# Declines in the Abundance of Thompson River Coho Salmon in the Interior of Southern British Columbia, and Canada's Coho Recovery Plan

James R. Irvine
Fisheries and Oceans Canada, Pacific Biological Station
3190 Hammond Bay Road, Nanaimo, BC, V9R 5K6, Canada
irvinej@pac.dfo-mpo.gc.ca

Michael Bradford
Fisheries and Oceans Canada
c/o School of Resource and Environmental Management
Simon Fraser University, Burnaby, BC, V5A 1S6, Canada

## ABSTRACT

Populations of unenhanced coho salmon (*Oncorhynchus kisutch*) in the North and South Thompson River watersheds have declined at rates >50% per generation since 1988. In recent years, <5 female spawners/km were seen on average in these streams. Of a sample of 34 extant populations in 1988, no coho were observed in 11 of these in 1997. Populations were judged to be at a high risk of biological extinction. To conserve these populations, managers were advised that fishing mortality should be as close to zero as possible. In 1998, major changes were made to salmon fisheries in British Columbia. No directed fisheries on wild stocks of coho were permitted, and there was mandatory non-retention of coho. In areas where Thompson coho were expected to be prevalent, only a few experimental salmon fisheries were allowed. In areas where Thompson coho were not expected to be prevalent, the only salmon fisheries permitted were directed at the other species. These restrictions appear to have improved spawning escapement in some areas. Conservation must continue to be a high priority in the management of Pacific salmon to reduce the risk of extinction for populations of Thompson coho salmon.

**Key words:** coho salmon, conservation, extinction, Fraser River, *Oncorhynchus kisutch*, risk, Thompson River.

Coho salmon (*Oncorhynchus kisutch*) are widely distributed throughout the North Pacific basin (Sandercock 1991). Coho is an economically important species, contributing to commercial, recreational, and aboriginal catches along the Pacific coast of North America. Unfortunately, numbers of coho salmon are declining in many regions, and some populations have become extinct (e.g., Nehlsen et al. 1991, Weitkamp et al. 1995, Slaney et al. 1996, Northcote and Atagi 1997).

In the United States, the Endangered Species Act considers a species to be endangered if it is in danger of extinction throughout all or a significant portion of its range (Weitkamp et al. 1995). A species is threatened if it is likely to become endangered within the foreseeable future. The U.S. National Marine Fisheries Service proposed 6 evolutionarily significant units (ESUs) for coho salmon extending from central California to southern British Columbia. Coho were considered to be in danger of extinction in 1 ESU (central California coast), likely to become so in 4 ESUs, and not presently in danger of extinction, nor likely to become so, in 1 ESU. Small et al. (1998*a,b*) recently examined genetic variation among coho salmon populations in British Columbia. They found coho salmon from the upper Fraser and Thompson River watersheds in south-central British Columbia to be genetically distinct from other British Columbia coho, and proposed that coho salmon in the upper Fraser and Thompson River drainages form an ESU.

In this paper we examine trends in abundance of unenhanced coho salmon populations in the Thompson River, a major tributary to the Fraser River, arguably the largest salmon producer in the world. We also describe fishery management changes made by Canada's Department of Fisheries and Oceans (DFO) during 1998 to conserve threatened stocks of coho salmon.

## STUDY AREA AND METHODS

The Thompson River watershed is large and diverse. At Kamloops, the North Thompson from the north and the South Thompson from the east join to form the Thompson River. We assembled a time series of spawner escapement estimates for >50 streams from the North and South Thompson watersheds. Most of these estimates used data

L. M. Darling, editor. 2000. Proceedings of a Conference on the Biology and Management of Species and Habitats at Risk, Kamloops, B.C., 15 - 19 Feb.,1999. Volume Two.
B.C. Ministry of Environment, Lands and Parks, Victoria, B.C. and University College of the Cariboo, Kamloops, B.C. 520pp.

**Table 1.** Annual ($r_{an}$) and finite rates of change (per year = $1-e^{r_{an}}$; per generation = $1-e^{3r_{an}}$) for coho stock aggregates from the North and South Thompson watersheds.

| | Annual | | | Finite | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Stock aggregate | 75-88 Annual | 88-97 Annual | 75-97 Annual | 75-88 Per Year | 88-97 Per Year | 75-97 Per Year | 75-88 Per Gen. | 88-97 Per Gen. | 75-97 Per Gen. |
| South Thompson -19 streams | 0.09 | -0.26 | -0.04 | 0.09 | -0.23 | -0.40 | 0.30 | -0.54 | -0.11 |
| North Thompson - 8 streams | 0.04 | -0.27 | -0.06 | 0.04 | -0.23 | 0.06 | 0.13 | -0.55 | -0.18 |

gathered by DFO officers and other DFO staff, and were based on multiple stream walks. Although the accuracy of most estimates was unknown, we felt many were relatively precise, and when aggregated by geographic area, provided valuable trends on spawner abundance. The data that we considered reliable extended to 1975.

