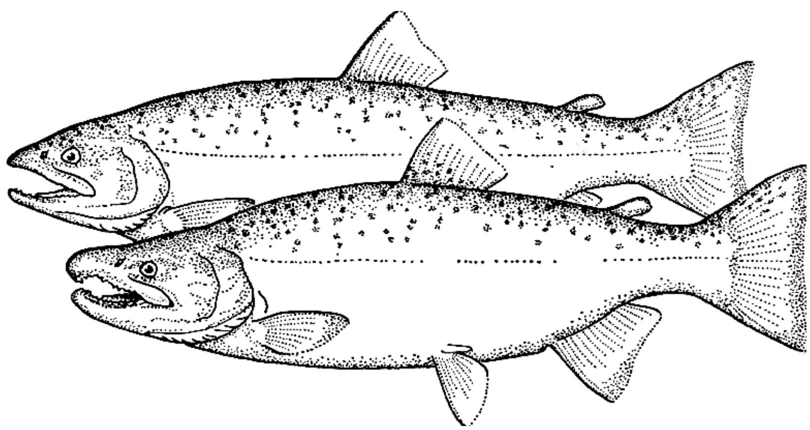
COSEWIC
Assessment and Status Report

on the

Coho Salmon
Oncorhynchus kisutch
Interior Fraser population

in Canada



ENDANGERED
2002

COSEWIC
COMMITTEE ON THE STATUS OF
ENDANGERED WILDLIFE
IN CANADA

COSEPAC
COMITÉ SUR LA SITUATION DES
ESPÈCES EN PÉRIL
AU CANADA

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Coho Salmon — provided by Fisheries and Oceans Canada, Freshwater Fishes of Canada, ©1973 Fisheries Research Board of Canada, Bulletin 184, Catalogue No. FS94-184, Page 158 – line drawing of coho salmon. Reproduced with the permission of the Minister of Public Works and Government Services, 2001.

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COSEWIC
Assessment Summary

Assessment Summary – May 2002

Common name
Coho Salmon (Interior Fraser population)

Scientific name
Oncorhynchus kisutch

Status
Endangered

Reason for designation
A nationally significant population that has experienced declines in excess of 60% in number of individuals due to changes in freshwater and marine habitats and to overexploitation. COSEWIC was concerned that reductions in fishing pressure may be insufficient or not maintained, that marine survivorship may not improve, that habitat loss or deterioration in the watershed is continuing, and that use of hatcheries threatens recovery. COSEWIC concluded that there is a serious risk of extinction of Interior Fraser coho.

Occurrence
British Columbia

Status history
Designated Endangered in May 2002.

COSEWIC
Executive Summary

Coho Salmon
Oncorhynchus kisutch
Interior Fraser population

Species information

Coho salmon is one of seven species of the genus *Oncorhynchus* native to North America. Adult coho usually weigh from 2 - 5 kg (45 - 70 cm in length) and only rarely exceed 9 kg. Most coho spend their first year in freshwater and the next 18 months in the ocean before returning to freshwater to spawn and die. Jacks (precocious males) that spend only six months in the ocean are found in some populations.

The status of coho salmon from the interior Fraser River watershed (including the Thompson River) is evaluated in this document. The Fraser is the largest river in British Columbia (BC) and the interior Fraser (i.e. upstream of the Fraser canyon) constitutes most of the drainage basin. Interior Fraser coho occupy a significant proportion (~25%) of the range of coho salmon within Canada. Interior Fraser coho are genetically unique and can be distinguished from coho from the lower Fraser River watershed and other areas of Canada.

Distribution

Coho salmon occur naturally only within the Pacific Ocean and its tributary drainage. The interior Fraser watershed is part of the Southern Mountain COSEWIC Ecological Area. Coho salmon are widespread throughout the Thompson River system, the largest watershed in the Fraser River system. Their distribution in non-Thompson tributaries of the interior Fraser is not well known. Coho are probably spawning in fewer streams within the interior Fraser than previously when they were more abundant. Coho salmon that were spawned in the interior Fraser River watershed have been recovered in fisheries from Alaska to Oregon, but most were caught off the West Coast of Vancouver Island and in the Strait of Georgia.

Habitat

The distribution of spawning habitat for coho salmon is usually clumped within watersheds. Juvenile coho salmon tend to cluster in areas of suitable habitat in shallow gradient streams and sometimes lakes. Much of the interior Fraser watershed where coho are found has been logged and is used for a variety of agricultural activities.

Juvenile coho salmon migrate down the Fraser River and spend an unknown time in the highly developed Fraser River estuary. The majority of their oceanic residence is usually spent near the coast in southern BC. Although marine areas used by Fraser coho are relatively undeveloped by humans, climate-related changes have reduced the ability of the marine environment to support these fish in southern BC in many recent years.

Biology

Interior Fraser coho salmon return to freshwater in the fall and spawn during fall and early winter. Fry emerge from the gravel the following spring and usually reside in freshwater for a year before migrating to sea as smolts. Almost all coho spend 18 months at sea before returning to freshwater and therefore have a 3-year life cycle.

Female coho salmon are larger than males in most interior Fraser systems, but less abundant (~45% of returns). Interior Fraser coho are smaller and usually less fecund than most similar-aged coho. Temporal patterns in size have not been documented.

Population sizes and trends

Our time series of reliable estimates of spawners begins in 1975. Spawner numbers in the North and South Thompson watersheds peaked in the mid-1980’s, declined rapidly until about 1996, and have been stable or potentially increasing since then. Slightly more than half of recent estimates of the total population of 24,000 occur within the North and South Thompson watersheds. Most coho salmon returning to the interior Fraser are produced by natural spawning (~20,000 of ~24,000 total, mean of 1998-2000 estimates). Decline estimates for the 1990-2000 10-year period averaged 60%. Peak escapements and abundances during the mid-1980’s (100,000 and 300,000 respectively) were somewhat less than crude estimates derived for the 1920’s and 1930’s (200,000 and 400,000).

Recent marine survivals have been 3% or less, much lower than during the 1970’s and 1980’s. Fishery exploitations (proportion of adults caught in fisheries) averaged 68% until 1996. In response to conservation concerns, exploitations were reduced to ~40% in 1997 and averaged 6.5% the next three years.

Productivity declined between the 1980’s and the 1990’s. There were four years (1991, 1995, 1997, and 1998) when some populations may not have been able to replace themselves, even in the absence of fishing. Spawner numbers in 1999 and 2000 have exceeded parental escapements. However, the outlook for interior Fraser coho is highly uncertain and depends on fishing, habitat perturbations, and climate-related changes in survival.

Limiting factors and threats

Overfishing, changing marine conditions, and habitat perturbations all contributed to declines. Excessive fishing resulted when harvest rates were not reduced quickly in response to climate-driven declines in marine productivity. In addition, coho declines were often related to the intensity of human disturbance in freshwater.

Special significance and existing protection

Coho salmon remain an important species, contributing to catches along the Pacific coast of North America. Numbers of coho are declining throughout much of its range. In the United States, coho salmon are considered to be threatened by extinction in three Evolutionarily Significant Units (ESUs), candidates for listing in two ESUs, and not likely to become endangered in only one ESU. Stock status for coho in BC varies depending on location, but coho from the interior Fraser appear to have declined at a greater rate than coho from other areas.

The responsibility for managing salmon and salmon habitat in BC is shared between the federal and provincial governments. A variety of legislative processes, some international, are in place to ensure salmon conservation. The federal Fisheries Act is a powerful piece of legislation providing the authority for the management and regulation of fish and fish habitat. Recent regulatory changes made to conserve interior Fraser coho salmon were probably the most significant fishery changes ever implemented within the Pacific Region of Canada. Since there is no consensus regarding future marine survivals for interior Fraser coho salmon, a continuing and extremely cautious approach to managing both fisheries and habitat will be required to ensure the long-term viability of these fish.

Summary of status report

This report focuses on coho salmon from the interior Fraser River of British Columbia. These genetically distinct salmon constitute an Evolutionarily Significant Unit made up of at least five subpopulations. Slightly more than half of recent estimates of the total population of 24,000 (~20,000 wild) occur within the North and South Thompson watersheds. The best abundance indicators are spawner estimates for the North and South Thompson watersheds, which peaked in the mid-1980’s, declined until about 1996, and have been stable or increasing since then. Rates of decline for 1990-2000 averaged 60%. There is no evidence that the extent of occurrence has changed, although spawners were seen in fewer streams as populations declined. The main reason for the decline in numbers of interior Fraser coho salmon is excessive fishing that resulted when harvest rates were not reduced quickly in response to climate-driven declines in marine survival. Freshwater habitat degradation also played a role — coho declines were related to the intensity of human disturbance in the watershed. Fishing pressures have been reduced dramatically the last several years, and this combined with an apparent stabilization in marine survivals resulted in improved returns. But the outlook for interior Fraser coho is highly uncertain and will depend on impacts due to fishing, habitat perturbations, and climate-related changes in survival. An extremely cautious approach to managing both fisheries and habitat is required to ensure the viability of populations of coho salmon within the interior Fraser River watershed.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) determines the national status of wild species, subspecies, varieties, and nationally significant populations that are considered to be at risk in Canada. Designations are made on all native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fish, lepidopterans, molluscs, vascular plants, lichens, and mosses.

COSEWIC MEMBERSHIP

COSEWIC comprises representatives from each provincial and territorial government wildlife agency, four federal agencies (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biosystematic Partnership), three nonjurisdictional members and the co-chairs of the species specialist groups. The committee meets to consider status reports on candidate species.

DEFINITIONS

Species	Any indigenous species, subspecies, variety, or geographically defined population of wild fauna and flora.
Extinct (X)	A species that no longer exists.
Extirpated (XT)	A species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A species facing imminent extirpation or extinction.
Threatened (T)	A species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.
Not at Risk (NAR)**	A species that has been evaluated and found to be not at risk.
Data Deficient (DD)***	A species for which there is insufficient scientific information to support status designation.

* 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.

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.

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

on the

Coho Salmon
Oncorhynchus kisutch
Interior Fraser population

in Canada

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2002

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SPECIES INFORMATION

Name and classification

Coho salmon (*Oncorhynchus kisutch* Walbaum) (Fig. 1) is one of seven species of the genus *Oncorhynchus* native to North America. Other species are sockeye (*O. nerka*), chum (*O. keta*), pink (*O. gorbuscha*), and chinook (*O. tshawytscha*) salmon and steelhead (*O. mykiss*) and cutthroat (*O. clarki*) trout.

While the common name most frequently used for this species is coho, they are sometimes referred to as silver salmon, sea trout, hooknose, or bluebacks, the latter term usually referring to small coho caught early in their final marine year. The French common name is *saumon coho*.

