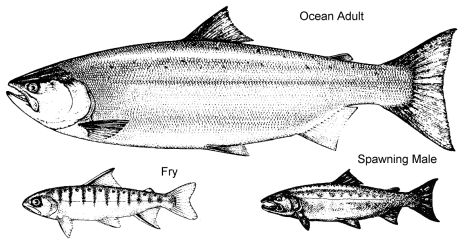

Interior Fraser River Coho Salmon

Background

Coho salmon (Oncorhynchus kisutch Walbaum) is one of seven species of the genus Oncorhynchus native to North America. Coho salmon are found in most coastal streams and rivers of British Columbia, including the Fraser River (Figs. 1 and 2), the largest river in the province .

The interior Fraser River watershed includes those coho systems within the Fraser River watershed upstream of the Fraser River canyon (Fig. 2). Coho salmon are prevalent within the Thompson River, the largest watershed within the Fraser River system, but their distribution in non-Thompson Fraser systems is not well-known. They have been reported from watersheds as far upstream as the Nechako River watershed. As a group, interior Fraser coho are descended from coho of the upper Columbia River, and are genetically distinct from other coho populations including those in the lower Fraser River watershed.

Coho salmon return to the interior Fraser watershed during 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. Interior Fraser coho spend 18 months at sea before returning to freshwater and therefore have a 3-year life cycle.

In response to conservation concerns for Thompson coho, severe restrictions were placed on salmon fisheries in southern BC commencing in 1998. It was expected that these restrictions would be required for six to eight years. In general, no directed fisheries on coho were permitted, and there was mandatory non-retention and non-possession of coho in all areas, with the exception of some terminal hatchery locations. Coho populations have benefited as a result of significantly reduced fishery exploitation.

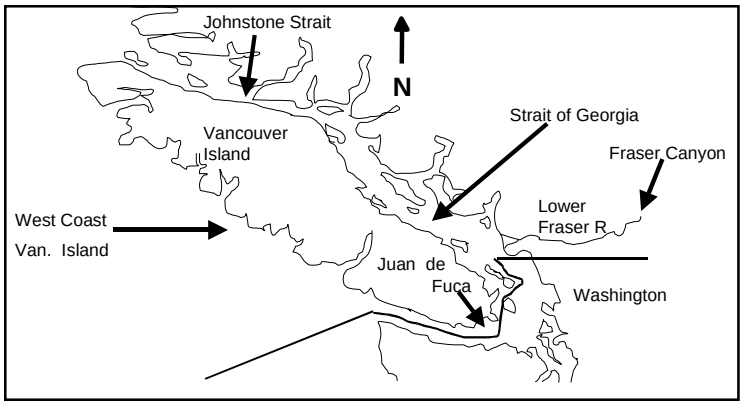

Figure 1. Map of southern B.C. showing location of lower Fraser River, Vancouver Island and important catch regions for interior Fraser River coho salmon.

