DEVELOPMENT OF AN ANNUAL SALMONID PRODUCTIVITY ASSESSMENT PROGRAM FOR THE NICOLA RIVER WATERSHED

prepared for:
Pacific Salmon Foundation

prepared by:
M. Mathews[1], B. Bocking[1], G. Glova[1], N. Todd[2], T. Sampson[3]

[1]LGL Limited
environmental research associates
9768 Second Street
Sidney, BC V8L 3Y8

[2] Diversified Ova Tech Ltd.,
Merritt, BC

[3]Nicola Watershed Stewardship and Fisheries Authority
Room 204-2090 Coutlee Avenue
Merritt, BC V1K 1B8

on behalf of the:
Nicola Tribal Association
Nicola Watershed Stewardship and Fisheries Authority
Box 188, Merritt, BC
V1K 1B8

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Table of Contents

List of Figures

Executive Summary

This report provides a review of current state of knowledge of juvenile salmonid production, exploitation, adult returns and enhancement of coho, Chinook and steelhead stocks of the Nicola/Coldwater system.

- Relative to historical data records, there is evidence that these fish stocks have declined appreciably over time.
- The Coldwater River is the most significant contributor of these salmonids to the Nicola watershed.
- Within the last 20 years, hatchery releases have contributed significantly to smolt production in the Nicola watershed.
- Wild coho smolt output from the Coldwater has ranged from 7,000 to 16,800 fish in the early 1980s and from 16,134 to 26,651 fish between 2002 and 2006.
- Similarly, Chinook smolt output has ranged from 1,840 to 49,600 fish (wild only) in the early 1980s, and from 22,968 to 104,325 fish (wild and hatchery combined) in the early 2000s.
- Steelhead smolt historically ranged from 6,000 to 10,700 fish, and in recent times from 2,499 to 10,017 fish.
- At current habitat capacity, coho smolt production for the Coldwater is limited to approximately 60,000 fish.
- Exploitation of interior Fraser coho has declined markedly in the last decade from a peak 88% in 1993 to 13% at present (the latter mainly of by catch).
- Exploitation data for Chinook are limited to the Nicola watershed (1982-present), and range from 12.7 to 42.9% and from 18.5 to72.7% for the Nicola and Coldwater, respectively.
- Estimated total fishing mortality (by catch, sport and First Nations catches) of Fraser River summer run steelhead, of which the Nicola stock is a major contributor, historically has been as high 80% and reduced to 10-20% within the last decade.
- For the period of data record (1975 to present), adult returns for these salmonids for the Nicola watershed have ranged from 598 to 11,455 for coho, 1,211 to 16,400 for Chinook and from 549 to 3,284 for steelhead.
- Enhancement of these stocks has occurred within the last two decades (mainly on coho and Chinook) comprising hatchery releases of fry and smolts in the Nicola watershed, and has contributed significantly to smolt production and adult returns.

Key information gaps needed to be filled for improved management of these stocks include:

1. Improved reliability of wild coho and Chinook smolt population estimates
2. Improved understanding of early life histories (migration and rearing) for Coldwater coho, Chinook and steelhead.
3. Estimates of marine survival of wild coho and Chinook.

A research strategy is proposed to help close these information gaps, involving improved coho and Chinook mark/recapture smolt estimates and determination of relative contributions of the different rearing components in the migration corridor between the Coldwater and the sea to adult returns.

1 Introduction

The Nicola River, a tributary of the Thompson River which is a major component of the Fraser River watershed, is a sixth order stream, 189 km long, draining an area of 7,227 km^2 located in the interior of southern British Columbia (Figure 1). The Nicola River is an important contributor of early-run Chinook, coho, and steelhead to the Thompson and Fraser River system. Important tributaries to the Nicola for salmonids (Walthers and Nener 1998) include the Coldwater River and Spius, Quilchena, Clapperton and Guichon creeks. The Coldwater River, the largest tributary, drains an area of 914 km^2 (Figure 1) and is the most important stream for coho and early-run Chinook, as well as steelhead in the Nicola watershed (Nelson et al. 2001). Nicola Lake, is the largest lake in the watershed (area 2,500 hectares), with its outlet controlled by a dam for power and irrigation purposes some years ago. The lake is no longer used for hydro generation, and regulation of its water levels is now minimal (Kosakoski and Hamilton 1982). The majority of salmonid production occurs downstream of Nicola Lake; although there is potential for production upstream, it is seasonally sporadic due to insufficient water during summer.