Description

Coho and other Pacific salmon can be distinguished from trout and char by the presence of 12 or more rays in the anal fin. The anal fin of juvenile coho is sickle-shaped and its leading edge is longer than its base. Adult coho can be differentiated from other salmon by the presence of white gums at the base of the teeth in the lower jaw. As well, black spots, when present on the caudal fin, occur usually on the upper lobe only (Fig. 1a). Sexual dimorphism develops as coho salmon become sexually mature. Male coho become darker and often bright red, their upper jaw develops an elongated hooked snout, and their teeth become enlarged. Females are usually less brightly coloured and their upper jaw development is less extreme than males (Fig. 1b). Adult coho usually weigh from 2 - 5 kg (45 - 70 cm in length) and only rarely exceed 9 kg. Jacks (precocious males) are common in some populations, are usually less than 30 cm in length, and often superficially resemble small females. More detailed descriptions of coho salmon are provided in Scott and Crossman (1973), Hart (1973), Pollard et al. (1997), and Sandercock (1991).

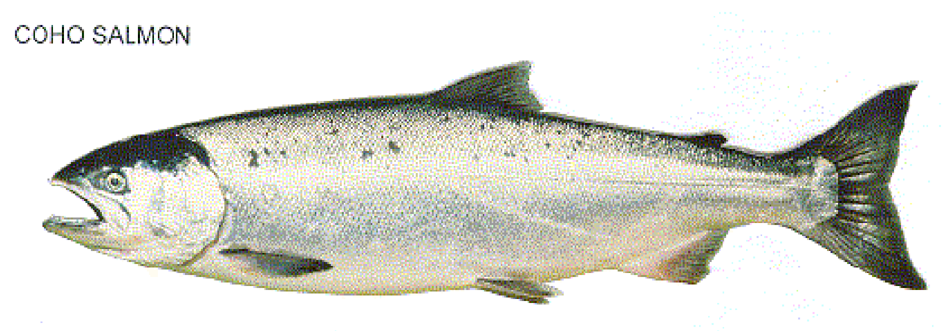

Figure 1a. Adult coho salmon (marine phase).

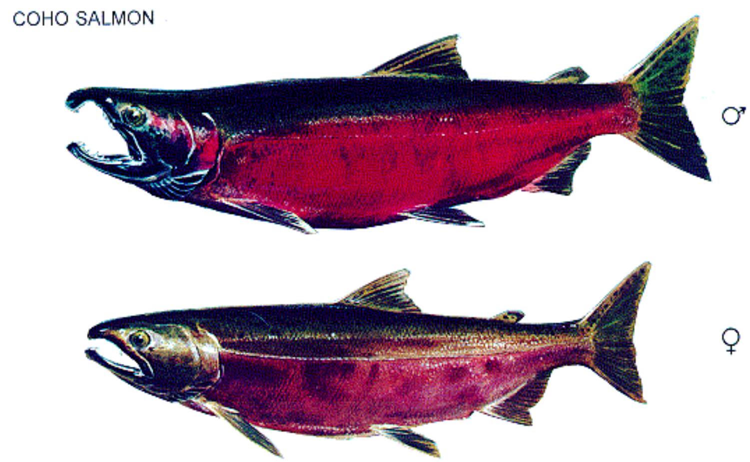

Figure 1b. Adult coho salmon (male and female) showing spawning morphology and colouration (by H. Heine).

Nationally significant population

Coho salmon warrant more than one status designation. In the United States, the National Marine Fisheries Service proposed six evolutionarily significant units (ESUs) for coho salmon (Fig. 2) extending from central California to southern British Columbia (Weitkamp et al. 1995). 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).

Most of British Columbia (BC) was covered by ice 15,000 years ago (Fulton 1969), after which a period of global warming began (Roed 1995). During the period of glaciation, anadromous salmon were able to exist in several glacial refugia including the lower two-thirds of the Columbia River, which was ice-free. As the ice retreated, much of the Fraser River drained through the Okanagan watershed, entering the ocean via the Columbia River. At this time, the Fraser canyon was blocked with ice near Hell's Gate (Fig. 3). It was during this period that coho salmon (and other species) colonized the interior Fraser/Thompson River watershed. Fish entered by postglacial lake connections in the Okanagan-Nicola areas and by upper mainstem Fraser/Columbia connections (Northcote and Larkin 1989). Coho in the Columbia are extinct upstream of the Deschutes River (Fig. 2) (Nehlsen 1997). In contrast to the inland dispersal pattern found for most interior Fraser fish populations, many fish now found in the lower Fraser River watershed, including coho salmon, colonized along the coast via the sea. The Fraser canyon remains a velocity barrier for many species of fish, resulting in a discontinuous distribution of many species and populations within species (McPhail and Lindsey 1986).

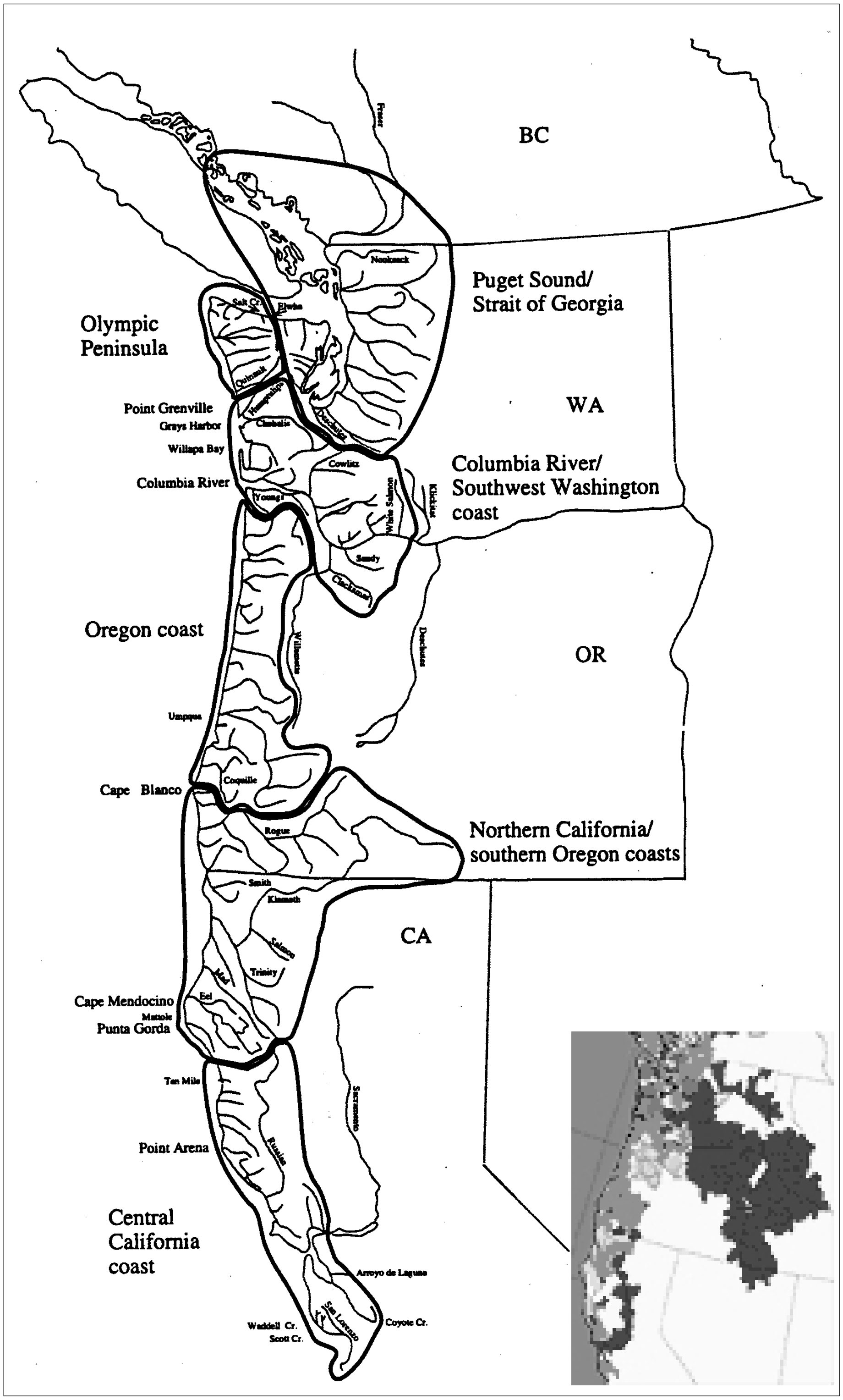

Figure 2. Coho salmon evolutionarily significant units (from Weitkamp et al. 1995). Dark shaded areas in inset show locations of extinct populations in Washington, Oregon, and California (from Ecotrust 1999).