We filtered our escapement database to remove confounding effects of inconsistent monitoring. We used data only from unenhanced systems for which we had 18 annual escapement estimates (out of a maximum of 23). To account for missing estimate(s), we used the average of the numbers preceding and following the missing data. If a missing datum was at the beginning or end of a time series, we used the estimate for the nearest year. The result was a time series of spawner abundance estimates for 19 streams from the South Thompson drainage, and 8 streams from the North Thompson.

We converted our estimates of spawner escapements to numbers of females/km of stream accessible to migrating salmon. The DFO is attempting to develop limit reference points for coho using these units. We assumed the proportion of females among spawners to be 0.45 based on data in Irvine et al. (1999).

To examine trends in escapement, the slope of the regression of the natural log of escapement on year $r_{an}$ was used to estimate the annual intrinsic rate of change of each stock aggregate. Finite rates of change per year were calculated as $1-e^{r_{an}}$ and per generation rates as $1-e^{3r_{an}}$ (assuming all fish had a 3-year life cycle consisting of 1 winter in freshwater and 1.5 summers at sea). Positive numbers indicated an increasing trend while negative numbers indicated a declining trend.

This approach does not illustrate the fate of many of the small populations that comprise these aggregates. To examine this, we determined which streams had population estimates in both 1988 and 1997, and determined whether the estimates for these streams increased or decreased.

## RESULTS

In the South Thompson, female spawner densities were moderate but variable from 1975 through 1983, and generally at higher levels until about 1989, after which they declined (except 1992) (Fig. 1). Escapements to the unenhanced North Thompson aggregate (Fig. 2) followed a similar temporal pattern. Modest returns from the mid-1970s to 1983 preceded about 7 years of generally higher densities. Since 1991, spawner numbers and densities have been relatively low, with the exception of 1992. For each aggregate, spawner numbers in 1997 exceeded those in 1996; 1997 densities were less than the parental brood escapement (i.e., 1994) for South Thompson streams, and almost identical to the brood year for North Thompson streams. Spawner densities were lower in the South Thompson than they were in the North Thompson.

The rates of change for the South and North Thompson, respectively, were +30 and +13% per generation during 1975–1988 and -54 and -55% per generation since 1988 (Table 1).

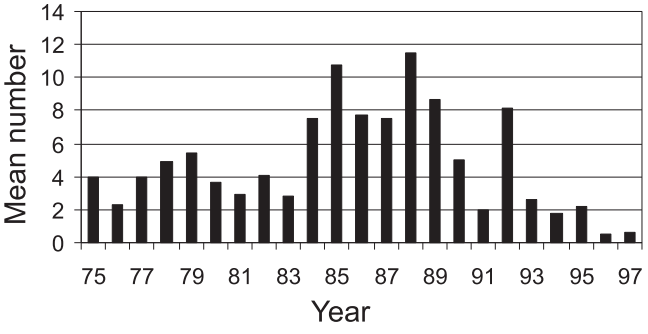


**Figure 1.** Mean numbers of female coho/km accessible habitat in 19 streams in the South Thompson watershed.

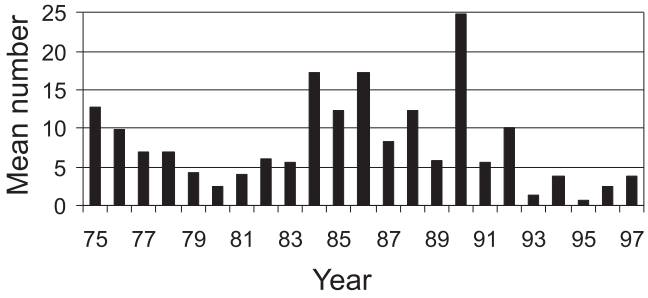


**Figure 2.** Mean numbers of female coho/km accessible habitat in 8 streams in the North Thompson watershed.

The fate of individual populations during the period that large generational declines occurred (i.e., 1988–1997) can be seen by plotting results for those streams with fish count data for 1988 and 1997 (Fig. 3). A few populations increased during this period, but the vast majority decreased, and about 30% of the streams with coho extant in 1988 had no coho observed in them during 1997. For more detailed results, see Bradford (1998) and Irvine et al. (1999).

