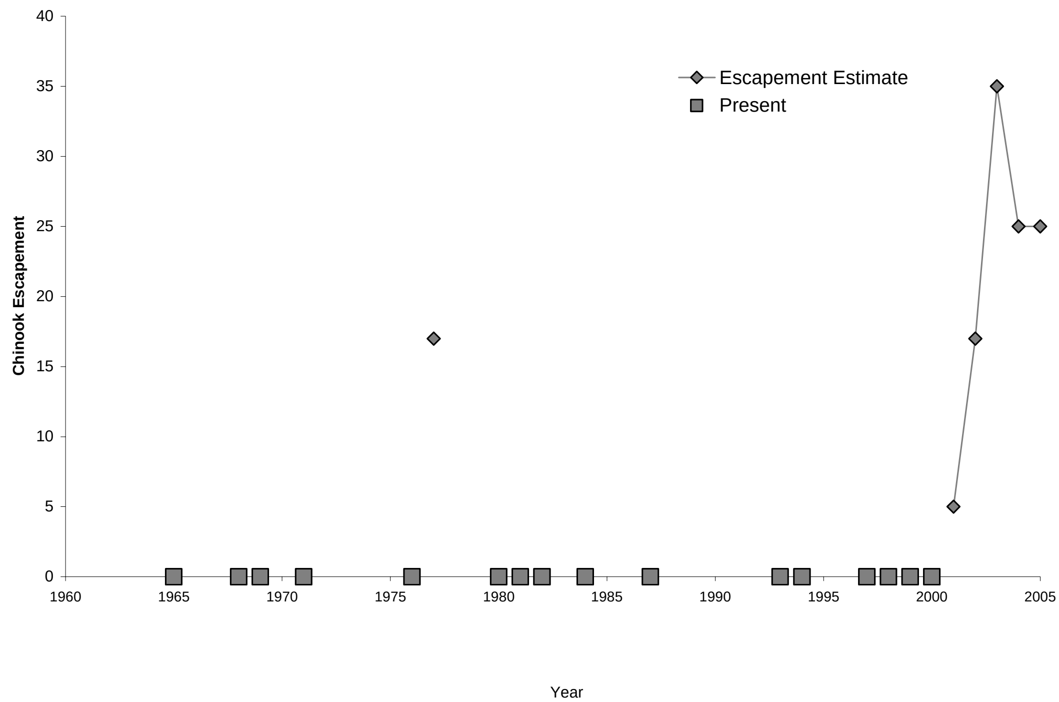


Figure 6. Presence documentation and escapement estimates (where possible) of chinook to the Canadian Okanagan River.

The summer chinook population in the U.S. portion of the Okanagan basin appears to be closely related to the Canadian population. This population is considered to be “of special concern” or “depressed” by state fisheries agencies, with the primary identified threat being loss of habitat through habitat destruction or lack of access (Nehlsen *et al*., 1991; WDF *et al*., 1993). The Washington Department of Fish and Wildlife (WDFW) has been conducting aerial redd surveys since 1956, the results of which are summarized in Figure 7 (Miller 2004). In 2002 WDFW used a redd expansion factor of 2.3 to estimate adult escapement (Miller 2004), which is consistent with the expansion factor (2.2) used for interior Fraser populations (Bailey 2004, personal communication). Between 1956 and 1998 redd estimates have been relatively stable. However, since 1999 redd estimates have been increasing. This is thought to be due to years of high run-off during smolt migration and improved ocean survival in recent years (PSC Joint Chinook Technical Committee 2003). Hatchery contributions during this period (1999-2002) may also have contributed to increased population abundance, and have been estimated at 56% with a range of 20-70% (Todd Miller, 2004 personal communication). Murdock and Miller (1999) estimated a spawner escapement of about 1300 summer-run (ocean-type) chinook in 1998, with about 47% being of hatchery origin. Historical accounts of chinook in the U.S. portion of the Okanagan Basin do not include run size estimates, but local newspapers between the 1880s and 1930s regularly mentioned active food fisheries (Smith, 2003a, b).