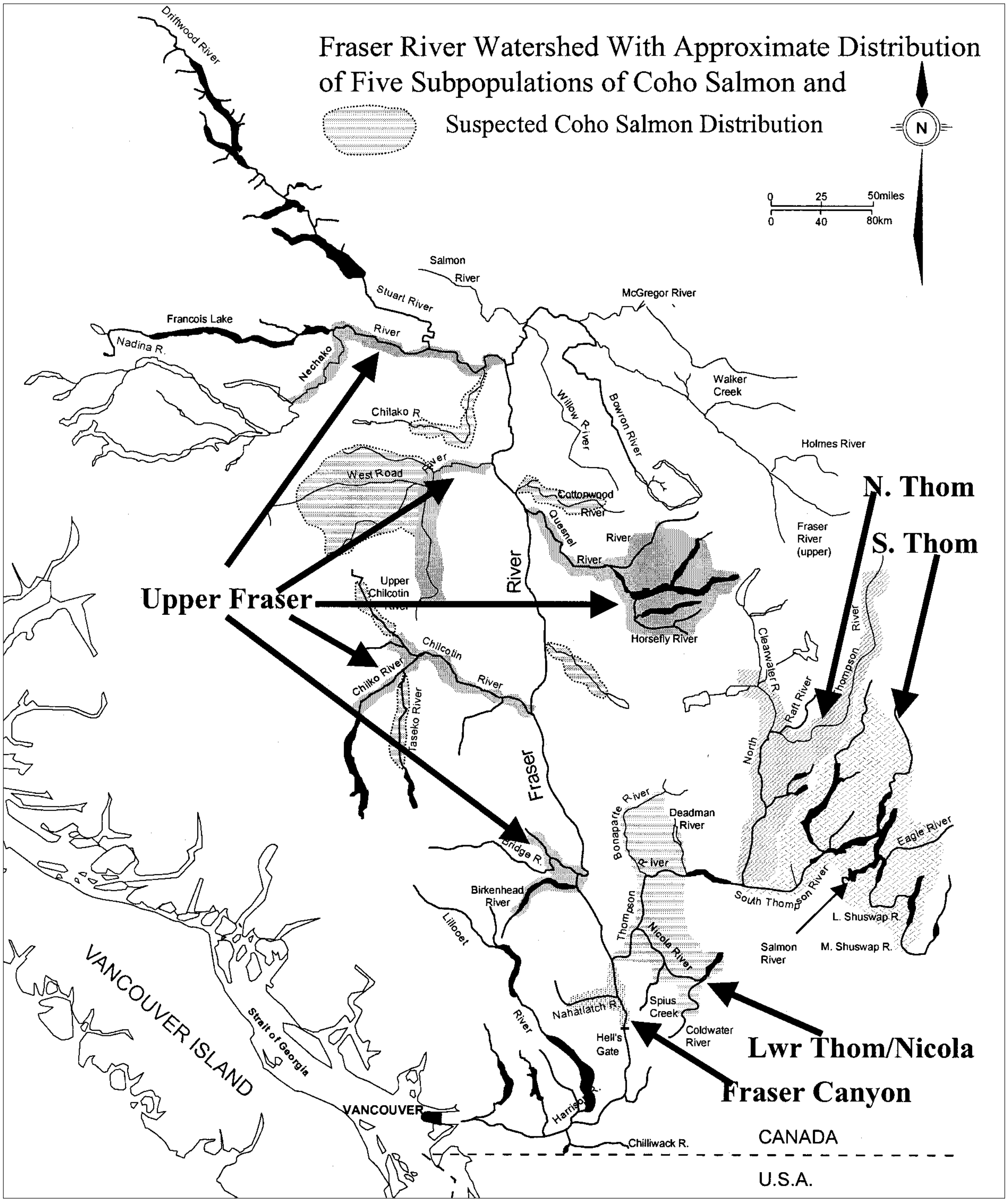

Figure 3. Approximate distribution of 5 subpopulations of coho salmon (North Thompson, South Thompson, Lower Thompson/Nicola, Fraser Canyon, and upper Fraser) within the interior Fraser River watershed. Distribution of coho in the upper Fraser is not well known as indicated by the areas in the upper Fraser where coho are suspected to occur but have not been confirmed.

Results from earlier work documenting the genetic uniqueness of interior Fraser coho (Small et al. 1998a, 1998b, Shaklee et al. 1999) were confirmed by Beacham et al. (2001) and Irvine et al. (2000, 2001) who examined larger data sets. Co-ancestry coefficients (Fst values)[1] were used to produce a dendrogram illustrating the relatedness of coho from samples taken in the entire Fraser River watershed (Fig. 4). Interior Fraser coho were genetically distinct from fish in the lower Fraser (Fst $\cong$ 0.02). Coho from the Fraser Canyon (Nahatlatch River) appeared to be more closely related to lower Fraser River coho than other interior Fraser coho, implying that some genetic exchange may have occurred between the canyon and the lower river. Samples taken in the major basins (Fig. 3, North Thompson, South Thompson, and lower Thompson/Nicola) grouped together. Fish from upper Fraser sites (Bridge and McKinley) did not pair with a recent sample from the Fraser Canyon. Irvine et al. (2000) describe the genetics of interior Fraser coho in more detail, and Beacham et al. (2001) discuss the population structure for BC coho salmon resulting from the analysis of ~28,000 coho salmon, mostly from sites in BC.

Since Fraser coho salmon that spawn upstream of the Fraser canyon are substantially reproductively isolated from other coho salmon, and they constitute an important component in the evolutionary legacy of the species by virtue of their Columbia River heritage, they constitute an ESU. Within the interior Fraser, there appear to be at least five separate subpopulations (North Thompson, South Thompson, lower Thompson/Nicola, Fraser canyon, and upper Fraser) which should perhaps be considered as separate conservation/management units. Genetic data suggest considerable genetic exchange among individual tributaries within these subpopulations, and less genetic exchange among subpopulations. Additional baseline sampling and analysis is required to finalize the delineation of subpopulations within the total interior Fraser coho population.

In summary, interior Fraser coho originated from populations that survived glaciation in Columbia River refugia. Coho in the mid-upper Columbia River watershed that may have been similar genetically to interior Fraser coho are now extinct. Interior Fraser River watershed coho salmon are genetically unique and can be readily distinguished from coho from the lower Fraser and other areas of Canada. The Fraser River canyon appears to be a natural boundary that separates many fish populations into upper and lower Fraser units. The Fraser is the largest river in BC draining over 220,000 km^2, about one-quarter of the province (Northcote and Atagi 1997) and the interior Fraser constitutes most of this large drainage basin. Interior Fraser River (Southern Mountain Ecozone) coho are a nationally significant population that occupy ~25% of the natural freshwater range of coho salmon within Canada.

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[1] Fst is the correlation of genes of different individuals in the same population. The higher the value (maximum 1), the more closely related individuals are to one another other than they are to individuals in other samples.

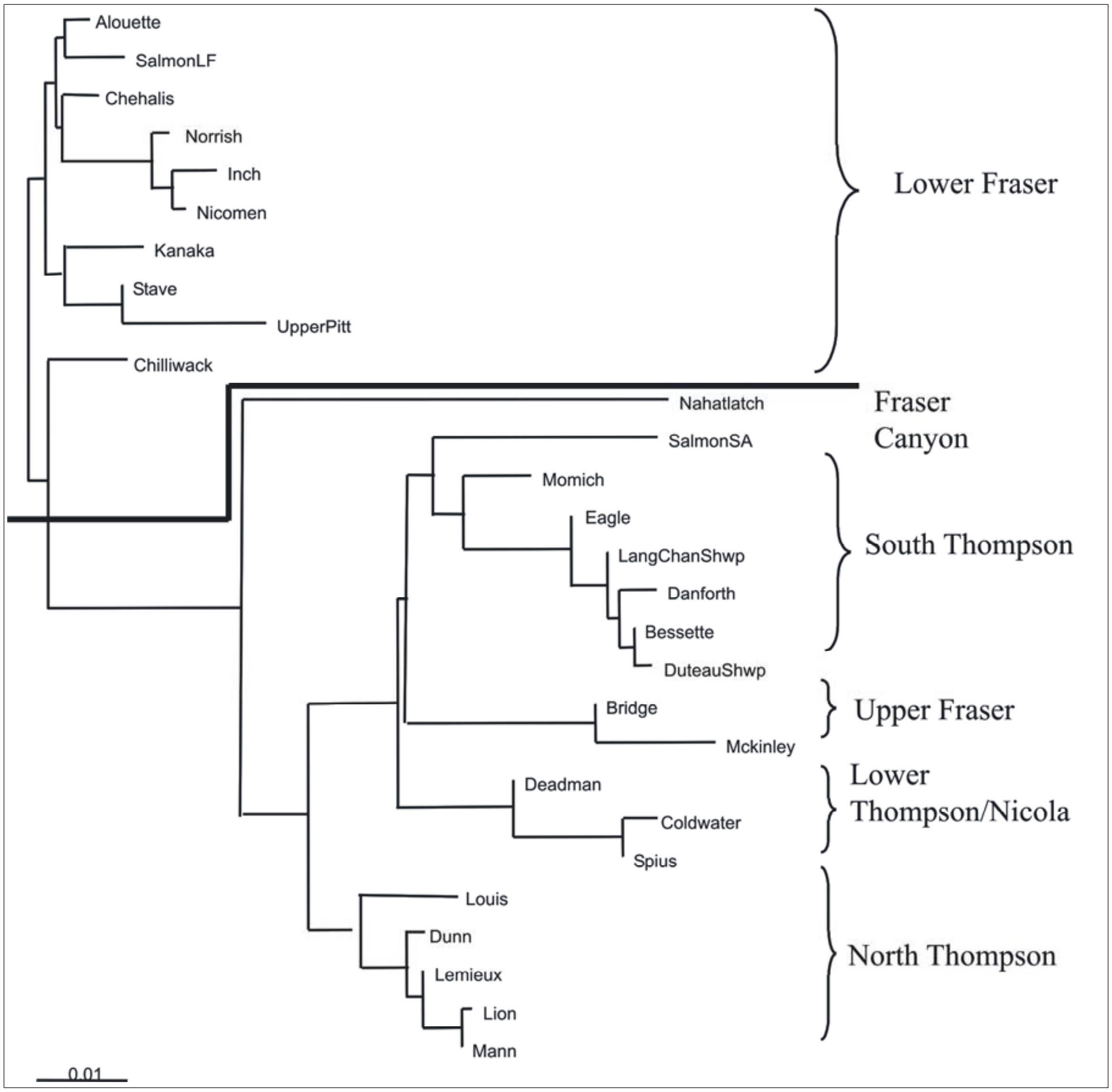

Figure 4. Neighbor joining dendrogram of Fraser River coho salmon populations based on Fst values calculated from six microsatellite loci and two MHC class I and class II loci (from Irvine et al. 2001). Heavy line separates Fraser River populations into those from the interior Fraser and the lower Fraser. Fst scale is shown on bottom left.

DISTRIBUTION

Global range

Coho salmon occur naturally only within the Pacific Ocean and its tributary drainage (Scott and Crossman 1973). Within North America, naturally spawning coho salmon occur in streams and rivers from California north through BC to Alaska. Their distribution extends across the Bering Sea through Kamchatka to Sakhalin Island and rarely as far

