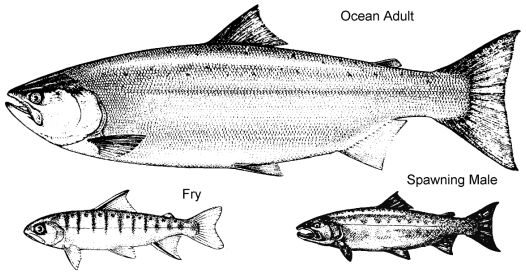

Interior Fraser River Coho Salmon

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, the largest river in the province (Figs. 1 and 2).

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. 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 and some limited mark selective fisheries. Coho populations have benefited as a result of significantly reduced fishery exploitation and what appears to be stabilized marine survivals.

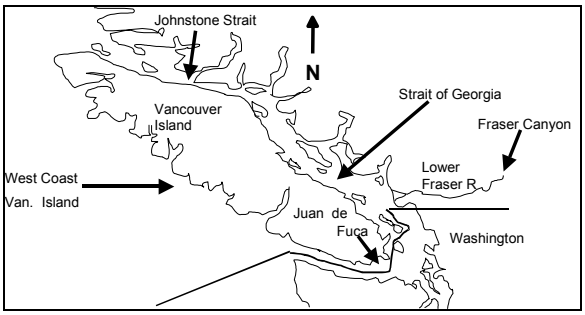

Figure 1: Map of southern B.C. showing location of lower Fraser River, Vancouver Island and important catch regions for interior Fraser River coho salmon.

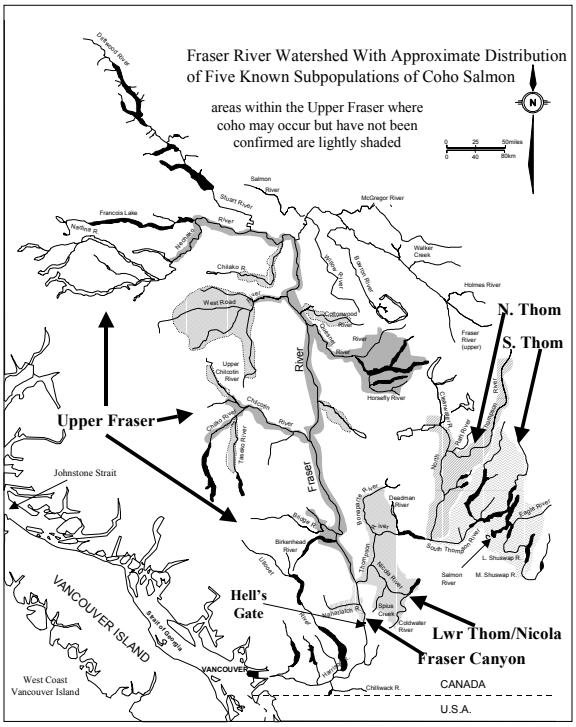

Figure 2. Approximate distribution of 5 subpopulations of coho salmon (North Thompson, South Thompson, Lower Thompson/Nicola, Fraser Canyon, and Upper Fraser) within the interior Fraser River watershed. Distribution of coho in the upper Fraser is not well known as indicated by the areas in the upper Fraser where coho are suspected to occur but have not been confirmed.

Summary

- Genetically unique 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 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% the last four years.
- Productivity measured in recruits per spawner has improved and in 2000 and 2001 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 continue 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 (WCVI) 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 the Strait of Georgia each year and supported major sport and troll fisheries. In 1991 and from 1994-2000, many coho in their last year at sea (when they are of fishable size) resided instead off WCVI. Most probably occupied the Strait in 2001 but many are predicted to be off WCVI again in 2002. Marine fishery exploitations (catch as a proportion of catch plus escapement) for interior Fraser coho averaged 68% during 1986-96.

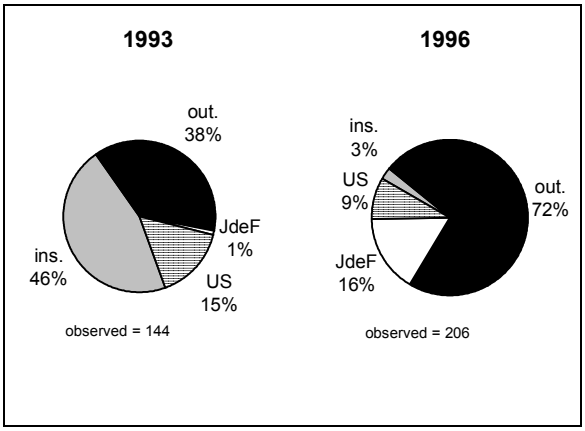

Figure 3: Estimated marine catch distributions of coded-wire tagged Thompson coho during 1993 (an inside distribution year) and 1996 (an outside distribution year). Fisheries included were inside and outside of the Strait of Georgia, within Juan de Fuca and Washington State (US) with total observed recoveries 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 in southern BC (~2%) amongst all fisheries (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 genetically 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 (1997-2000).