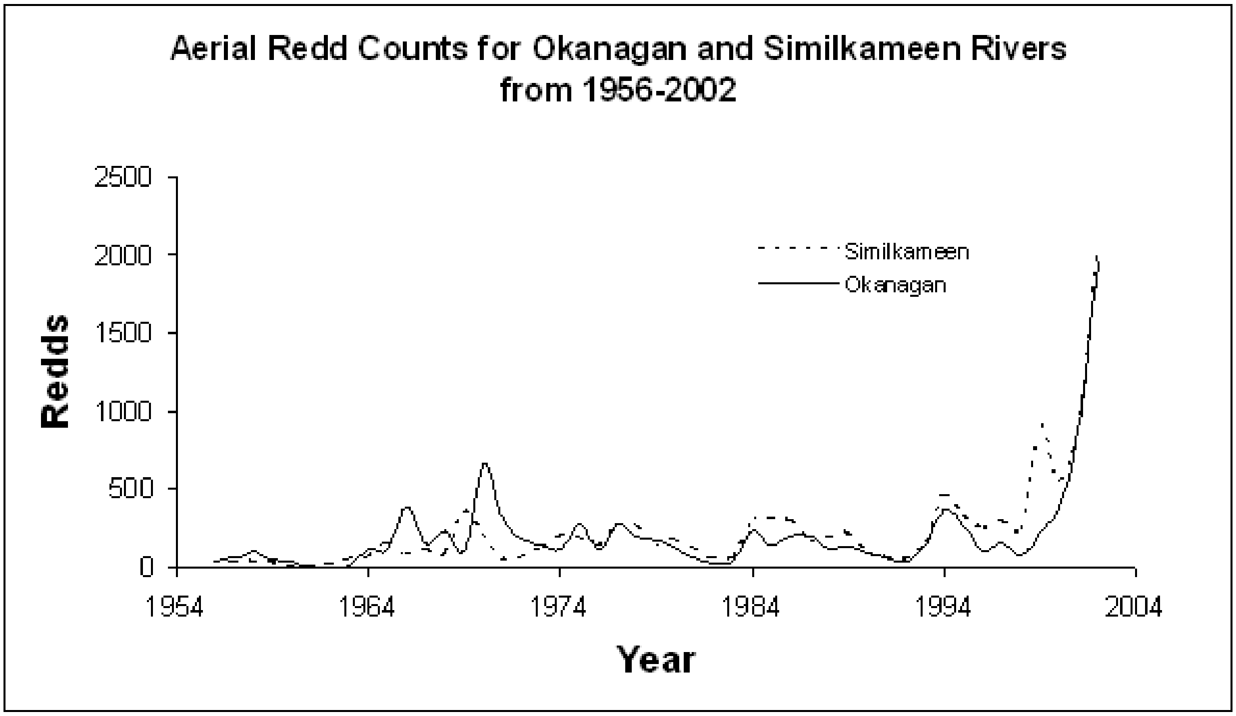


Figure 7. Summary of aerial redd surveys for Okanagan (U.S. portion below Osoyoos Lake) and Similkameen Rivers from 1956-2002 (data adapted from Miller, 2004).

Rescue Effect

There is a long history of hatchery activity within the Upper Columbia ESU, starting with hatcheries on the Methow and Wenatchee Rivers in 1899. In the 20th century both local and, occasionally, lower Columbia chinook stocks were used for propagation (Mullan, 1987; Myers *et al*., 1998). In the past decade, between 300,000 and 1 million yearlings and sub-yearlings have been stocked annually in the U.S. portion of the Okanagan basin (FPC, 2004).

The summer chinook that have been out-planted from hatcheries are the progeny of broodstock collected either in the U.S. Okanogan River or at Wells Dam. The broodstock collected at Wells Dam is a mix of Okanogan and Methow River chinook populations.

There was a decades-long hiatus from stocking spring chinook in the Okanagan Basin until 1991. Between 1991 and 1993, a total of about 480,000 yearling or sub-yearling spring chinook were planted in the U.S. portion of the Okanagan River and its tributaries (FPC, 2004). All of the recent hatchery releases of spring chinook are Carson stock, which have been derived from a composite of Upper Columbia River spring chinook stocks collected during the Grand Coulee Fish Maintenance Program (GCFMP) (Busack and Marshall, 1995).

During the 2003 enumeration surveys in the Okanagan River upstream of Osoyoos Lake, half (four of eight) of the anadromous chinook that were captured on the spawning grounds were of hatchery origin (Wright and Long, 2005), suggesting that in some years a significant portion of the population of anadromous chinook salmon in the Canadian Okanagan River is comprised of strays from U.S. hatchery and, possibly, wild populations. However, none of the anadromous chinook observed in 2004 showed evidence of hatchery origin, and only 1 of 29 anadromous adults in 2005 showed evidence of hatchery origin (adipose clip). The hatchery-origin fish observed in 2003 were likely summer (ocean-type) chinook, as no spring (stream-type) chinook were stocked in the Okanagan basin during the appropriate brood years (C. Fisher, personal communication, 2005). None of the Okanagan chinook caught in Osoyoos Lake have had clips or other hatchery markings (Wright and Long, 2005). As only roughly half of chinook production in the U.S. Okanogan comes from hatcheries, the proportion of fish in the Canadian Okanagan River with hatchery marks represents a lower bound on the number of strays from the U.S. portion of the drainage.

There are plans for a new hatchery to be located at the base of Chief Joseph Dam (C. Fisher, personal communication, 2005). One of its goals is to increase production of Okanagan chinook to levels sufficient to sustain a food and sustenance harvest for the Colville Confederated Tribes (CCT). Additional acclimation ponds are proposed in the U.S. portion of the Okanagan River where currently there is only a long-term acclimation pond on the Similkameen. In their hatchery plan the CCT have expressed an interest in looking at potential hatchery options in Canada. Through their collaborative arrangements with the CCT, the Okanagan Nation Alliance have identified several unknowns that need to be addressed prior to the use of a hatchery in population restoration. Among the issues that must be considered are the genetic relationships between the Canadian and U.S. Columbia Basin chinook populations.