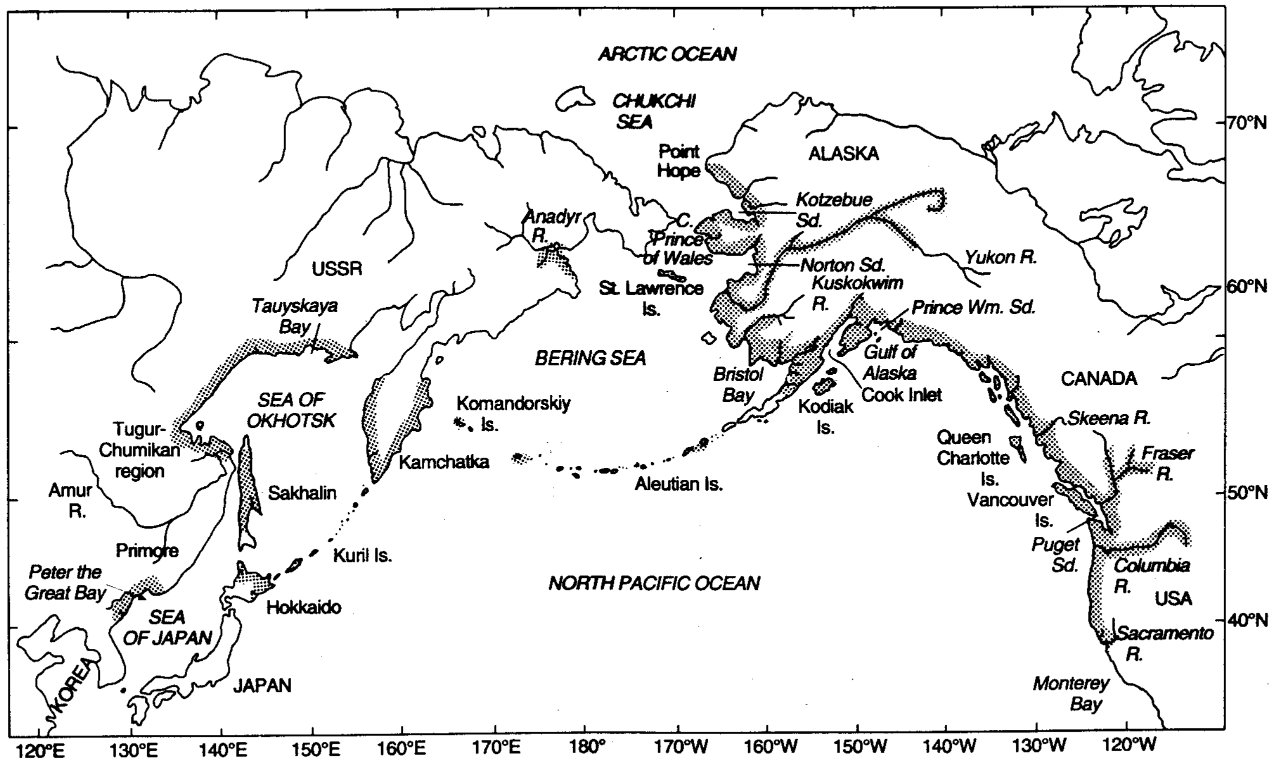

Figure 5. Approximate distribution of naturally spawning coho salmon globally (from Sandercock 1991, reproduced with permission of C. Groot).

south as Peter the Great Bay (Fig. 5, Sandercock 1991[2]). In addition, coho have been introduced to many locations including the Great Lakes.

Canadian range

Coho salmon spawn and rear in most coastal streams and rivers of BC (Fig. 5). The marine distribution of many populations is reasonably well understood from results obtained through the Mark Recovery Program (MRP) operated by Fisheries and Oceans Canada (DFO). Magnetic coded-wire tags (CWTs) are inserted into large numbers of young salmon annually as these fish leave freshwater. Recoveries of these binary coded tags from fish sampled in the various fisheries provide information on fishery exploitation rates and apparent marine distributions.

CWTs from coho salmon that were spawned in the interior Fraser River have been recovered in fisheries from Alaska to Oregon. Most were gathered during troll and sport fisheries off the West Coast of Vancouver Island and in the Strait of Georgia (Fig. 3). Recent catch distributions of coho from streams draining into the Strait of Georgia including the Fraser have been dominated by dramatic swings between fisheries inside

[2] Sandercock (1991) reports that coho have been found in rivers in Hokkaido, northern Japan, but these fish probably were not coho, or if they were coho they were strays; coho spawning naturally in Japan have not been confirmed (J. R. Irvine, unpub.).

and outside of the Strait of Georgia. Prior to 1991, large numbers of coho remained inside Georgia Strait each year and supported major sport and troll fisheries. In 1991, and during 1995-2000, the majority of coho appeared to leave the Strait of Georgia and spend most of their adult lives off the West coast of Vancouver Island. Marine conditions including ENSO events and climate change are known to affect the marine distribution of coho salmon (Pearcy 1992; Beamish et al. 1999a).

Distribution within the Interior Fraser River Watershed

The Fraser River is the largest river in BC and produces more salmon than any other river in the world (Northcote and Larkin 1989). The interior Fraser watershed is part of the Southern Mountain COSEWIC Ecological Area. Coho salmon are widespread throughout the Thompson River system, the largest watershed within the Fraser River system. However, their distribution in non-Thompson Fraser tributaries is not well known. Coho salmon occur at least as far upstream as the Nechako River, but there are several major upper Fraser watersheds where coho probably occur but their presence has not been confirmed (Fig. 3).

For the North and South Thompson drainages where the spawner survey data are the most reliable, there is evidence that coho are spawning in fewer streams than they were when coho were more abundant. Bradford (1998) noted that 32% of streams that had fish observed in them in 1988 had reached ‘none-observed’ status in 1997 (i.e. 3 generations later). This proportion was reduced to 18% in 1999. In a preliminary assessment of the possibility of using stream occupancy to assess the status of Thompson coho, Bradford and Irvine (2000a) found a non-linear reduction in stream occupancy with declining coho abundance. Reductions in stream occupancy began to occur when the overall abundance was reduced by about 75% from peak abundance.

HABITAT

Since coho salmon spawn in freshwater and juveniles normally spend one full year in freshwater before migrating to the sea, their survival depends on having adequate habitat in freshwater as well as the ocean. The distribution of spawning habitat for coho salmon is usually clumped within watersheds, often at the heads of riffles in small streams, and in side channels of larger rivers. Females generally construct nests in shallow (30-cm) areas where the gravel is less than 15-cm diameter and has good circulation of well-oxygenated water (Sandercock 1991). Low or high flows, freezing temperatures, siltation, predation, and disease can reduce egg survival. Major episodes of fry dispersal include spring movements away from spawning sites (Chapman 1962; Gribanov 1948) and pre-winter movements into small tributaries and off-channel habitat. Juvenile densities are generally higher in pools than riffles, although as the fish grow they will occupy areas of faster moving water. Juvenile coho tend to cluster in areas of suitable habitat, most frequently in streams with gradients less than 3%. Structurally complex habitats (large organic debris and large substrate), and habitats with slow moving water are both necessary to ensure high overwinter survival of young coho. Coho utilize lakes for rearing less frequently than streams, and are usually restricted to the littoral regions of lakes. Productivity (food abundance), as well as habitat, plays a role in regulating densities in streams (Chapman 1966).

The Thompson River watershed supports most of the coho salmon of the interior Fraser and the habitat is far from pristine. Many valley bottoms were logged, and subsequently used for agriculture (mainly livestock, dairy, and animal feed crops) for at least 50 years (Burt and Wallis 1997). In some cases, riparian vegetation has been removed, livestock have destabilized stream banks, and off-channel habitats and wetlands have been destroyed or isolated by dikeing. In most non-agricultural areas the old-growth timber on the valley floors has been removed, and logging is now occurring in the headwaters of many watersheds. In addition, much of the southern and western part of the Thompson drainage is in a semi-arid area, and high rates of water withdrawal in summer for irrigation cause low flows and high water temperatures (Rood and Hamilton 1995). Specific freshwater habitat concerns, by watershed, have been collated in a series of Fraser River Action Plan (FRAP) reports (e.g., Harding et al. 1994, DFO 1998a, b).

Juvenile coho salmon from the interior migrate down the Fraser River, live for an unknown time in the highly developed and constrained estuary of the Fraser River at Vancouver (Fig. 3), and usually spend the majority of their oceanic residence near the coast in southern BC. Over two million people live along the lower Fraser River and, as a consequence, riverine and estuarine habitats have been severely impacted. For instance, most of the streams in the lower Fraser River valley are classified as threatened or endangered due to landscape alterations in watersheds, riparian zone degradation, and pollution (FRAP 1998). Fortunately, it appears that habitat loss may have slowed in recent years with the release by DFO of its national “no net loss” habitat policy in 1986 (Langer et al. 2000, Levings 2000). Interior Fraser coho salmon leave the estuary and share a marine environment with other coho salmon and myriad other species. Although marine areas used by Fraser coho are less developed than the Fraser estuary is, these fish still face a variety of habitat issues within the ocean. Coho generally remain closer to the coast than most other salmon and they have to deal with impacts resulting from a rapidly increasing human population. Effects from pulp mills, sewage effluent, and fish farms, however, are difficult to quantify.

Climate related changes have had a major influence on the ability of the marine environment to support coho salmon and other species of salmon (Beamish et al. 1999b). A shift to a lower productivity regime in 1989/90 coincided with substantial reductions in the marine survival of coho salmon (Noakes et al. 2000).

BIOLOGY

General

Most coho salmon return to freshwater in the fall and spawn during fall and early winter. All fish die after spawning. Fry emerge from the gravel the following spring and usually reside in freshwater for a year before migrating to sea as smolts. Most coho spend 18 months at sea before returning to freshwater and therefore have a 3-year life cycle. Variations on this general life cycle include juveniles that emigrate to sea immediately upon emergence, juveniles that emigrate as 2-year-old smolts, and precocious male coho that return to spawn after only 6 months at sea (jacks). More detailed general descriptions are provided in Scott and Crossman (1973) and Sandercock (1991).

Interior Fraser Coho

Biological characteristics were reviewed in Irvine et al. (1999a) and only a brief update and summary is provided here. Female coho are larger than males in most interior Fraser systems, but less abundant (~45% of returns), traits characteristic of many coho populations. Interior Fraser coho are smaller than most similar aged coho documented by Sandercock (1991) and Weitkamp et al. (1995). Mean post-orbital hypural lengths[3] (cm) for coho from the North, South, and lower Thompson drainages (sample sizes in brackets) were 42.3 (7149), 45.7 (256), and 44.0 (1,853) respectively. Temporal patterns in fish size have not been found for interior Fraser coho, although Weitkamp et al. (1995) documented declines in fish size over time for many populations of coho salmon. Fecundities for interior coho are highly variable, and generally less than for coho returning to the lower Fraser or provincial averages (Irvine et al. 1999a), as expected given the generally smaller sizes of coho in the interior Fraser.

Most (93%) interior Fraser coho went to sea in their second year (i.e. European age 1._), with a small proportion (7%) remaining in freshwater for one or two more years (n= 2,274 adult coho aged with scale analysis). Almost all fish from this sample returned to freshwater after the normal 1 winter at sea; only 2 fish were aged as jacks and 6 as having spent more than 1 winter at sea.

POPULATION SIZES AND TRENDS

Aboriginal Traditional Knowledge

Aboriginal Traditional Knowledge (ATK), sometimes referred to as Traditional Ecological Knowledge, describes the knowledge originating with First Nations peoples pertaining to their immediate environments, and the cultural practices that build on that knowledge (Ford and Martinez 2000). Communities with a long history of resource use can acquire a deep but qualitative knowledge about the resource that they depend upon (Kurien 1998).

Interior Fraser coho return to spawn primarily within the traditional territories of the Secwepemc people (North and South Thompson and Clearwater rivers) and of the Nlaka'pmux, Sce'exmx and Okanagan people of the upper Fraser canyon and Nicola valley. Some coho spawning also takes place within the traditional territories of the St'at'imc, (Lillooet/Bridge River areas) and Tsilhqot'in (Chilcotin river system). The Secwepemc Fisheries Commission (SFC) and the Nicola Valley Stewardship and Fisheries Authority (NWFSA) represent bands with knowledge of traditional fisheries. In addition,

[3] Measured from the hind margin of the eye to the posterior end of the hypural plate.

there are various bands not affiliated with these organizations that also possess ATK. ATK pertaining to some natural resources in the interior Fraser has been assembled (e.g. Turner et al. 2000) but no thorough review of ATK has been undertaken for salmon. Irvine et al. (2000) review issues concerning the role of ATK in the assessment of interior Fraser coho salmon.