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

Reference points are benchmarks against which the status of fish populations can be measured. 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 lower 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 reference point.

To date, no biologically based escapement goals have been determined for the South Thompson, Lower Thompson or Fraser River subpopulations.

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. These estimates are referred to as trend escapements. A second time series of escapement estimates is currently being developed, representing a better estimate of the true number of coho in the system resulting from increased survey efforts, instituted in 1998 (Irvine et al. 2001).

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, i.e. the Fraser Canyon, lower Thompson River and the upper Fraser River, is shorter. These are presented here for comparison of recent patterns in escapement (Figure 6).

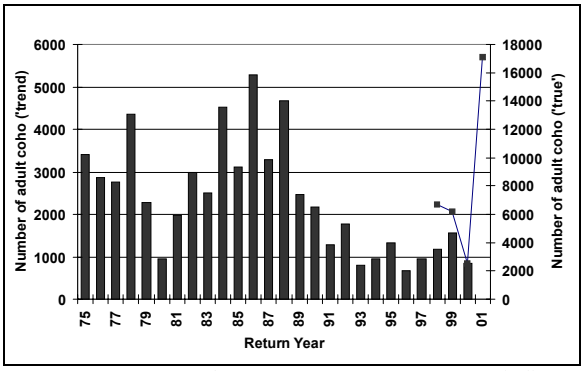

Figure 4. Aggregate coho escapement to 10 escapement indicator streams in the North Thompson watershed. The overlap of bar and line series for the period 1998 – 2000 indicates the availability of both a 'trend' estimate (shaded bar) and a 'true' estimate (line) of the number of coho.

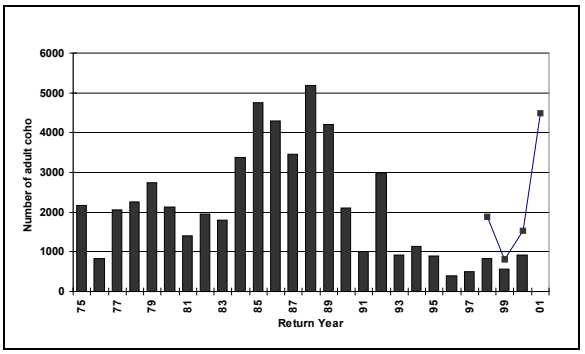

Figure 5. Aggregate coho escapement to 16 escapement indicator streams in the South Thompson watershed. The overlap of bar and line series for the period 1998 – 2000 indicates the availability of both a 'trend' estimate (shaded bar) and a 'true' estimate (line) of the number of coho.

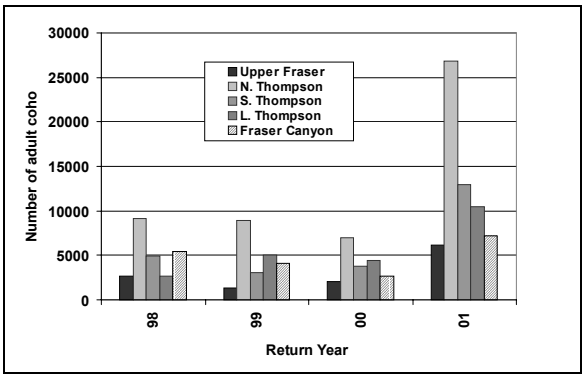

Figure 6. Recent aggregate escapement to 5 subpopulations of coho in the Interior Fraser River watershed.

Role of Freshwater Habitat

Bradford and Irvine (2000) related the rate at which the abundance of coho returning to individual spawning streams has declined in relation 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 7).

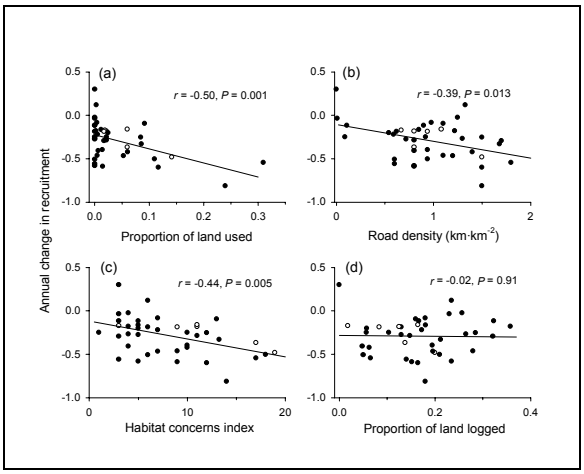

Figure 7. Relations between four land use measures and the rate of decline (year^{-1}) in the recruitment of coho salmon to 40 Thompson tributaries (from Bradford and Irvine 2000) (a) proportion of land in each catchment dedicated to agricultural or urban use, (b) density of forest, agricultural and 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. 7). Since much of the logging in the interior Fraser was undertaken before our abundance time series began, logging related impacts might have occurred that were not detectable with our analysis. The lack of a relationship does not mean that logging did not had 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

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 female coho salmon per km of habitat accessible to them.