## DISCUSSION

Numbers of coho salmon returning to spawn in streams in the Thompson River watershed declined significantly, particularly during the most recent decade. Returns the last 2 years to unenhanced streams in the South Thompson ranged between 15 and 25% of longer term averages, while returns to North Thompson streams were only about one-third of previous returns.

If populations continue to decline, local although perhaps temporary extinctions in individual streams are inevitable. In 1997, no spawning coho were seen in about 30% of streams where coho had been seen in 1988. Note that spawning coho can be in a stream, but not observed. Surveyors typically only examine portions of a stream, adult coho tend not to occur in high densities, and their cryptic colouration makes coho difficult to see. Nevertheless, coho are clearly in danger of extinction in some streams in the Thompson River.

Straying will reduce extinction rates. However, coho appear to have relatively little genetic exchange among populations. For instance, Labelle (1992), studying 14 coho populations on Vancouver Island, found that most strays contributed <1% of the escapement. Sandercock (1991) summarizes several studies that document that coho usually exhibit very low rates of straying from home streams. Small et al. (1998 *a,b*), using microsatellite DNA analysis, found a correlation between rates of gene flow within the Thompson/Fraser and the geographic proximity of coho populations. Coho salmon from the North, South, and lower Thompson regions could be differentiated by allele frequency.

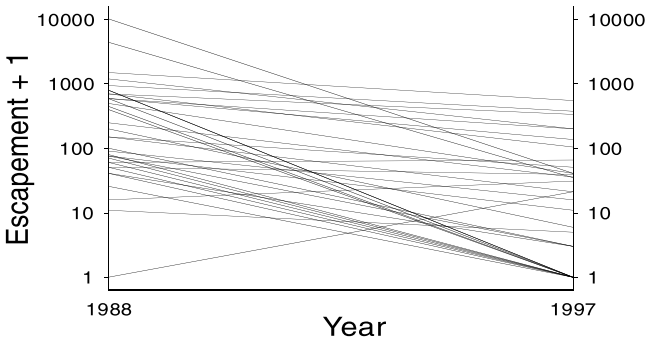


**Figure 3.** Fate of 34 spawning populations from the North and South Thompson watersheds between 1988 and 1997 showing the variation in the rate of decline among populations. Many streams have declined to "none-observed" status for this broodline in 3 generations.

We are unsure of the likelihood or frequency of streams in the Thompson River being recolonized from nearby populations. To minimize social, genetic, and economic costs associated with the loss of coho populations in individual streams, and to maximize potential rebuilding rates, we (Bradford 1998, Irvine et al. 1999) recommended maintaining as large a population base within the watershed as possible. This recommendation meant that fishing mortality should be as close to zero as practicable.

Low and declining marine survivals (e.g., Coronado and Hilborn 1998), combined with overfishing in mixed stock fisheries, have contributed to the decline of Thompson coho (Bradford 1998, Irvine et al. 1999). Because coho spend approximately 1 year in freshwater before migrating to the ocean, they are also sensitive to changes in their habitat. There are many examples of habitat degradation causing reductions in carrying capacity for coho in the Thompson watershed (e.g., Harding et al. 1994, Department of Fisheries and Oceans 1997). To best conserve these fish, we need to better understand the role of habitat alterations.

## MANAGEMENT IMPLICATIONS

The status of Thompson coho was reviewed (Irvine et al. 1999), and a risk assessment undertaken (Bradford 1998) early in 1998. The Pacific Stock Assessment Review Committee (PSARC) accepted our findings and advised that Thompson River coho were extremely depressed and would continue to decline even without 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 3 years, scientific evidence demonstrates conclusively that wild coho stocks are declining and some are at extreme risk." Minister Anderson proclaimed a conservation objective of zero fishing mortality for critical Thompson (and upper Skeena) coho stocks. On 19 June 1998, he and Pierre S. Pettigrew, Minister of Human Resources Development Canada, identified significant new management measures for the 1998 salmon fishery. Federal funding of $400 million was provided to help rebuild the resource, restructure the fishery, and help people and communities adjust to the changing fishery.