Abundance Estimates

We have no estimates of the abundance of coho salmon in the interior Fraser prior to the arrival of Europeans. Northcote and Burwash (1991) calculated that the average annual abundance (catch plus spawners) for Fraser River coho salmon in the 1920's to early 1930's was approximately 1.2 million. Assuming ~1/3 of these fish were from the interior Fraser, the abundance of interior Fraser coho during this period was ~400,000 and assuming as Northcote and Burwash did that 50% of these fish were harvested, the annual escapement of coho was in the order of 200,000 fish. In their report on fish of the Fraser River basin, Northcote and Burwash (1991) estimated that coho salmon in the Fraser watershed underwent a 7.7 fold decrease between the 1920's and the period between the 1950's and the 1980's. However, they cautioned that data for coho were the least reliable of the salmon data.

Spawning coho salmon are notoriously difficult to count. Although escapement estimates (number of salmon escaping marine fisheries and returning to freshwater to spawn) exist for some streams in the interior Fraser as far back as 1951, older estimates are of unknown accuracy and precision. Consequently they are of little use for time series analysis, other than to confirm species presence in a watershed.

A variety of techniques are currently used to estimate coho salmon escapements for ~71 streams in the interior Fraser River watershed. Although essentially all known spawning streams in the Thompson watershed are assessed, many in the upper Fraser are not.

Precision is more important than accuracy in time series analysis, and high precision requires that field and estimation methods should be consistent through time.Two approaches were used to examine recent trends in spawner numbers, an escapement indicator approach and an approach using an adjusted escapement series.

The escapement indicator approach relied on escapement estimates to unenhanced North and South Thompson streams with reasonably consistent monitoring. Total escapements to the 10 North Thompson escapement indicator streams followed similar temporal patterns as escapements to the 16 South Thompson escapement indicators (Irvine et al. 2001). Numbers appeared to be relatively stable during the late 1970's, increased during the early 1980's, peaking in the latter part of the decade. Since then, escapements declined rapidly until 1996, after which a small increase may have occurred. Using procedures documented in Simpson et al. (2001), the adjusted escapement series consisted of total numbers of coho salmon spawners returning to the major basins within the Thompson watershed, and included hatchery-origin fish (Table 1). Similar to the wild indicator data set, the adjusted escapement estimates for the North and South Thompson also peaked in the mid-1980's, declined until about 1996, and were then stable or increasing (Fig. 6). It was difficult to reconstruct the time series for lower Thompson/Nicola and non-Thompson populations. A significant portion of returns to the lower Thompson/Nicola is enhanced, and many estimates are unreliable. Escapements to the lower Thompson appear less variable than to other parts of the Thompson, although they also may have increased in recent years (Fig. 6). The time series for non-Thompson streams is too short to assess temporal patterns.

At the peak of our time series of reliable estimates, escapements to the interior Fraser were in the order of 100,000 and abundance in two years appeared to exceed 300,000 (Table 1). The size of the total population spawning more recently was estimated by averaging escapement estimates for each of the five subpopulations (i.e. North Thompson, South Thompson, lower Thompson/Nicola, Fraser canyon, and upper Fraser) during 1998-2000 (Table 1). All estimates will be biased low to a small degree simply because it is not possible to see all fish. Of greatest concern is the degree of bias for upper Fraser streams. Results from a fishwheel mark recapture program imply that this bias may be in the order of 57% (Irvine et al. 2001). The total population of interior Fraser coho spawning annually in recent years is probably in the order of 24,000 (23,914) fish (Table 2), of which ~15% are of hatchery-origin. The North and South Thompson populations collectively include slightly more than half the total population of coho in the interior Fraser

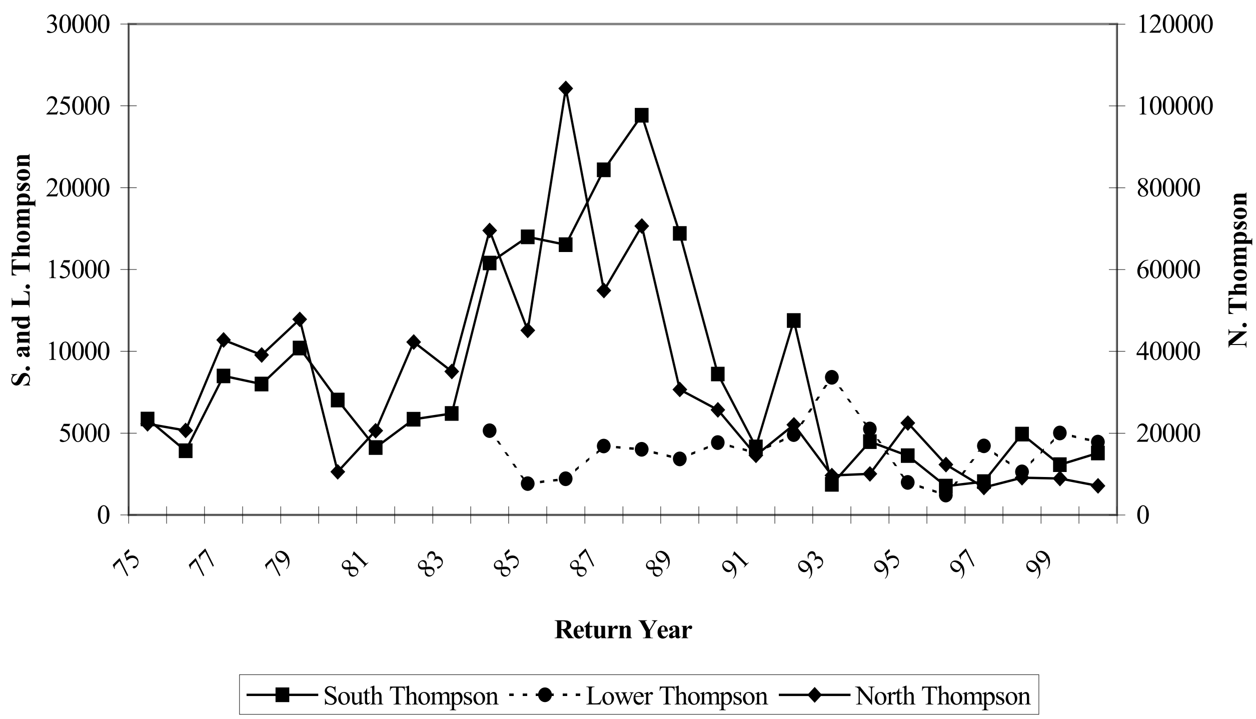

Figure 6. Adjusted historical escapement estimates for coho salmon (wild and hatchery fish) returning to the South, lower, and North Thompson watersheds (data are in Table 1).

Table 1. Estimated fishery exploitation rates (expl), escapements (esc), marine fishery catches, and total abundances (abund) for interior Fraser coho salmon (hatchery and wild fish combined, data updated from Irvine et al. 2001). Exploitation was not measured prior to 1987 but was assumed to be the same as the average exploitation during 1987-1996. 2001 estimates are preliminary. The Fraser Canyon and the Upper Fraser subpopulations have been merged into Non-Thompson Fraser.

Return		South Thompson			North Thompson			Lower Thompson			Non-Thompson Fraser		
Year	expl	esc	catch	abund	esc	catch	abund	esc	catch	abun	esc	catch	abun
1975	0.68	5864	12490	18354	22286	47468	69754						
1976	0.68	3920	8349	12268	20675	44037	64713						
1977	0.68	8490	18082	26572	42804	91171	133975						
1978	0.68	7996	17032	25028	39095	83269	122364						
1979	0.68	10198	21720	31918	47819	101851	149670						
1980	0.68	7025	14964	21989	10542	22454	32996						
1981	0.68	4120	8775	12895	20615	43909	64524						
1982	0.68	5849	12459	18308	42295	90087	132382						
1983	0.68	6196	13196	19392	35086	74731	109816						
1984	0.68	15394	32789	48183	69552	148141	217692	5155	12050	17205			
1985	0.68	16998	36205	53204	45160	96188	141349	1913	4060	5973			
1986	0.66	16521	31665	48186	104267	199846	304113	2211	4300	6511			
1987	0.54	21087	24478	45564	54884	63710	118594	4208	4945	9153			
1988	0.71	24426	60376	84802	70612	174539	245150	4013	9830	13843			
1989	0.65	17208	31288	48496	30677	55779	86455	3423	6340	9763			
1990	0.74	8609	24069	32677	25697	71844	97542	4421	12600	17021			
1991	0.68	4160	8737	12896	14585	30633	45217	3794	8825	12619			
1992	0.81	11886	52239	64125	22042	96875	118917	4905	21000	25905			
1993	0.88	1873	13172	15045	9669	67999	77667	8416	61500	69916			
1994	0.43	4485	3430	7915	10031	7671	17702	5252	3965	9217			
1995	0.56	3622	4639	8261	22477	28794	51272	1984	2525	4509			
1996	0.83	1760	8906	10667	12319	62325	74645	1209	5900	7109			
1997	0.40	2034	1384	3418	6722	4573	11295	4217	2820	7037			
1998	0.07	4946	375	5321	9125	685	9810	2628	200	2828	8147	610	8757
1999	0.09	3074	305	3379	8916	885	9801	5007	495	5502	5389	535	5924
2000	0.03	3785	134	3919	7032	250	7282	4459	157	4616	4723	144	4867
2001	0.07	13239	996	14235	26429	1989	28418	9828	740	10568	13515	1018	14533

Table 2. Mean number (percentages) of spawners escaping to the major basins of the interior Fraser during 1998-2000. In the lower two rows, the number of spawners estimated in the upper Fraser was divided by 0.57 to account for fish in streams that were not surveyed.

Origin	South Th.	North Th.	Lwr Th/Nicola	Fraser Canyon	Upper Fraser	Total
Wild + hatchery	3935 (18)	8358 (37)	4031 (18)	4092 (18)	1994 (9)	22410
Wild + hatchery	3935 (16)	8358 (35)	4031 (17)	4092 (17)	3498 (15)	23914
Wild only	3904 (19)	7202 (35)	1617 (8)	4092 (20)	3498 (17)	20313

Enhancement

Hatchery production of coho salmon began in the early 1980's, peaking during the mid- to late 1980's when enhancement strategies were being tested for coho in the Eagle, Salmon, and Coldwater systems. The main objectives of enhancement during this period were to evaluate the effectiveness of different strategies and to assess the impact of enhanced production on natural stocks (Perry 1995, Pitre and Cross 1993). These authors concluded that fry releases might be a useful supplementation strategy when progeny from natural spawning do not fully occupy available habitat. However, negative interactions between wild and hatchery coho salmon can occur, particularly when the release of hatchery coho fry results in the carrying capacity of a stream being exceeded.