LIMITING FACTORS AND THREATS

Limiting factors and threats associated with spawning and rearing habitat in the Okanagan basin in Canada have already been addressed under Habitat Trends. In addition, the National Marine Fisheries Service (1998) identified the section of the Okanagan River below McIntyre Dam as the highest priority within the Okanagan-Okanogan Basin for protection and restoration. They also identified the greatest habitat risk as the potential loss of suitable rearing area in Osoyoos Lake. Although the statement is for sockeye, it is also applicable to chinook. This rest of this section will focus on threats outside of the basin.

Broodstock collection for hatcheries (see Rescue Effect) and in-river and ocean fisheries on the hatchery-enhanced population are unquantified threats.

Chinook migrating to and from the Okanagan River face increased mortality due to predation or injury at each of the mainstem dams and their impoundments. There are nine mainstem hydroelectric dams that adult and juvenile chinook migrate through, four of which are federally operated (Bonneville, Dalles, John Day, and McNary) and five operated by Public Utility Districts (PUDs) (Priest Rapids, Wanapum, Rock Island, Rocky Reach, and Wells). Ferguson *et al*. (2004) estimated a survival rate of 80-85% for adult chinook migrating past 8 hydroelectric dams on the Columbia and Snake Rivers (tributary to the Columbia). While not specific to chinook in the Upper Columbia River basin, a similar estimate for chinook passing the nine Columbia River dams downstream of the Okanagan River may be appropriate. In the current sub-basin planning efforts for the Okanagan, survival rates for migrating smolts are estimated at between 86% and 91% per dam for stream-type chinook (Moore *et al*., 2004), which suggests that between 26% and 43% of the smolts that leave the Okanagan River make it through Bonneville Dam.

<u>Fishery Impacts</u>

Okanagan chinook likely migrate with the Upper Columbia summer chinook salmon, although direct observations to confirm this are not available. The Joint Chinook Technical Committee (CTC) (PSC 2003) uses coded-wire-tag (CWT) releases from Wells Dam Hatchery to monitor exploitation of Columbia River summer chinook (including Upper Columbia stocks), which is one of the 36 exploitation rate indicators monitored. CWT recoveries in all fisheries (including associated incidental mortality) and escapement are used to reconstruct cohort size by brood year for each indicator stock. Based on these data, total fishing mortalities by catch year and brood year exploitation rates are estimated.

Total fishing mortalities for Columbia River Summer chinook have been calculated to catch year 2003 (Table 2) (PSC 2003, CTC unpublished data from R. Sharma, 2005 personal communication). For years 1979-1980 and 1987-1990, total fishing mortality averaged 71% and 66.9% respectively. For 1991-1998, total fishing mortality has averaged 32.7%, with a high of 50.2% and a low of 17.6%. Since 1999, total fishing mortality has averaged 62.8%, and increased steadily from 46.1% in 1999 to 76.4% in 2003. In recent years, fishing mortality has been distributed approximately equally between Canadian, Alaskan and southern U.S. fisheries. Canadian exploitation has primarily occurred in the Northern BC and West Coast Vancouver Island troll fisheries, while U.S. exploitation occurs mainly in the Alaskan troll and southern U.S. troll and sport fisheries (which include in-river harvest).

The Columbia summer chinook mortality distributions described above are by catch year, with captured fish being three to six years old (i.e., mixed broods). Brood-year exploitation rates provide a measure of fishing impacts on each brood across all years during which fisheries harvest that brood. Currently, the most recent completed brood year for which such rates are available is 1999 (Figure 8). Exploitation rates for the 1975-1977 brood years ranged between about 60%-70%, subsequently decreasing from 70% in 1983 to 20% by 1991 and 1992. Exploitation rates have been considerably higher than this (70% to 80%) on more recent broods (1997-1999). In addition, there is an increase in the contribution of the Columbia River fisheries to the brood year exploitation rates on more recent broods (1997-1999).

Table 2. Sources of Columbia River summer chinook Total Fishing Mortality in Canada (shaded) and the United States by catch year (from PSC, 2003; CTC unpublished data from R. Sharma, personal communication).