Historically, Nicola River was an important contributor to interior Fraser River salmonid production. Currently, salmonid escapement to the Nicola system is much lower than previously, and higher levels are considered essential for survival of these stocks. Interior Fraser River coho stocks were COSEWIC listed in 2002, but are not listed under the Species at Risk Act (SARA). The COSEWIC designation prompted the need for immediate recovery goals to be established by the Interior Fraser Coho Recovery Team (DFO 2005). In addition, Nicola River steelhead is an important component of the Thompson River stocks, and regarded as an extreme conservation concern by the Ministry of Environment (MOE) (Bos 2006). Excessive exploitation rates, habitat alteration, disruption and destruction from various human activities in the watershed, as well as effects of climate change appear to be contributing to the decline of fish stocks in the Nicola River (DFO 2005).

The Coldwater River was selected as the first watershed to receive attention in the Thompson-Nicola region salmonid recovery planning process for coho and steelhead by the Pacific Salmon Endowment Fund Society. The selection was due to several factors including the mix of anadromous species, the importance of this tributary to the Nicola River, the current fisheries management infrastructure of programs supported by federal, provincial and First Nations governments, land development concerns, the manageable size of the river, and reasonable chance of success in stock recovery.

A number of initiatives including the Coldwater Recovery Plan (Nelson et al. 2001), Interior Fraser Coho Recovery Plan (DFO 2005) and Thompson Steelhead Path to Recovery (Bos 2006) have identified the need for improved stock information to support recovery efforts and more intensive management requirements. In particular, an improved understanding of early migration and rearing life histories for coho, Chinook and steelhead is needed. Recovery and water use management plans have been developed through consultation with various users such as local stewardship groups, community stakeholders, industry, First Nations representatives, and both federal and provincial resource managers. Many stock assessment projects were recommended in the recovery plan. The coho and steelhead smolt enumeration project was initiated and subsequently conducted for a period of five years. The plan also recommended that a feasibility study be undertaken addressing the needs and procedures required to increase the quality and reliability of coho, Chinook and steelhead escapements.

This report provides a review of the current state of knowledge of early-run Chinook, coho and steelhead stocks of the Nicola/Coldwater system, with an emphasis on coho because of its relative importance in the system and current COSEWIC status. The Coldwater River is considered a key indicator stream by DFO for the lower Thompson population of Interior Fraser coho. Likewise, MOE regards the Coldwater as a key stream for the production of steelhead in the Thompson River watershed. Accordingly, in this report the information on these salmonids will be primarily for the Coldwater, the watershed for which there is most information to date.

This report begins with a brief overview of key watershed issues affecting the well-being of these stocks, and subsequently provides a review of the current state of knowledge on juvenile production, marine survival, harvest rates, adult returns, and stock enhancement works. This is followed by a brief review of key information gaps in our knowledge of these stocks and why it is important to fill them. The report concludes outlining a research strategy to help close the information gaps needed for better management of these threatened salmonid stocks.

2 Key Watershed Issues Affecting Fish Stocks

The Nicola River watershed is an important contributor to populations of interior Fraser early-run Chinook and coho salmon and Thompson steelhead. In spite of its importance, the river is one of the most threatened rivers in the province, mainly due to impacts from forestry, agriculture, irrigation and urban developments. Forestry is the major land use in the area, with harvesting operations and associated road building often causing increased levels of suspended sediments in streams from erosion of roads and cutbanks, landslides and soil disturbances in general (Rood and Hamilton 1995, DFO 1998). Other sources of impacts to flow and water quality in streams include agricultural developments, water diversion, alteration/loss of riparian habitat, linear and urban influences, pipeline construction, and mining activities (Rood and Hamilton 1995, Kosakoski and Hamilton 1982, DFO 1998). There has been considerable loss of riparian vegetation along the Nicola River, which has reduced stream shading and resulted in warmer stream temperatures during summer. Additional thermal stresses are imposed due to flows being reduced by water withdrawals for irrigation and other land use practices, resulting in greater daily temperature variations (Walthers and Nener 1997). Also, frequent destabilization of stream banks has resulted in wider channels and shallower waters being more susceptible to warming during summer. Increases in water temperature, if too great, can adversely affect growth, distribution, behaviour, disease resistance and ultimately survival and production of salmonids. Studies by Walthers and Nener (1997) suggest that salmonid production in both the Nicola and Coldwater rivers are constrained by relatively high water temperatures, with the distribution of fish influenced by local variations in water temperatures as fish tend to seek cooler areas with groundwater inflows, shade, and other features.