There are no large production facilities for coho salmon in the interior Fraser. There are ~13 small enhancement projects producing coho as well as habitat restoration at various sites. Enhancement efforts currently focus on rebuilding depressed stocks and obtaining assessment information that can be used for both wild and enhanced stocks. Since temporal patterns for the adjusted escapement series (Fig. 6) that included hatchery fish were similar to those of the wild indicator series, it appears that enhancement had a relatively minor effect on overall population trends. Bradford and Irvine (2000) reached a similar conclusion. They found that the presence of hatchery activities had no significant effect on rates of decline. Enhancement activities are described in more detail by Irvine et al. (1999a, 2000).

Since many of the coho salmon released from hatcheries are marked, and most of the salmon returning to these systems are examined for marks, it was possible to estimate the proportion of the escapement that are of hatchery origin. During 1998-2000, hatcheries contributed a significant proportion of the fish returning to streams in the lower Thompson/Nicola watersheds (Table 2), but relatively few fish elsewhere.

Survivals and Fishery Exploitations

Temporal patterns of salmon abundance are often analysed by partitioning survival into freshwater and marine components. Freshwater survival estimates are not available for interior Fraser coho salmon. Marine survivals declined during the decade following the late 1980's, a pattern that has been documented for many coho south of northern British Columbia (Coronado and Hilborn 1998). While marine survivals may have improved in the last two years, they are still generally less than 3%, much less than they were in the late 1980's (Irvine et al. 2000).

Estimates of fishery exploitations up to 1997 are available through the MRP, and since then from an analysis of DNA from tissue samples from fish taken in fisheries (Irvine et al 2001). Unprecedented restrictions in Canadian salmon fisheries commencing in 1997 and increasing in 1998-2000 are apparent in the time series of exploitation rates (Table 1). Exploitation rates (i.e. catch/catch plus escapement) during 1998-2000 averaged 6.5% (Canada and USA combined). In contrast, the mean annual exploitation during the ten-year period from 1987-1996 was 68% (Table 1).

Rates of Decline

Rates of decline were computed based on:

1. The escapement time series consisting of data from the 10 North Thompson and 16 South Thompson indicator streams, which have relatively few missing data and are unaffected by hatchery activities.[4]
2. The adjusted total escapement estimates for the North and South Thompson watersheds (Table 1).

Declines were estimated in two ways. The first approach used annual estimates of abundance and the standard COSEWIC formula for calculating declines.[5] The second (smoothed) used running averages calculated over 3-year periods, the normal generation time for these fish. This approach reduced year to year variations in abundance, which are common with semelparous animals including coho salmon that reproduce primarily at one age.

Each approach resulted in relatively large rates of decline (Table 3). Estimates for the 10-year period from 1990 – 2000 ranged from 27 – 73% (overall mean 60%).[6] The lowest estimated decline resulted when the smoothed approach was used to interpret escapement indicator data from the North Thompson watershed. Differences between methods and data sets were not consistent.

Annual estimates of productivity for Thompson coho were estimated as:

$$r_{an} = ln\ [R_t/S_{t-3}]$$

where R_t is recruitment (i.e. catch plus escapement) and S_{t-3} is the abundance of parent spawners (i.e. escapement). Thus r is a measure of survival from spawners to returning (i.e. prefishery) adults. The time series of r_{an} for the mean of the 10 North and 16 South Thompson indicator streams is presented (Fig. 7).

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[4] North Thompson watershed index streams are: Barrièrre, Blue, Cook, East Barrièrre, Fennel, Lion, N. Thompson, Raft, Reg Christie, and Tumtum, while South Thompson watershed index streams are Adams (lwr), Adams (up), Bessette, Blurton, Bolean, Canoe, Hunakwa, Kingfisher, Scotch, Shuswap (lwr), Shuswap (mid), South Pass, Tappen, Trinity, Wap, and Sinmax.

[5] Formula provided by COSEWIC (http://www.cosewic.gc.ca/COSEWIC/authors/).

[6] Preliminary escapement estimates for 2001 became available as this report was being revised. When the smoothed approach was used to compute declines during 1991-2001 using the adjusted escapement data set, estimates for the South and North Thompson aggregates were 12 and 34% respectively. These estimates were more positive than estimates for 1990-2000 for two reasons: 2001 escapements were much higher than in recent years, and the 1991-2001 data set excluded the relatively large escapements of 1990 (relative to 1991).

Table 3. Rates of decline (percentages) for South and North Thompson coho salmon escapement indicator data (wild coho only) and adjusted estimates of total escapements (wild and hatchery) during 1990-2000. Estimates were calculated using the standard COSEWIC formula, as well as using 3 year smoothed data.

	South Thompson			North Thompson			Overall
Method	Esc. Indic.	Adjusted	Mean	Esc. Indic.	Adjusted	Mean	Mean
COSEWIC	56.5	61.2	58.9	56.0	72.6	64.3	61.6
Smoothed	79.3	65.6	72.4	27.2	57.7	42.5	57.5

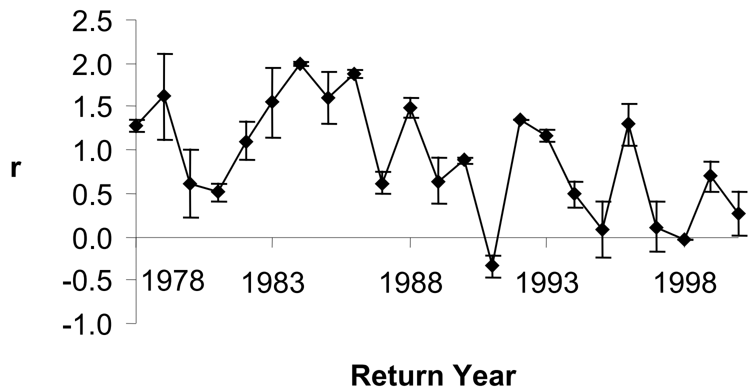

Figure 7. Time series of r_{an}, the annual rate of population growth of Thompson coho salmon (from Irvine et al. 2001). Each point is the average (±SE) of two time series (North and South indicator stream aggregates). When $r<0$, populations are unable to replace themselves, even in the absence of fishing.

There was an overall decline in r_{an} from the mid-1980's until 1997-1998 (Fig. 7). During some years (1991 and possibly 1995, 1997, and 1998) r_{an} may have been < 0, meaning that some populations were unable to replace themselves, even if fishing mortality was zero. Fortunately, the average r_{an} for the 1999 and 2000 returns was positive.

Reference Points

Biological reference points are benchmarks against which the status of fish populations can be measured (Collie and Gislason 2001). Irvine et al. (2001) computed provisional reference points for coho from the North Thompson watershed (see also Chen et al. 2002) which are used here to identify somewhat arbitrary categories of abundance. Results are presented in terms of numbers of adult female coho salmon per km of habitat accessible to them.

The estimated number of female spawners that would produce maximum sustained yield (24.9 females/km of accessible habitat) was selected to identify the transition between zones of moderate and high abundance (Fig. 8). The mean of two lower reference points was chosen as the boundary between critical and poor categories of abundance. One lower reference point was the minimum escapement that the population has recovered from (6.1), and the second was a value computed as the theoretical 10% probability of extinction for a single brood line in one generation (4.3) (Irvine et al. 2001; Chen et al. 2002). The zone between poor and moderate abundance was two times this mean value (10.4).

As can be seen in Fig. 8, with one exception spawner numbers were in the moderate and abundant categories from 1975-1990, were in the poor or low moderate zones from 1991-1996, and were near but generally below the poor-critical boundary from 1997-2000 (Fig. 8).

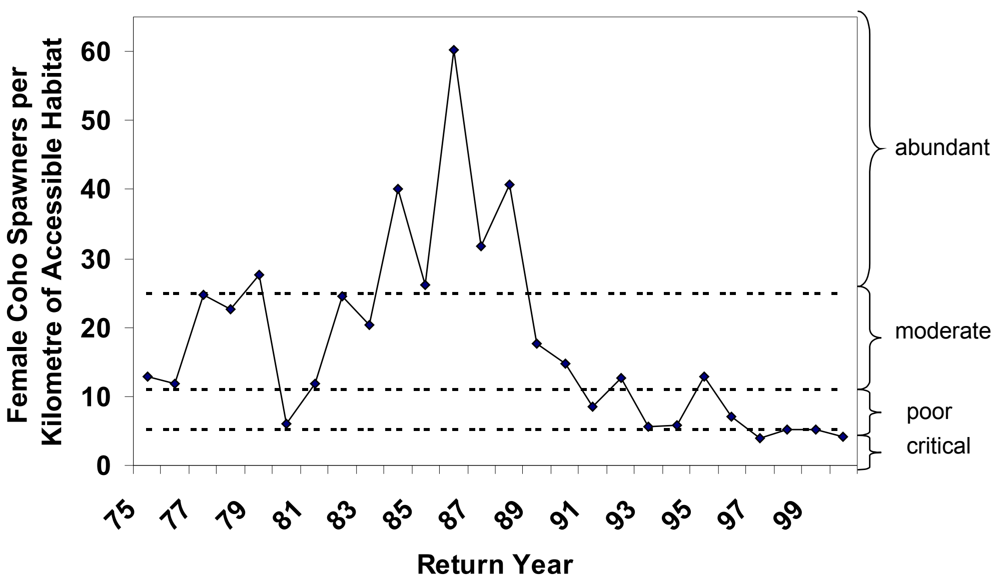

Figure 8. Annual estimates of numbers of adult female coho salmon (wild and hatchery) per kilometre within the North Thompson watershed (adapted from Irvine et al. 2001). Horizontal lines indicate boundaries between abundance categories.

Future Scenarios

The future for interior Fraser coho is highly uncertain and depends on impacts due to two categories of human-induced activities, fishing and habitat perturbations, and one category that is largely out of our control, climate-related changes in salmon survival. The human population in the Pacific Northwest (including British Columbia) is expected to increase by 2-7 fold this century (Lackey 2001). Hartman et al. (2000) discuss how human activities affect salmon at local, regional, and global levels and conclude that human population growth likely represents the greatest threat to Pacific salmon.