Regulatory changes made to salmon fisheries in 1998 to

conserve threatened coho stocks were probably the most significant ever implemented within the Pacific Region of Canada. In 1998, no directed fisheries on wild stocks of coho were permitted, and mandatory non-retention of coho was implemented in all areas. The coast of British Columbia was divided into a series of Red and Yellow zones. In the south, Red zones consisted of those areas and times where Thompson coho stocks were expected to be prevalent. Yellow zones were areas where Thompson coho were not expected to be prevalent. In Red zones, only a few restricted experimental fisheries for commercial, aboriginal, and recreational sectors were allowed; these fisheries were closely monitored. In Yellow zones, the only salmon fisheries permitted were directed on salmon species other than coho. Many fisheries involved modifications to gear types, and all were carefully monitored to ensure that coho bycatches were minimal.

Preliminary information suggests that fishing restrictions improved coho spawning escapements in some areas. Restrictive fishery management measures to conserve threatened coho stocks are needed for at least the next 5–7 years. On 9 January 1999, Minister Anderson announced that conservation would continue to be the priority in the management of Pacific salmon. Ongoing diligence is required to minimize the risk of extinction for Thompson River and other endangered populations of coho salmon.

## LITERATURE CITED

Bradford, M. 1998. A risk assessment for Thompson River coho salmon. Fisheries and Oceans Canada, Ottawa, ON. Can. Stock Assessment Secretariat Res. Document 98/92.

Coronado, C., and R. Hilborn. 1998. Spatial and temporal factors affecting survival in coho salmon (*Oncorhynchus kisutch*) in the Pacific Northwest. Can. J. Fish. Aquat. Sci. 55:2067–2077.

Department of Fisheries and Oceans. 1997. Strategic review of fisheries resources for the South Thompson - Shuswap Habitat management area. Fraser River Action Plan, Vancouver, BC. 132pp.

Harding, T., L. Jaremovic, and G. Kosakoski. 1994. Strategic review of fisheries resources, North Thompson Habitat Management Area. Fraser River Action Plan, Dep. Fish. Oceans, Vancouver, BC. 164pp.

Irvine, J. R., K. Wilson, B. Rosenberger, and R. Cook. 1999. Stock assessment of Thompson River/Upper Fraser River coho salmon. Fisheries and Oceans Canada, Ottawa, ON. Can. Stock Assessment Secretariat Res. Document 99/28.

Labelle, M. 1992. Straying patterns of coho salmon (*Oncorhynchus kisutch*) stocks from southeast Vancouver Island, British Columbia. Can. J. Fish. Aquat. Sci. 49:1843–1855.

Nehlsen, W., J. E. Williams, and J. A. Lichatowich. 1991. Pacific salmon at the crossroads: stocks at risk from California, Oregon, Idaho, and Washington. Fisheries 16(2):4–21.

Northcote, T. G., and D. Y. Atagi. 1997. Pacific salmon abundance trends in the Fraser River watershed compared with other British Columbia systems. Pp. 199–219 *in* D. J. Stouder, P. A. Bisson, and R. J. Naiman, eds. Pacific salmon and their ecosystems, status and future options. Chapman & Hall, New York, NY.

Sandercock, F. K. 1991. Life history of coho salmon (*Oncorhynchus kisutch*). Pp. 397–445 *in* C. Groot, and L. Margolis, eds. Pacific salmon life histories. Univ. B.C. Press, Vancouver, BC.

Slaney, T. L., K. D. Hyatt, T. G. Northcote, and R. J. Fielden. 1996. Status of anadromous salmon and trout in British Columbia and Yukon. Fisheries 21(10):20–35.

Small, M. P., T. D. Beacham, R. E. Withler, and R. J. Nelson. 1998*a*. Discriminating coho salmon (*Oncorhynchus kisutch*) populations within the Fraser River, British Columbia, using microsatellite DNA markers. Mol. Ecol.7:141–155.

_____, R. E. Withler, and T. D. Beacham. 1998*b*. Population structure and stock identification of British Columbia coho salmon (*Oncorhynchus kisutch*) based on microsatellite DNA variation. Fish. Bull. 96:843–858.

Stocker, M., and D. Peacock, eds. 1998. Rep. PSARC Salmon Subcommittee Meeting 27 April – 1 May 1998 and the Steering Committee Meeting 4 May 1998. Can. Stock Assessment Proc. Ser. 98/08.

Weitkamp, L. A., T. C. Wainwright, G. J. Bryant, G. B. Milner, D. J. Teel, R. G. Kope, and R. S. Waples. 1995. Status review of coho salmon from Washington, Oregon, and California. U.S. Dep. Commer., Natl. Oceanic Atmos. Adm. Tech. Memo. Natl. Mar. Fish. Serv.-Northwest Fish. Sci. Cent.-24.