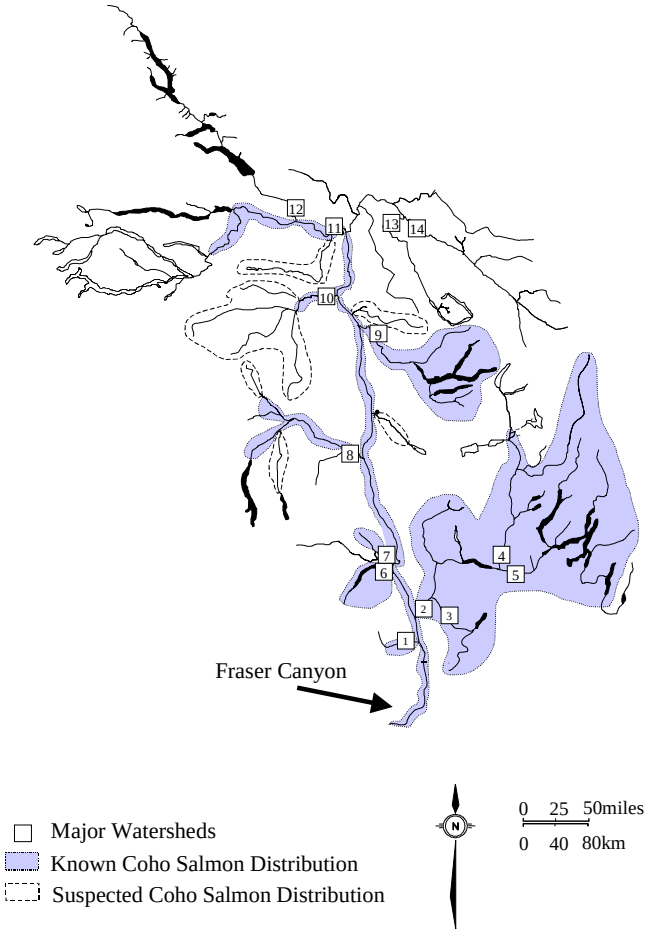

Figure 2. Known and suspected coho salmon distribution within the interior Fraser River watershed. Major rivers indicated are 1- Nahatlatch, 2-L. Thompson, 3-Nicola, 4-N. Thompson, 5-S. Thompson, 6-Seton, 7-Bridge, 8-Chilcotin, 9-Quesnel, 10-Westroad, 11-Nechako, 12-Stuart, 13-Bowron, and 14-Upper Fraser.

Summary

- Coho salmon living in the interior Fraser River watershed originated from now extinct populations that survived glaciation in Columbia River refugia.
- Coho salmon returned to the interior Fraser in modest numbers during the 1970s, subsequently increased in abundance, peaking during the late 1980s, and then underwent rapid declines until 1996.
- Overfishing, changing marine conditions, and habitat perturbations contributed to the declines in numbers of coho salmon in the interior Fraser. Overfishing resulted when harvest rates were not adjusted in response to climate-driven declines in productivity.
- Fishery exploitation (proportion of adults caught in fisheries) averaged 68% until 1996. In response to conservation concerns for these fish, exploitation was reduced to ~40% in 1997 and has averaged 6.5% the last three years.
- Fishery exploitation in 2000 was the lowest on record, ~3.4% in total, of which half was in British Columbia. Productivity measured in recruits per spawner has improved and in 1999 and 2000 spawner numbers generally exceeded parental escapements.
- The extreme fishery management measures undertaken in BC since 1998 to conserve Thompson coho appear to have stopped the declining trend for these and other interior Fraser coho populations.
- A cautious approach to fisheries management needs to remain in place, along with initiatives to maintain and restore habitat, to allow these populations the opportunity to rebuild.

The Fishery

Fisheries harvesting interior Fraser coho have changed significantly in recent years. Prior to 1997, coded wire tags (CWTs) from Thompson and other interior Fraser River coho were regularly recovered in fisheries from Alaska to Oregon. Most were gathered from troll and sport fisheries off the West Coast of Vancouver Island and in the Strait of Georgia (Fig. 1). Interior Fraser coho have also been caught incidentally in net fisheries for other species in Johnstone Strait, Juan de Fuca Strait, the Strait of Georgia, San Juan Islands, and in the Fraser River. Their catch distribution has been dominated by swings between fisheries inside and outside of the Strait of Georgia (Fig. 3). Prior to 1991, large numbers of coho remained inside Georgia Strait each year and supported major sport and troll fisheries. In 1991 and from 1995-2000, the majority of coho appeared to leave Georgia Strait. Marine fishery exploitations (catch as a proportion of catch plus escapement) for interior Fraser coho averaged 68% during 1986-96.

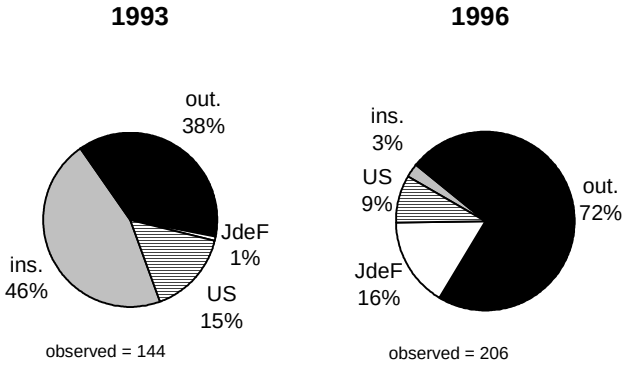

Figure 3. Estimated marine catch distributions of coded-wire tagged Thompson coho during 1993 (an inside distribution year) and 1996 (an outside distribution year). Fisheries included were inside and outside of the Strait of Georgia, within Juan de Fuca and Washington State (US) with total observed recoveries of CWTs from the same fisheries.