In Fig. 9, the outlook for coho in the North Thompson watershed is forecast beginning in 2001 under three simplistic scenarios. In the most optimistic scenario, survivals are assumed to improve to levels recorded during 1978-1997 (recruits/spawner (R/S) = 3.31); in the average scenario, survivals remain the same as during 1998-2000 (R/S = 1.47); and in the worst case scenario, survivals are the same as recorded for fish returning in 1998, a poor survival year (R/S = 0.96).[7] It is assumed that there will be no additional impact of habitat development and that fishing will remain at the same low levels as during 1998-2000 (i.e. ~7%). In addition, spawners are assumed to be all 3 years old, and spawner numbers cannot exceed 50 female coho per kilometer, a level reached only once in the previous 25 years (Fig. 8).

For North Thompson and presumably other populations of coho, a return to survival levels experienced historically, combined with continued low fishing pressures and no additional habitat impacts, would theoretically produce rapid increases in escapements and rebuilding within two generations. If survivals continue at recent average levels, populations will take 5-6 generations to reach the abundant category. However, if survivals are as poor as they were in 1998, numbers will decrease, eventually resulting in extinction (Fig. 9).

These forecasts are simplistic and probably overly optimistic for several reasons: the capacity of the environment to produce coho salmon has probably been reduced in recent years due to habitat changes and this has been ignored in the model; the extremely low fishing pressures assumed have come at a large socioeconomic cost and may be difficult to maintain; and, finally, no variability in survival is assumed in the model. Routledge and Irvine (1999) found that even small increases to the amount of chance variation in recruitment can significantly reduce population survival rates.

LIMITING FACTORS AND THREATS

Anthropogenic and natural factors can limit populations of coho salmon. Human population growth has resulted in increased demands for water, waste disposal, and because of altered land-use patterns, habitat degradation. Since many coho live in near shore marine environments, they are susceptible to natural and man-made changes to the marine ecosystem. However, impacts of human activities on salmon populations are often difficult to quantify. This is especially true in the coastal ecosystem where interrelationships among physical and biological processes are not well understood. In contrast, various studies have documented the role of climate change in altering the marine ecosystem and related this to shifts in ocean survival for salmon (e.g. Beamish et al. 1999a, b; Coronado and Hilborn 1998).

[7] Spawner recruitment data all from the North Thompson indicator stream data set.

Since coho salmon spend a full year in freshwater, they are also susceptible to freshwater habitat degradation. Bradford and Irvine (2000b) related the rate at which the abundance of coho returning to individual spawning streams declined to the extent of human activity in the corresponding watershed. The hypothesis being tested was that average rates of decline (for years 1988-1998) for individual spawning populations would be negatively related to land use in the catchment. It was assumed that all spawning populations were experiencing the same rates of fishing and ocean mortality so that variability among spawning populations might be related to freshwater productivity. Bradford and Irvine showed that rates of decline were correlated with agricultural land use, road density, and a qualitative index of stream habitat status (Fig 10).[8]

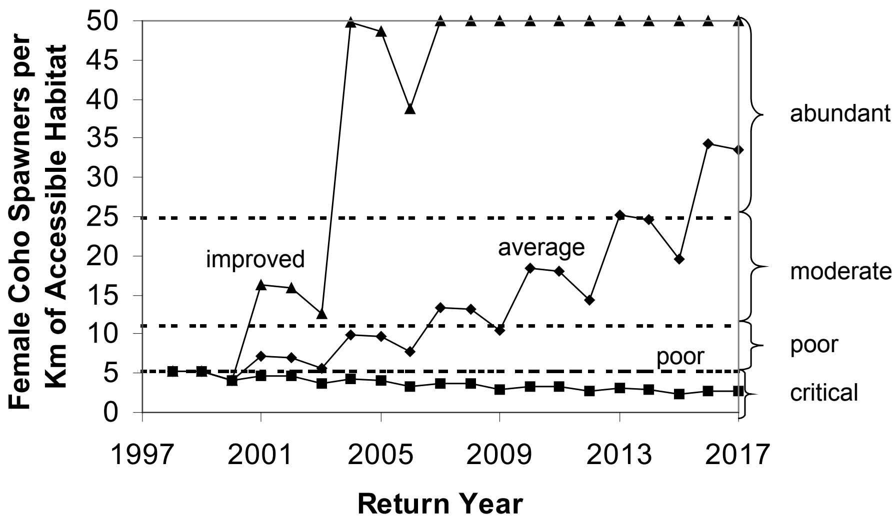

Figure 9. Projected escapements of female North Thompson coho under improved (3.21 recruits/spawner), average (1.47), and poor (0.96) survival conditions assuming current low exploitation rates (7%). Horizontal lines indicate boundaries between abundance categories.

Land use patterns may be one reason why the abundance of spawners in the last 25 years in the South Thompson declined at a greater rate than those of the North Thompson did (Irvine et al. 2000). Watersheds in the South Thompson are more impacted by human activities; average scores for the three measures of land use that are correlated with coho declines (Fig. 10) were higher for the South than the North Thompson basin.

Productive freshwater habitats can help sustain salmon populations during periods of adverse marine conditions (or overexploitation) because they maximize the number of smolts produced per spawner. The analysis of Bradford and Irvine (2000b) shows that spawning populations are at greater risk when the watershed is subject to extensive

[8] Note that in Fig. 7, r_{an} is the annual mean of two indicator stream time series (1978-1998) while in Fig. 10, individual stream values of r are plotted for 40 streams, averaged over 1988-1998.

human modification. Populations from healthy watersheds experienced the smallest declines, and are likely to recover at a faster rate if ocean conditions improve. Thus, the recovery and sustainability of coho will be improved through a balanced program of habitat protection and watershed restoration.

To evaluate the role of fishing in the decline of interior Fraser coho salmon, mean annual estimates of *r* for the North and South Thompson were used to calculate the harvest rate that would have maintained wild spawner abundances at levels similar to those of the parental escapement:

$$h^* = 1- e^{-r_{an}}$$

where $h^* = 0$ if $r \leq 0$ (Bradford and Irvine 2000b). For years when $r > 0$, h^* would have maintained populations at stable levels (i.e. $S_t = S_{t-3}$) assuming all other mortality factors remained constant. Fishing contributed to declines in abundance when exploitations exceeded h^*.

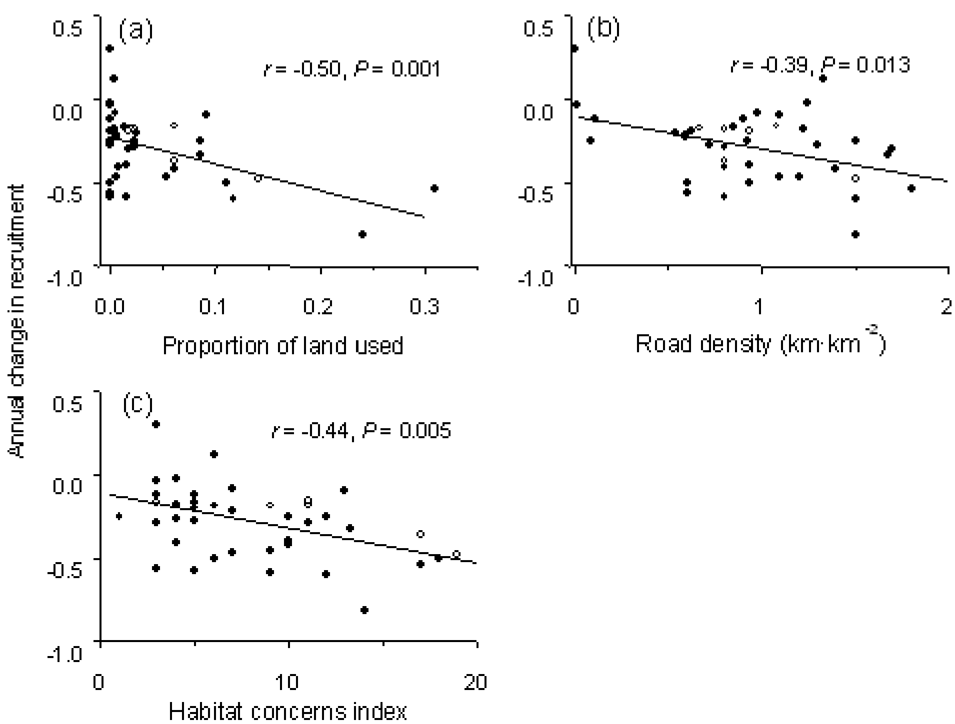

Figure 10. Relationships between three land use measures and productivity of coho salmon (i.e. *r*) for 40 Thompson tributaries (adapted from Bradford and Irvine 2000b). (a) proportion of land in each catchment dedicated to agricultural or urban use, (b) density of forest, agricultural and hard surface roads in each catchment, and (c) index of habitat concerns. Open circles are streams that have had hatchery programs.

When actual exploitation rates were compared to estimates of *h**, it was found that harvest rates were excessive from 1989 until 1998 (Fig. 11). In 1999 and 2000, exploitations were low enough that populations were above replacement levels.

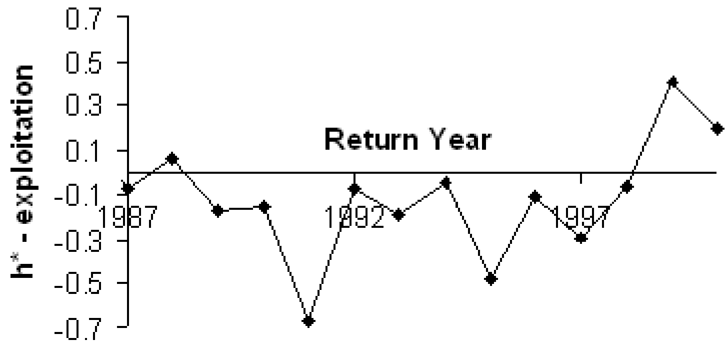

Figure 11. Differences between exploitation rates that would have maintained coho production at the brood year escapement level (i.e. h*; $S_t = S_{t-3}$) and calculated exploitations for North and South Thompson indicator stream aggregates. Negative values indicate that populations were overexploited.

SPECIAL SIGNIFICANCE

Coho salmon remain an economically important species, contributing to commercial, recreational, and aboriginal catches along the Pacific coast of North America. Numbers of coho are declining throughout much of its range and some coho populations have become extinct (e.g. Nehlsen et al. 1991, Weitkamp et al. 1995, Slaney et al. 1996, Northcote and Atagi 1997) (Fig. 2). As of December 2001, coho salmon were threatened by extinction in three ESUs, candidates for listing by the US Endangered Species Act in two, and not likely to become endangered in only one ESU (Fig. 2). Coho salmon from the interior Fraser River coho are genetically distinct, constitute an ESU, and are a nationally significant population.