Catch year	Alaska Troll	Alaska Net	Alaska Sport	North Troll	Central Troll	N/C BC Net	N/C BC Sport	WCVI Troll	Geo. St. Troll and Sport	Canada Net	Canada Sport	South U.S. Troll	South U.S. Net	South U.S. Sport	Total Alaska	Total South U.S. WA/OR	Total Canada	Total Mortality	Escapement
1979	14.4%	0.0%	1.0%	9.0%	4.0%	8.5%	0.0%	18.9%	7.0%	1.5%	0.0%	0.5%	4.0%	4.5%	15.4%	9.0%	48.9%	73.3%	26.7%
1980	32.8%	0.0%	0.9%	9.2%	4.3%	1.1%	0.0%	18.1%	0.0%	0.0%	0.0%	1.7%	0.6%	0.0%	33.7%	2.3%	32.7%	68.7%	31.3%
1987	16.0%	0.0%	0.0%	8.0%	3.7%	4.3%	2.5%	7.4%	0.0%	0.0%	0.0%	19.8%	11.7%	0.6%	16.0%	32.1%	25.9%	74.0%	26.0%
1988	1.9%	2.2%	0.0%	10.0%	0.0%	7.5%	1.9%	20.9%	0.0%	1.2%	4.0%	3.4%	13.1%	2.8%	4.1%	19.3%	45.5%	68.9%	31.1%
1989	7.1%	2.1%	0.7%	5.6%	0.7%	0.3%	0.6%	16.4%	1.4%	1.9%	2.4%	14.9%	7.5%	2.5%	9.9%	24.9%	29.3%	64.1%	35.9%
1990	10.6%	0.0%	0.0%	7.6%	1.1%	1.3%	0.0%	20.3%	0.6%	0.3%	0.0%	5.7%	10.3%	2.6%	10.6%	18.6%	31.2%	60.4%	39.6%
1991	4.1%	0.0%	0.0%	2.3%	0.5%	1.7%	0.0%	6.3%	0.0%	1.1%	0.7%	3.6%	4.0%	2.3%	4.1%	9.9%	12.6%	26.6%	73.4%
1992	18.5%	0.0%	0.0%	3.4%	1.9%	0.9%	0.0%	15.4%	0.6%	0.0%	0.0%	6.6%	1.3%	1.6%	18.5%	9.5%	22.2%	50.2%	49.8%
1993	7.8%	0.0%	0.0%	1.4%	0.0%	2.8%	0.0%	15.6%	0.0%	0.0%	1.8%	5.5%	3.2%	1.4%	7.8%	10.1%	21.6%	39.5%	60.5%
1994	17.5%	0.0%	0.0%	0.0%	0.0%	0.0%	15.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.0%	0.0%	17.5%	10.0%	15.0%	42.5%	57.5%
1995	4.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.4%	0.0%	1.4%	0.0%	2.0%	2.7%	0.0%	4.1%	4.7%	8.8%	17.6%	82.4%
1996	21.3%	0.7%	0.0%	1.8%	0.0%	3.0%	0.0%	2.5%	2.5%	0.2%	0.0%	2.5%	3.2%	3.9%	22.0%	9.6%	10.0%	41.6%	58.4%
1997	8.9%	0.1%	3.7%	0.2%	0.0%	0.4%	1.2%	1.8%	0.0%	0.0%	0.0%	3.3%	1.1%	0.9%	12.7%	5.3%	3.6%	21.6%	78.4%
1998	10.2%	0.5%	1.2%	0.5%	0.0%	0.1%	0.7%	0.0%	0.0%	0.0%	0.6%	2.1%	4.9%	1.0%	11.9%	8.0%	1.9%	21.8%	78.2%
1999	13.9%	5.0%	3.0%	0.4%	0.0%	0.6%	3.9%	0.5%	0.0%	0.0%	5.2%	9.3%	1.0%	3.3%	21.9%	13.6%	10.6%	46.1%	53.9%
2000	25.8%	2.3%	3.5%	0.4%	0.0%	0.0%	1.9%	4.2%	0.7%	0.1%	5.3%	3.3%	1.0%	4.0%	31.6%	8.3%	12.6%	52.5%	47.5%
2001	16.3%	6.1%	1.4%	0.5%	0.0%	0.0%	1.6%	11.1%	0.2%	0.0%	4.4%	17.5%	0.7%	6.5%	23.8%	24.7%	17.8%	66.3%	33.7%
2002	21.5%	0.1%	1.3%	18.1%	0.0%	0.0%	2.3%	14.1%	0.1%	0.0%	0.8%	8.3%	0.6%	5.6%	22.9%	14.5%	35.4%	72.8%	27.2%
2003	24.3%	1.9%	1.0%	17.1%	0.0%	0.0%	5.9%	11.3%	0.1%	0.0%	1.0%	6.2%	2.6%	5.0%	27.2%	13.8%	35.4%	76.4%	23.6%
1979-1980	23.6%	0.0%	1.0%	9.1%	4.2%	4.8%	0.0%	18.5%	3.5%	0.8%	0.0%	1.1%	2.3%	2.3%	24.6%	5.7%	40.8%	71.0%	29.0%
1987-1990	8.9%	1.1%	0.2%	7.8%	1.4%	3.4%	1.3%	16.3%	0.5%	0.9%	1.6%	11.0%	10.7%	2.1%	10.2%	23.7%	33.0%	66.9%	33.2%
1991-1998	11.6%	0.2%	0.6%	1.2%	0.3%	1.1%	2.1%	6.1%	0.4%	0.3%	0.4%	3.2%	3.8%	1.4%	12.3%	8.4%	12.0%	32.7%	67.3%
1999-2003	20.4%	3.1%	2.0%	7.3%	0.0%	0.1%	3.1%	8.2%	0.2%	0.0%	3.3%	8.9%	1.2%	4.9%	25.5%	15.0%	22.4%	62.8%	37.2%