Commencing in 1998, Canadian salmon fisheries saw unprecedented restrictions that were designed to minimize mortalities of coho from the Thompson River watershed. The strategy that Canadian fishery managers took was to allocate

a very low exploitation for Thompson coho (~2%) amongst all fisheries in southern BC (Irvine et al. 2001). As most BC fisheries were non-retention for coho, few coho were sampled for CWTs, and a novel approach was required to assess fishery impacts. Fortunately, interior Fraser/Thompson coho are sufficiently distinct to allow estimation of numbers of fish caught using a DNA-based approach.

An in-season monitoring programme was developed to estimate coho encounters in southern BC. Tissue samples were taken from coho caught in most fisheries. Samples were analysed and the proportion of the sample that was of interior Fraser origin was estimated. Mortalities in BC fisheries were determined by applying standard gear mortality estimates (sport 10%, gill net 60%, troll 26%, and seine 25%) to the encounter data.

Total fisheries exploitations (Canada and U.S.A.) were reduced to approximately 40% in 1997 and have been less than 10% since then.

Freshwater harvest of interior Fraser coho has been relatively minor. Even prior to conservation concerns in the late 1990s, fisheries for coho salmon by recreational anglers and First Nations in the interior Fraser River and tributaries were limited and often focused on enhanced stocks. In the lower Fraser River, through which interior Fraser coho must migrate, harvests of interior Fraser coho have also been small.

Escapement Targets

Three provisional reference points were determined (Irvine et al. 2001) using data for North Thompson coho (Table 1). Spawner numbers were converted to females/km and vice versa using the estimated length of streams within the North Thompson watershed accessible to coho (780 km) and assuming the proportion of the escapement made up by females was 0.45.

The first two values in Table 1 are potential limit reference points below which one would not like to go. The lowest escapement on record to the North Thompson watershed that the population has recovered from (10535 coho) occurred in 1980. The next value (S_{offset}), estimated through stock recruitment analysis, is the value equivalent to a 10% probability of yielding 0 recruitment from that spawning year. S_{MSY}, the optimal number of spawners for maximum sustained yield (MSY), also estimated using stock recruitment analysis, is a potential target reference point.

Model	*S*	Females/km
Minimum escapement popn. recovered from	10535	6.1
S_{offset} (10% extinction possibility)	7438	4.3
mean	8986	5.2
S_{MSY}	43085	24.9

Table 1. Summary of provisional reference points for North Thompson coho salmon. See text for explanation (*S* = spawners).

Status

Spawner Escapements

Many of our inferences about the status of Interior Fraser coho stocks rely upon spawner escapement data. To evaluate trends, we used a time series of spawner escapement estimates from unenhanced North and South Thompson streams with reasonably consistent monitoring. Results provided are the total fish estimated to return to spawn in 10 unenhanced streams in the North Thompson, and 16 unenhanced streams in the South Thompson, and have not been corrected for bias.

Temporal patterns for the North and South Thompson drainages (Figs. 4 and 5) were reasonably similar to each other. Escapements peaked between 1984 and 1989, declined until about 1996, and have been stable or increasing since then. The time series of reliable escapement data for other regions within the interior Fraser River watershed is shorter and not provided here.

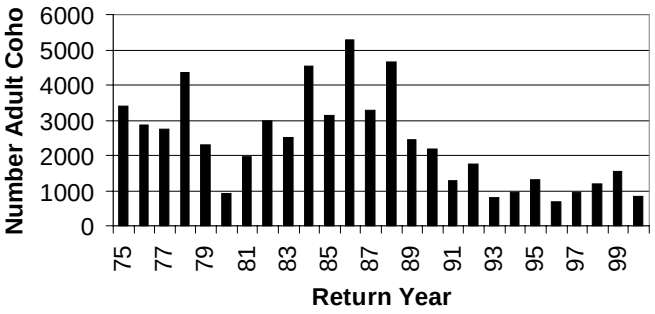

Figure 4. Aggregate coho escapement to 10 escapement indicator streams in the North Thompson watershed.