The estimated number of female spawners that would produce maximum sustained yield (24.9) was selected to identify the transition between zones of abundant spawner densities (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) (see Table 1). 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). The increase in 2001 (~16 females/km vs. ~4 in 2000) resulted from greater proportions of fish surviving to maturity and returning to spawn because of an apparent increase in marine survival and continuing low levels of fishing pressure. This increase, although significant, still leaves the number of females per kilometre in the North Thompson watershed well below the estimated optimal number required for MSY.

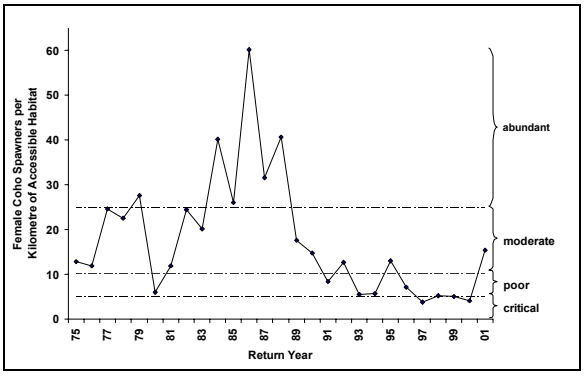

Figure 8. Annual estimates of numbers of female coho per kilometre within the North Thompson watershed (adapted from Irvine et al. 2001). Horizontal lines indicate boundaries between abundance categories.

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 2002 is ~25,000, greater than the estimated abundance in the brood year, but only about 29% of the long term mean abundance. In 1999, ~5 females per kilometre were estimated to return to spawn in the North Thompson watershed; we expect an increased number to escape in 2002 (~7 females per kilometre) assuming increased prefishery abundance as in 2001 (related to improved marine survival) and continuing low fishery exploitation rates.

Outlook

The extreme management measures undertaken in BC since 1998 to conserve coho, combined with an apparent improvement in marine survivals, appear to have stopped the decline of interior Fraser coho populations (Irvine et al. 2001). The short-term forecast for Thompson coho is for gradually increasing abundance, assuming marine survivals remain at their

current level and fishing pressures remain low. 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.

For more information contact:

Dr. J. R. Irvine
Fisheries and Oceans Canada
Stock Assessment Division
Pacific Biological Station
Nanaimo, B.C. V9T 6N7
Tel: (250) 756-7065
Fax: (250) 756-7138
E-Mail: IrvineJ@pac.dfo-mpo.gc.ca

Richard E. Bailey
Fisheries and Oceans Canada
Stock Assessment Division
Kamloops, B.C.
Tel: (250) 851-4814
Fax: (250) 851-4949
E-Mail: BaileyRi@pac.dfo-mpo.gc.ca

Susan L. Lemke
Fisheries and Oceans Canada
Stock Assessment Division
Kamloops, B.C.
Tel: (250) 851-4947
Fax: (250) 851-4949
E-Mail: LemkeS@pac.dfo-mpo.gc.ca

References

Bradford, M. J. and J. R. Irvine. 2000. Land use, fishing, climate change and the decline of Thompson River, British Columbia, coho salmon. Can. J. Fish. Aquat. Sci. 57:13-16.

Chen, D. G., J. R. Irvine, and A. J. Cass. 2002. Incorporating Allee effects in fish stock-recruitment models and applications for determining reference points. Can. J. Fish. Aquat. Sci. 59:242-249.

Irvine, J., C. K. Parken, D. G. Chen, J. Candy, T. Ming, J. Supernault, W. Shaw, and R. E. Bailey. 2001. 2001 stock status assessment of coho salmon from the interior Fraser River. Can. Stock Assess. Secretariat Res. Doc. 2001/083. Available from CSAS, 200 Kent St., Ontario, K1A 0E6, Canada or http://www.dfo-mpo.gc.ca/csas/.

This report is available:

PSARC Secretariat
Pacific Biological Station
Nanaimo, BC V9T 6N7
Phone: (250) 756-7208
Fax: (250) 756-7209
E-Mail: psarc@pac.dfo-mpo.gc.ca
http://www.dfo-mpo.gc.ca/csas

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