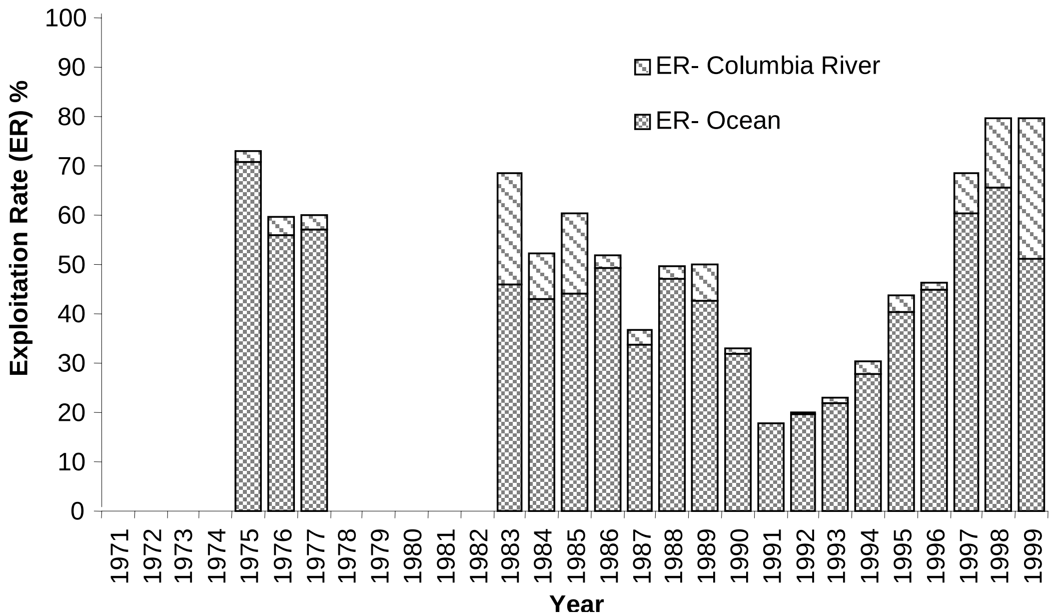


Figure 8. Brood year total exploitation rate for Columbia River summer run. Note that 1999 is still incomplete as five-year-old CWT data have not been processed.

However, further cohort analysis on total fisheries mortality conducted by the National Oceanic and Atmospheric Administration (NOAA) suggests that impacts specifically on Okanagan/Similkameen chinook may not be properly represented by Wells Dam hatchery stock and fisheries impacts may be less than predicted, but further analysis is required (NOAA 2005).

Prior to fisheries catch year 1999, the majority of fishing mortality is associated with the ocean fisheries, while mainstem Columbia River treaty ceremonial and sustenance harvest is estimated to have been less than 3% since 1986 (U.S. vs. Oregon Technical Advisory Committee 1999). However, in-river fisheries have increased since 2001 (Figure 9) due to the increase in escapement (Figure 10).

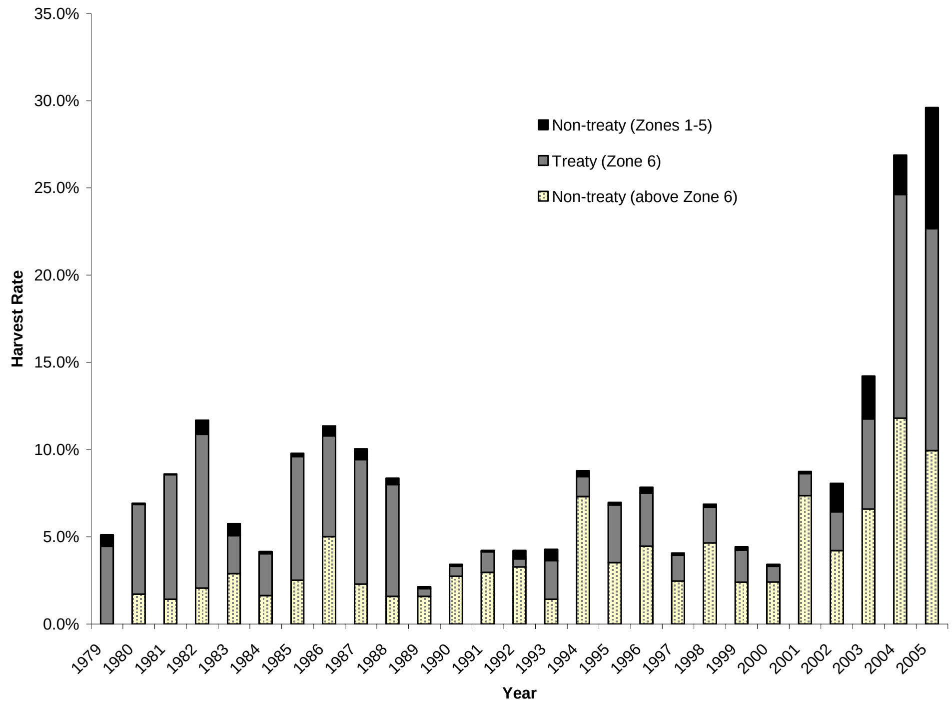


Figure 9. Terminal harvest rates of Upper Columbia Summer chinook Management Group in the Columbia River (Data from CRITFC, Colville Tribes, and WDFW).