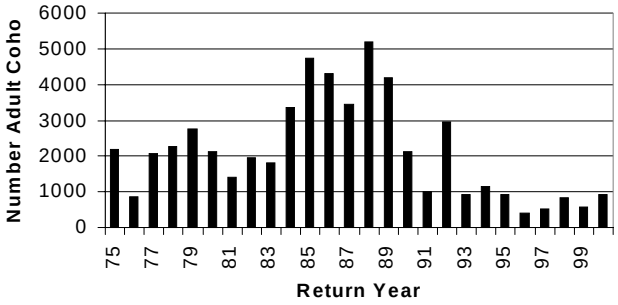

Figure 5. Aggregate coho escapement to 16 escapement indicator streams in the South Thompson watershed.

Productivity

For this analysis, the escapement time series consisting of data from 10 North Thompson and 16 South Thompson streams that have relatively few missing data, and were unaffected by hatchery activities, was again used.

We derived annual estimates of the productivity of Thompson coho as:

$r = ln\,[R_t/S_{t-3}]$

where R_t is recruitment (i.e. catch plus escapement) and S_{t-3} is the abundance of parent spawners. Thus *r* is a measure of survival from spawner to returning (i.e. prefishery) adult. We present the time series of *r* for the mean of the 10 North and 16 South Thompson indicator streams (Fig. 6).

There was an overall decline in *r* from the mid-1980s until the mid-1990s (Fig. 6). Fortunately, the average values for *r* for the 1999 and 2000 returns were positive.

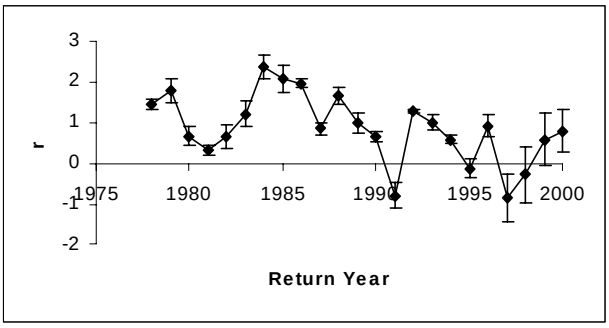

Figure 6. Time series of *r*, the intrinsic rate of population growth of Thompson coho salmon. Each point is the average (±SE) of two time series (North and South indicator stream aggregates). When *r*<0, populations are unable to replace themselves, even in the absence of fishing.

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:

$h^* = 1 - e^{-r}$

where $h^* = 0$ if $r \leq 0$ (Bradford and Irvine 2000). 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 the observed harvest value (i.e. *h*) exceeded *h**.

When we compared the actual exploitation rates to our estimates of *h**, we found that fishing mortality was well matched to the productivity of the aggregate between 1987 to 1989, but subsequently, until 1997, harvest rates were often excessive (Fig. 7). In 1999 and 2000, exploitation was low enough that populations were above replacement levels.

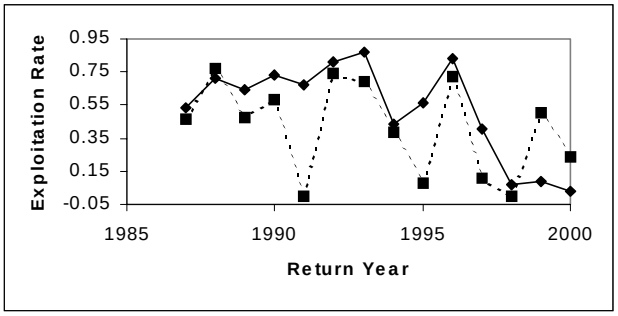

Figure 7. Exploitation rate estimates for Thompson watershed coho (solid line) and exploitation rate that would have maintained coho production (North and South indicator stream aggregates) (dashed line).

Role of Freshwater Habitat

Bradford and Irvine (2000) related the rate at which the abundance of coho returning to individual spawning streams has declined to the extent of human activity in the corresponding watershed. The hypothesis being tested was that the rates of decline (for years 1988-1998) in 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 used four measures of land use, and showed that the rates of decline in individual spawning populations were related to three of them (Fig. 8).