Within the Nicola system, Rood and Hamilton (1995) regarded the Nicola River, Spahomin Creek and Coldwater River as sensitive streams due to high water demands, whereas Spius and Maka creeks and the Coldwater River were regarded as sensitive due to their low flows. The same authors regarded the Coldwater River as sensitive due to high peak flows, whereas Maka Creek was regarded as sensitive due to recent logging activity covering more than 20% of the watershed

3 Review of Current State of Knowledge

3.1 Juvenile Salmonid Production

Production of juvenile salmonids in the Nicola system has been studied sporadically during the last few decades and the juvenile freshwater phase of these salmonids is understood to be complex and variable. For example, it is generally known that a portion of the coho, Chinook and steelhead emigrate from the Coldwater at times other than what is commonly known as the 'smolt window' (April–June) and/or from fry emigrating during this 'smolt window' to rear in other freshwater habitats between Merritt and the sea. Contribution of these juveniles to total adult returns is not presently known.

Whiteman (1979) provided the first estimates of standing crop and potential smolt yields of coho, Chinook and steelhead in the Coldwater system. Sebastian and Yaworski (1984) later estimated the abundance of salmonid fry and parr populations and respective smolt yields of the Nicola mainstem and major tributaries. Among the most recent projects, the Nicola Tribal Association, with technical and scientific support from LGL Ltd, Sidney, BC, completed a five-year smolt monitoring program on the Coldwater River from 2002 to 2006 using a rotary screw trap positioned in the Coldwater at Merritt. This program has been the most consistent juvenile salmon assessment study conducted in the Nicola watershed to date, which in conjunction with other past assessment projects, has added appreciably to current understanding of salmon productivity in the Coldwater River.

3.1.1 Coho Salmon

Whiteman (1979) estimated the summer population of coho at 165,000 fry and 16,500 age 1^+ parr in the Coldwater mainstem, and 9,000 fry and 1,000 parr in Juliet and Voght creeks combined. From these data, Whiteman estimated the total potential coho smolt yield at 29,500, and concluded that the reach from Kingsvale to the confluence with the Nicola produced approximately 50% of the total coho smolt production from the Coldwater.

Sebastian and Yaworski (1984) estimated that summer populations of coho ranged from 34,400 to 114,000 in the Coldwater River and from 5,700 to 35,500 in Spius Creek, with Maka Creek accounting for approximately 80% of the Spius production. Annual coho smolt yield was estimated at 7,000 to 16,800 and 2,000 to 10,200 for the Coldwater River and Spius Creek, respectively. Juvenile coho populations were only recorded in Spius Creek and the Coldwater River; no significant populations were found in the mainstem of the Nicola during four consecutive years of sampling. These authors concluded that habitat in the Nicola mainstem had been severely impacted by channelization and debris removal, and that only remnant juvenile coho populations were present. Coho presmolts have been recorded in side pools and side channels of the Nicola mainstem between Merritt and the Thompson (Kosakoski and Hamilton 1982). The current decline of the coho juvenile population and low spawner counts appear to be the most serious of the salmonid species present in the Nicola watershed.

During five years (2002-2006 inclusive) of smolt trapping in the Coldwater (Mathews et al. 2007), wild coho smolt abundance ranged from 16,134 in 2006 to 26,651 in 2005 (Figure 2). The entire Coldwater coho smolt population (including hatchery releases) has ranged from 77,837 smolts in 2005 to 134,509 smolts in 2004. During these trapping operations, significant numbers of coho parr were recorded emigrating from the Coldwater (range 2,469 in 2003 to 21,713 in 2006).