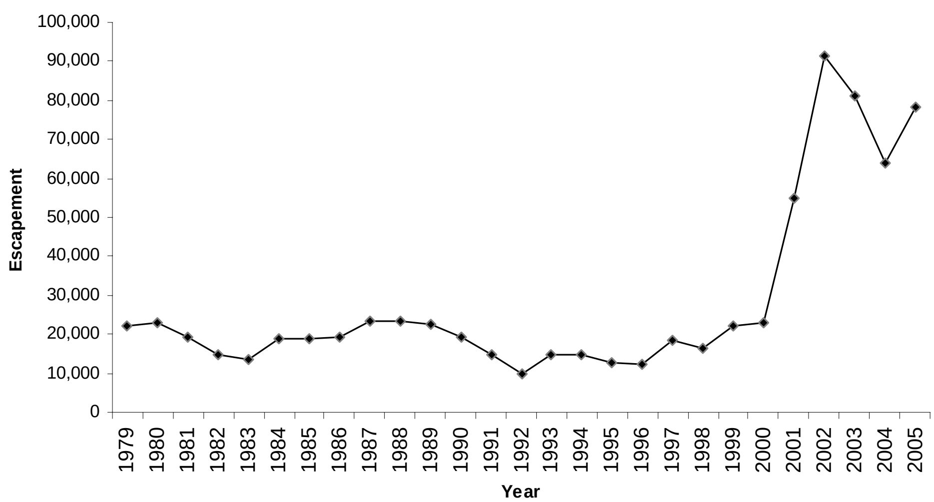


Figure 10. Summary of upper Columbia chinook escapement past Bonneville Dam and before the additional upstream fishery in the Columbia River (1979-2005).

The fishery in 2005 went through the following process. The escapement objective for the 2005 Upper Columbia Summer run at Bonneville Dam was decided to be 29,000 adults (hatchery plus wild). The projected run size for these fish was 62,400. Therefore, under the new management plan, the maximum allowable total harvest rate for this group was set at 47.6% (Treaty 23.8% and non-Treaty 23.8%) (Table 3).

Table 3. Summary of Columbia River escapement and harvest rates of upper Columbia summer chinook management group for 2005.

Time in 2005	Number past Bonneville Dam	Total Harvest Rate
Before run	62,400 (predicted)	47.6% (allowable)
After run	60,173 (actual)	30.3% (actual)

The actual escapement was 60,173 summer chinook. Preliminary estimates (www.wdfw.wa.gov/fish/crc/crcindex.htm) indicate that the actual treaty harvest (Zone 6- Between Bonneville and McNary Dams) was about 7,642 summer chinook, or 12.7%, less than the 23.8% allocated (Matylewich, 2005 personal communication). The lower harvest rate was likely due to the greater numbers returning than had been predicted, but may also be due to a decrease in the number of treaty fishers during summer 2005. Commercial capture of summer chinook has been limited by the total annual allowable bycatch of endangered steelhead trout: the summer chinook fishery (and its incidental catch of steelhead) is constrained by the need to reserve some steelhead trout bycatch for the lucrative fall chinook fishery. Fishers attempt to use large-meshed gill netting gear to target chinook since this gear generally excludes steelhead trout; however, large steelhead individuals (called B-type) are still captured (Matylewich, 2005 personal communication).

For 2005, non-treaty harvest (23.8%) is allocated to several groups (commercial, sport, and non-treaty tribal fisheries; http://wdfw.wa.gov/fish/regs/2005/2005sportregs.pdf). The 2005 sport fisheries in the Columbia River for Upper Columbia Summer chinook below Bonneville Dam (Zones 1-5) were changed from mark-selective to non-selective as of 1 July 2005 (i.e., both hatchery-origin and wild chinook could be retained). The non-treaty harvest below Bonneville Dam was estimated to be 4174 individuals, or 7.0% (using the actual escapement return of 60,173 summer chinook). The non-treaty harvest above McNary Dam was estimated to be 5968 or 10.0% (Matylewich, 2005 personal communication). In summary, the Columbia River fishery for 2005 had an allocation of 47.6%, but actual harvest was approximately 18,196 chinook or 30.31% (Table 3). This is still an increase from previous years.