Stock status for coho in BC varies depending on location. The sizes of many populations in southern BC have declined greatly from historical levels (Simpson et al. 2000). Population status for coho from the central coast is poorly understood; coho from northern BC are generally doing better than their southern counterparts although the viability of populations in the upper Skeena River drainage was considered at risk several years ago (Holtby and Finnegan 1997). The status of coho salmon from the interior Fraser watershed appears to be worse than the status of coho from other areas in BC.

EXISTING PROTECTION

The legislative framework for fish conservation in Canada was recently reviewed (Anonymous 2001). Canada is a signatory to the international Convention on Biological Diversity, which requires governments to develop legislation and policies to protect ecosystems and habitats and maintain viable species populations. The federal Fisheries Act requires proposed alterations to habitat to be authorized by DFO, although in BC, provincial and municipal governments also regulate many land and water use activities that can affect fish populations. For example, the provincial Water Act governs the allocation of water, water licences, and the regulation of works in streams. The Canada Oceans Act requires that Canada manage its marine resources to conserve biological diversity and natural habitats.

In 1998 DFO released its New Directions Policy for the Pacific region (DFO 1998c). The first two principles in this policy state that conservation of Pacific salmon stocks is the primary objective of Fisheries and Oceans and will take precedence in managing the resource, and that a precautionary approach to fisheries management will continue to be adopted. One of the consequences of the New Directions Policy is the (draft) Wild Salmon Policy (DFO 2000). The primary goal of the Wild Salmon Policy is to promote the long-term viability of Pacific salmon populations and their natural habitat. This policy document is currently being revised and it is expected that it will be completed in 2002.

The rationale for considering interior Fraser coho a nationally significant population was provided earlier. At the spring 1998 meeting of the PSARC (Pacific Scientific Assessment Review Committee) Salmon Subcommittee, the status of interior Fraser River coho was reviewed (Irvine et al. 1999a), and a risk assessment undertaken (Bradford 1998). The PSARC Steering Committee advised that Thompson River coho were extremely depressed, would continue to decline even in the absence of fishing mortality under current marine survival conditions, and that some populations were at high risk of biological extinction (Stocker and Peacock 1998). On 21 May 1998, David Anderson, Minister of Fisheries and Oceans Canada, announced that “despite significant conservation measures implemented by my department over the last three years, scientific evidence demonstrates conclusively that wild coho stocks are declining and some are at extreme risk”. Minister Anderson proclaimed a conservation objective of achieving zero fishing mortality for critical Thompson (and upper Skeena) coho stocks. It was expected that such restrictions would be required for six to eight years. However, as illustrated in Fig. 9, the time actually required for rebuilding is highly dependant on survival rates.

Regulatory changes made following Minister Anderson’s statements were probably the most significant fishery changes ever implemented within the Pacific Region of Canada (Irvine and Bradford 2000). In the last several years, managers have allocated what was considered to be an acceptable exploitation for Thompson coho in southern BC fisheries (~2%) amongst these fisheries. In 2000, the total exploitation of interior Fraser coho was the lowest on record, only 3.4% (Table 1), which was divided equally between southern BC and the USA (mostly Washington State). A combination of low fishing pressures, and what appear to be increasing although still low marine survivals, may have stopped the declining trend for interior Fraser coho salmon.

There is no consensus within the scientific community about future survival patterns for coho salmon. Since virtually all interior Fraser coho are three years old and there is little genetic exchange among broodlines, a minimum of three consecutive years with strong escapements are necessary to be confident of an improvement in abundance status. For nationally significant populations such as coho from the interior Fraser, an extremely cautious approach to fisheries and habitat management will be necessary to ensure the maintenance of viable populations. In particular, negative habitat impacts need to be prevented, and conservative fishery management measures as in place in recent years need to remain in place.

SUMMARY OF STATUS REPORT

Coho salmon are an important species, contributing to catches along the Pacific coast of North America. However, coho numbers are declining throughout much of their range, particularly in the northwestern United States and southern BC. This report focuses on coho salmon from the interior Fraser River of British Columbia. Coho in this region originated from populations that survived glaciation in Columbia River refugia. Since coho are now extinct in the upper Columbia, interior Fraser River coho are genetically distinct from other surviving coho salmon.

Coho salmon from the interior Fraser River constitute an Evolutionarily Significant Unit. The total population is comprised of at least five subpopulations (North Thompson, South Thompson, lower Thompson/Nicola, Fraser canyon, and upper Fraser). Genetic exchange among streams within subpopulations is much greater than among subpopulations. There is a concern that if the total population becomes too fragmented, genetic exchange within the total population may be insufficient to be assured of long-term survival.

The time series of reliable abundance estimates is 25 years duration for coho from the North and South Thompson drainages, 16 years from the lower Thompson/Nicola, and only 3 years for the Fraser canyon and upper Fraser tributaries. We have less confidence in the lower Thompson/Nicola time series than we do for the North and South Thompson. Spawner numbers in the North and South Thompson watersheds peaked in the mid-1980's, declined until about 1996, and have been stable or increasing since then. On average, North and South Thompson coho declined in numbers by ~60% during the 10-year period from 1990-2000. There were four years (1991, 1995, 1997, and 1998) when productivity was so low that some populations may not have been able to replace themselves, even if fishing mortality had been zero. Although spawner numbers in 1999 and 2000 exceeded parental escapements, numbers were still critically low. Three consecutive strong returns are necessary to have confidence in any improvement in status.

The recent size of the total interior Fraser coho population was estimated by averaging spawner estimates for each subpopulation (area) during 1998-2000. Slightly more than half of recent estimates of the total population of 24,000 occur within the North and South Thompson watersheds. Natural spawning is thought to be responsible for producing most of the fish escaping to the interior Fraser in recent years (~20,000 of 24,000 total) although in the lower Thompson/Nicola area, hatchery-origin fish outnumber wild coho. There is no evidence that the extent of occurrence has changed, although spawners were seen in fewer streams as populations declined.

Overfishing, changing marine conditions, and habitat perturbations all contributed to declines in numbers of coho salmon in the interior Fraser. Excessive fishing resulted when harvest rates were not reduced quickly in response to climate-driven reductions in marine survival. Coho declines were often related to the intensity of human disturbance in the watershed. Fishing pressures have been reduced dramatically the last several years, and this combined with an apparent stabilization in marine survivals resulted in improved returns.

The outlook for interior Fraser coho is highly uncertain and depends on impacts due to fishing, habitat perturbations, and climate related changes in survival. A return to higher survivals experienced until 1997, combined with continued low fishing pressures and no additional habitat impacts, would produce rapid increases in escapements and rebuilding. In contrast, if survivals return to low levels such as those recorded in 1998, spawner numbers will decrease, eventually resulting in extinction. Since there is no consensus about future marine survivals, an extremely cautious approach to fisheries and habitat management will be required to ensure the long-term viability of populations of coho salmon from the interior Fraser River watershed of BC.

TECHNICAL SUMMARY

Oncorhynchus kisutch
Coho salmon (Saumon coho)
Interior Fraser River watershed coho salmon
Fraser River watershed (BC) upstream of the Fraser canyon

Extent and Area information	
• *extent of occurrence (EO)(km²)* (watershed areas are provided; water-covered areas may be more appropriate but have not been estimated)	South Thompson -17,814 North Thompson – 20,676 Lwr Thompson/Nicola -17,181 Fraser Canyon - ~1,000 Upper Fraser – (excluding Nechako, Stuart and above Pr. George) – 80,941
• *specify trend (decline, stable, increasing, unknown)*	Unknown
• *are there extreme fluctuations in EO (> 1 order of magnitude)?*	No
• *area of occupancy (AO) (km²)* *(this presumably should be the water-covered areas minus areas of unsuitable habitat but these have not been estimated)*	This has not been estimated but will be much less than the watershed areas provided as EO
• *specify trend (decline, stable, increasing, unknown)*	Decline
• *are there extreme fluctuations in AO (> 1 order magnitude)?*	No
• *number of extant locations*	> 75 spawning streams
• *specify trend in # locations (decline, stable, increasing, unknown)*	Decline – as spawner numbers declined, they were seen in fewer streams
• *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*	Declining
Population information	
• *generation time (average age of parents in the population) (indicate years, months, days, etc.)*	Approximately 3 yrs
• *number of mature individuals (capable of reproduction) in the Canadian population (or, specify a range of plausible values)*	~24,000 of which ~20,000 are the result of natural spawning (mean of 1998-2000 estimates)
• *total population trend: specify declining, stable, increasing or unknown trend in number of mature individuals*	Declining (based on data for the 2 largest populations, North and South Thompson)
• *if decline, % decline over the last/next 10 years or 3 generations, whichever is greater (or specify if for shorter time period)*	~60% over 1990-2000 although 2001 data indicate an improvement.
• *are there extreme fluctuations in number of mature individuals (> 1 order of magnitude)?*	Yes (for N. and S. Thompson at least)

• *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)?*	Total population is divided amongst 5 (sub)populations. Genetic exchange amongst populations not quantified but potentially is a concern.
• *list each population and the number of mature individuals in each*	Total numbers for each (sub)population (wild fish in brackets) during 1998-2000: South Thompson – ~3900 (~3900) North Thompson - ~8400 (~7200) Lower Thompson/Nicola – ~4000 (~1600) Fraser Canyon – ~4100 (~4100) Upper Fraser – ~3500 (~3500)
• *specify trend in number of populations (decline, stable, increasing, unknown)*	There is no known change in number of populations. Spawners have been observed in fewer streams as escapements declined, but these are not considered to be separate populations.
• *are there extreme fluctuations in number of populations (>1 order of magnitude)?*	No
Threats (actual or imminent threats to populations or habitats) [add rows as needed]	
– Interior Fraser coho underwent significant reductions in marine survivals which were probably related to climate change. Reductions in marine survivals may have been up to an order of magnitude as measured for other populations in southern BC. – Fishery exploitations were generally greater than the population could withstand during much of the period of declining natural marine survival (1989-1997), and as a result, coho numbers declined. Exploitations during 1999 and 2000 were low enough that populations were able to replace themselves. Marine survivals for fish returning in 1999 and 2000 also appear to be improved, although they are still low (~3%). – Habitat alterations also contributed to declines in interior Fraser coho salmon and this has been demonstrated for freshwater – Estuarine and marine habitat perturbations have presumably also played a role in population declines, but have not been quantified – Hatcheries have contributed significant numbers of coho to some watersheds and enhanced fish may be a threat to wild salmon in these instances	
Rescue Effect (immigration from an outside source)	
• *does species exist elsewhere (in Canada or outside)?*	Yes
• *status of the outside population(s)?*	Variable but many are depressed
• *is immigration known or possible?*	Immigration is rare and is unlikely to have a rescue effect
• *would immigrants be adapted to survive here?*	Perhaps but introductions from other areas not recommended
• *is there sufficient habitat for immigrants here?*	Yes
Quantitative Analysis	Genetic analyses, various types of time series analyses

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