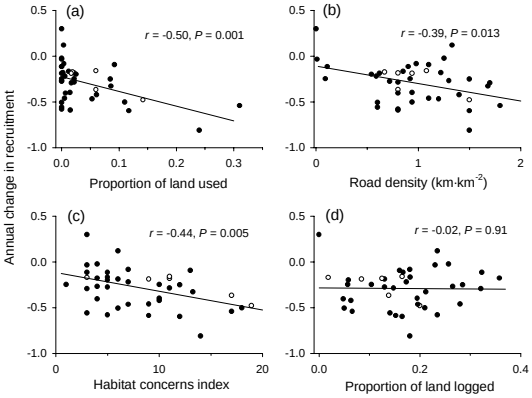

Figure 8. Relations between four land use measures and the rate of decline (year^{-1}) in the recruitment of coho salmon to 40 Thompson tributaries (from Bradford and Irvine 2000) (a) proportion of land in each catchment dedicated to agricultural or urban use, (b) density of forest, agricultural and hard surface roads in each catchment, (c) index of habitat concerns from various reports, and (d) the proportion of land recently (<20 years) logged. Open circles are streams that have had hatchery programs.

The rate at which individual coho populations declined between 1988 and 1998 was related to the extent of agricultural and urban land use, the density of roads in the watershed, and the index of habitat concerns, but there was no relation between salmon declines and recent logging (Fig. 8). Since much of the logging in the interior Fraser was undertaken before the abundance time series began, logging related impacts might have occurred that were not detectable with the analysis. The lack of a relationship does not mean that logging did not have an effect.

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 female spawner. The analysis of Bradford and Irvine (2000) shows that spawning populations are at greater risk when the watershed is subject to extensive human modification. Those populations from healthy watersheds showed the smallest declines, and are likely to recover at a faster rate if ocean conditions improve. Thus, the recovery and sustainability of interior Fraser coho will be improved through a balanced program of habitat protection and watershed restoration.

Escapements Compared to Targets

For this analysis, we used an escapement time series that included estimates for all streams. In Figure 9 we compare estimated numbers of female coho salmon per kilometre in the North Thompson watershed with the mean of our two provisional limit reference points (5.2 females per kilometre). It can be seen that spawner numbers have been near, but generally below this level, since 1997.

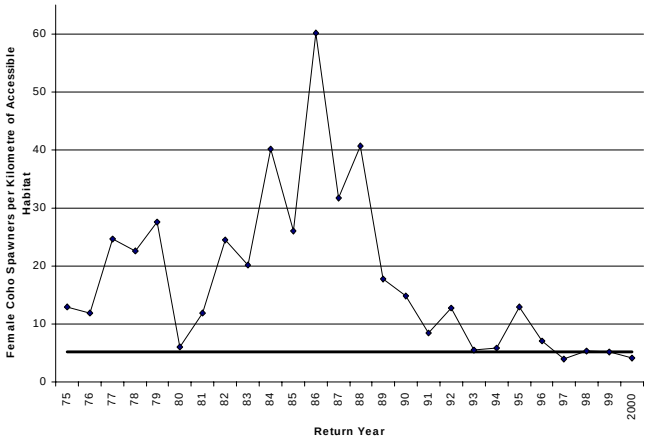

Figure 9. Annual estimates of numbers of female coho per kilometre within the North Thompson watershed. Horizontal line indicates the mean of two provisional limit reference points (5.2 females/km).

Forecast

In retrospective analysis, a 3-year averaging model (3YRA) has been found to be the model of choice for the Thompson watershed. With this model, abundances are forecast to be the mean of abundances during the three previous years, where abundances are first log transformed. The forecast abundance of Thompson River watershed coho in 2001 is ~17,500, similar to the estimated abundance in the brood year, but only about 20% of the long term mean abundance. In 1998, ~5.3 females per kilometre were estimated to return to spawn in the North Thompson watershed, and we expect a similar number in 2001, assuming similar survivals and fishing pressures exist. The prefishery abundance of Thompson coho has not increased significantly in recent years but spawner numbers are increasing because of reduced fishing. Escapements in 1999 and 2000 were both larger than brood year escapements. Greater proportions of fish surviving to maturity are returning to spawn because of significant reductions in fishing pressure.

Outlook

The extreme management measures undertaken in BC since 1998 to conserve coho appear to have stopped the decline of interior Fraser coho populations (Irvine et al. 2001). There is less concern about population extinction than there was several years ago. However, the short-term forecast for Thompson coho is for continued poor survivals, in large part because we do not have strong evidence that marine survival rates will increase. Assuming that marine survivals and fishing pressures remain low, the outlook for Thompson and other interior Fraser coho is for slow but gradual improvement. Continued low fishery exploitation, combined with balanced programs of habitat protection and watershed restoration, are required to ensure the long-term viability of these important fish.

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