SPECIAL SIGNIFICANCE OF THE SPECIES

Okanagan chinook comprise the only remaining population of Columbia basin chinook salmon that spawns in Canada and are genetically distinct from all other Canadian populations. This population may also represent a significant portion of the remaining genetic diversity of Upper Columbia River chinook salmon. The Okanagan chinook has had a significant historic role in the lives of First Nations peoples for hundreds (if not thousands) of years, and the Okanagan Nation Alliance is attempting to ensure its survival into the future.

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

In May 2005, COSEWIC assessed the Okanagan chinook as Endangered in an Emergency Assessment. Provincial and federal statutes and policies exist to protect fish and their freshwater and marine habitats. The provincial *Water Act* controls the diversion, usage, and storage of surface waters in B.C., which provides some protection to spawning and rearing habitat in the Okanagan River. The federal *International Boundary Waters Treaty Act* and *International Rivers Improvement Act* regulate the diversion, damming, and obstruction of international waterways, such as the Okanagan River and Osoyoos Lake, and provide some protection for migratory routes. The federal *Fisheries Act* regulates fishing and protects fish habitat from harmful alterations or destruction, and thus protects fish and their habitats throughout Canada.

In addition, Canada is a signatory to the United Nations *Convention on Biological Diversity* (1992), which states that where there is a threat of significant decrease or loss of biological diversity, lack of full scientific certainty should not be used as a reason for postponing measures to avoid or minimize such a threat. This principal is critical for a case such as the Okanagan chinook, which is not a well-studied population but appears to represent a significant portion of the biological diversity of chinook salmon in Canada. This convention states additional fundamental conservation principles that also apply to the Okanagan chinook, such as the need for conservation of biological diversity *in situ* and management of biological diversity in and outside of protected areas.

Fisheries and Oceans Canada's *Wild Salmon Policy (version 2005)* states that the primary goals of the Wild Salmon Policy are to ensure the long-term viability of Pacific salmon populations in natural surroundings and to maintain fish habitat for all life stages for the sustainable benefit of the people of Canada. This document sets forth the principles for managing and conserving wild Pacific salmon, and lists as a target the Okanagan chinook.

Finally, the *Pacific Salmon Treaty* (1999) between Canada and the United States regulates fishing such that each country receives benefits equivalent to the production of salmon originating in its waters, and is intended to prevent overfishing while providing for optimum production. The mechanism for establishing fish allocations and creating management regimes for transboundary stocks falls to the Pacific Salmon Commission and joint Transboundary Technical Committees, respectively. There is currently no such committee for the Okanagan/Columbia River system. However, the Canadian Okanagan Basin Technical Working Group (COBTWG) and an 'ad hoc' Bilateral Okanagan Basin Technical Working Group (BOBTWG) has been meeting periodically to discuss fisheries issues in the Okanagan Basin (http:www.obtwg.ca). The COBTWG is comprised of the federal, provincial and Okanagan Nation fisheries agencies.

TECHNICAL SUMMARY

Oncorhynchus tshawytscha

Common name: Chinook Salmon — Saumon chinook – population de l'Okanagan

Population name: Okanagan population

Range of Occurrence in Canada: British Columbia (Okanagan River, Osoyoos Lake, coastal Pacific Ocean)

Extent and Area information	
• *extent of occurrence (EO)(km²) (freshwater phase in Canada)*	About 16 km^2 (Okanagan River and Osoyoos Lake)
• *specify trend (decline, stable, increasing, unknown)*	Perhaps stable
• *are there extreme fluctuations in EO (> 1 order of magnitude)?*	Unlikely
• *area of occupancy (AO) (km²) (freshwater phase in Canada)*	About 15 km^2 (adults and juveniles)
• *specify trend (decline, stable, increasing, unknown)*	Decline in suitable lake rearing habitat
• *are there extreme fluctuations in AO (> 1 order magnitude)?*	No
• *number of extant locations*	One (river and lake)
• *specify trend in # locations (decline, stable, increasing, unknown)*	None
• *are there extreme fluctuations in # locations (>1 order of magnitude)?*	No
• *habitat trend: specify declining, stable, increasing or unknown trend in area, extent or quality of habitat*	Improving in river; likely declining in lake
Population information	
• *generation time (average age of parents in the population) (indicate years, months, days, etc.)*	4.5 years anadromous; 2 years nonanadromous
• *number of mature individuals (capable of reproduction) in the Canadian population (or, specify a range of plausible values)*	Likely under 50 (includes anadromous and non-anadromous)
• *total population trend: specify declining, stable, increasing or unknown trend in number of mature individuals*	Possibly stable at very low numbers
• *if decline, % decline over the last/next 10 years or 3 generations, whichever is greater (or specify if for shorter time period)*	Historic collapse likely due to overfishing and dams
• *are there extreme fluctuations in number of mature individuals (> 1 order of magnitude)?*	No
• *is the total population severely fragmented (most individuals found within small and relatively isolated (geographically or otherwise) populations between which there is little exchange, i.e., ≤ 1 successful migrant / year)?*	One population (Okanagan chinook is genetically and demographically isolated from all other chinook salmon populations in Canada; likely receives some gene flow from U.S.)
• *list each population and the number of mature individuals in each*	Not available
• *specify trend in number of populations (decline, stable, increasing, unknown)*	Not available
• *are there extreme fluctuations in number of populations (>1 order of magnitude)?*	Not available

Threats (actual or imminent threats to populations or habitats)	
- juvenile and adult mortality due to U.S. dams on Columbia River - fisheries exploitation in ocean and rivers - restricted spawning and rearing habitat in Canada due to dam - deterioration in juvenile habitat (Osoyoos Lake); loss of adult spawning and early juvenile rearing habitat (river) - predators including exotic fishes - hatchery projects and potential outbreeding depression	
Rescue Effect (immigration from an outside source)	High
• *does species exist elsewhere (in Canada or outside)?*	Yes (but this DU is genetically distinct from all other Canadian DUs)
• *status of the outside population(s)?*	Candidate for Washington State listing
• *is immigration known or possible?*	Some U.S. hatchery adults have been observed in Canada. Genetic evidence suggests that fish from the U.S. population have contributed to reproduction in Canada.
• *would immigrants be adapted to survive here?*	Unknown
• *is there sufficient habitat for immigrants here?*	Possibly
Quantitative Analysis	

Status and Reasons for Designation

Status: Threatened	**Alpha-numeric code**: Met criteria for Endangered, D1, but designated Threatened because of the rescue effect. Met criteria for Threatened: D1+2

Reasons for Designation:

The Chinook salmon (Okanagan population) are the only remaining Columbia Basin population of Chinook salmon in Canada, and are geographically, reproductively and genetically distinct from all other Canadian Chinook salmon populations. They consist of anadromous salmon that migrate to and from the Pacific Ocean through the Columbia River, and also individuals that remain in Osoyoos Lake. The Chinook salmon (Okanagan population) was once large enough to support an important food and trade fishery prior to settlement by non-native people. The population used to occupy the area from Osoyoos Lake to Okanagan Lake, but McIntyre Dam has limited access to only the area below the dam and in Osoyoos Lake. As well as this habitat loss, the population was depleted by historic overfishing in the Columbia River and juvenile and adult mortality due to dams downstream on the Columbia River. Fisheries exploitation in the ocean, deterioration in the quality of the remaining Canadian habitat, and new predators and competitors such as non-native fishes also contributed to the current depleted state of the population. Genetic data show evidence of successful reproduction and maturation by individuals in this population, but also that this small population has genetic diversity similar to much larger populations in adjacent areas of the Columbia River basin, and is closely related to those populations. The genetic data, as well as the presence of fish of hatchery origin in the Canadian portion of the Okanagan River indicate that it is very likely that fish from elsewhere in the upper Columbia River basin have contributed reproductively to the population. With spawning numbers as low as 50 adults, the population is at risk of extinction from habitat loss, exploitation and stochastic factors, but may also be subject to rescue from populations in adjacent areas of the Columbia River basin.

Applicability of Criteria

Criterion A: (Declining Total Population): Not applicable as percent decline in recent past is unknown; however, it is known that the population has not recovered following a severe decline in the 1880s.

Criterion B: (Small Distribution, and Decline or Fluctuation): Not applicable as decline in recent past is unknown; however, it is known that the distribution is greatly reduced due to the construction of a Canadian dam.

Criterion C: (Small Total Population Size and Decline): Not applicable, as percent decline is unknown.

Criterion D: (Very Small Population or Restricted Distribution): Meets Endangered, D1 (fewer than 250 mature individuals). Current estimate of N is fewer than 50 individuals. Meets Threatened D1+2 (fewer than 1000 individuals and area of occupancy less than 20 km^2). Estimated area of freshwater spawning and rearing habitat is 15 km^2.

Criterion E: (Quantitative Analysis): Not applicable.

ACKNOWLEDGEMENTS AND AUTHORITIES CONTACTED

The authors thank the following individuals for providing insights and guidance during the preparation of this document: Drs. Michael Healey, John Candy, and Kim Hyatt, and Richard Bailey (all from Fisheries and Oceans Canada); Chris Fisher (Colville Confederated Tribes), and Shane Bickford (Douglas County Public Utility District). Fisheries and Oceans Canada provided funding for preparation of this report.

Mart Gross, Michelle Herzog and Cory Robertson (all from Gross Lab, University of Toronto) have edited and prepared sections of the report, and are gratefully acknowledged by the Okanagan Nation Alliance Fisheries Department. Paul Bentzen contributed final edits to the report.

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COLLECTIONS EXAMINED

The Royal BC Museum, the Canadian Museum of Nature, the University of British Columbia Department of Zoology, and the University of British Columbia Fish Museum were all consulted to determine if they had any specimens of *Oncorhynchus tshawytscha* from the Okanagan Basin. Contact names are listed above.