The five years of coho smolt trapping on the Coldwater has allowed the development of a preliminary spawner/smolt recruitment curve (Figure 3). This figure indicates that wild coho smolt production from the Coldwater from 2002 to 2006 correlates with the abundance of brood year river spawners, with apparent density-dependent effects at spawner abundances above 4,000 fish. This supports the notion that the available habitat in the Coldwater is limited at spawner abundances above the lower capacity estimate of 4,400 fish suggested by the Coldwater Recovery Plan (Nelson et al. 2001). At current habitat capacity, coho smolt production is limited to about 60,000 fish. More habitat suitable for coho rearing (e.g., pools, backwaters, and off-channels with adequate cover) in the Coldwater system is required to increase coho smolt production.

Recent wild coho smolt estimates calculated from mark/recapture study (Mathews et al. 2007) are similar to those estimated some twenty years ago, although the wild population is well below the interim recovery target of 60,000 to 110,000 smolts to sustain a healthy Coldwater coho stock (Nelson et al. 2001). This target is currently being met with the addition of hatchery releases to the system.

The coho smolt mark/recapture study on the Coldwater relies on hatchery releases of adipose clipped pre-smolts upstream of the rotary screw trap. Two key assumptions of this design are 1) that the adipose marked hatchery fish mix completely with the wild population of migrating pre-smolts, and 2) that hatchery coho and wild coho are equally vulnerable to re-capture. These assumptions have never been tested, which raises concerns about the study design.

3.1.2 Chinook Salmon

Juvenile Chinook populations were estimated at 64,500 fry and 4,000 age 1^+ parr in the Coldwater mainstem, and 4,300 fry and 400 age 1^+ parr in Juliet and Voght creeks combined, equating to a total potential smolt yield of 19,250 fish (Wightman 1979). In terms of smolt yield, Whiteman (1979) concluded that the Brodie Y to Kingsvale reach of the Coldwater River accounted for nearly 35% of the total smolt production.

Sebastian and Yaworski (1984) estimated that the Nicola juvenile Chinook population ranged from 91,000 to 931,000 between 1980 and 1983, of which the total Coldwater population comprised 5-48% (5,000 to 224,000 fish). The contribution to the total population from above Nicola Lake was low, being less than 5% in most years. The highest densities of Chinook juveniles in the Nicola mainstem occur between the confluences of Spius Creek and the Coldwater River. The direct smolt yield from the Nicola system has ranged from 60,000 to 316,000 fish during a four-year period (1980-1983 inclusive), with the Coldwater contribution ranging from 1,840 to 49,600, comprising 3-27% of the total production.

Chinook smolt estimates from mark and recaptures of wild and hatchery fish on the Coldwater over three years (2002-2004 inclusive) ranged from 22,968 in 2004 to 104, 325 in 2002 (Figure 4; Bocking et al. 2003, Baxter et al. 2004a, Baxter et al. 2004b). Wild Chinook estimates ranged from 2,486 to 23,104 smolts in 2003 to 33,649 to 66,245 in 2002 (range in yearly estimates was based on varying survival rates and age class assumptions).

Chinook parr have also been observed emigrating from the Coldwater during the smolt migration window, with estimates ranging from 2,690 in 2004 to 3,493 in 2003.

To date, wild Chinook smolt estimates have been imprecise, varying considerably annually. Like for coho, Chinook estimates in the Coldwater are confounded by the use of hatchery fish as the marked group. In addition, not all hatchery releases are marked, and wild population estimates are therefore difficult to determine.

3.1.3 Steelhead

The juvenile rainbow trout/steelhead population was estimated at 248,400 fry and 68,000 parr (ages 1-4) in the Coldwater River mainstem, and 2,900 fry and 4,500 parr in Juliet and Voght creeks combined in the late 1970s (Wightman 1979). Although unverified, a 50% ratio of anadromous to resident fish was assumed, giving a total potential steelhead smolt yield of 8,000 fish.

Sebastian and Yaworski (1984) reported densities ranging from 0.5 to 1.0 fry/100m^2 in the lower Coldwater River, lower Maka Creek, and lower Nicola mainstem (near Spences bridge). These densities are considered to reflect the availability of good quality habitat. Lower fry densities were encountered upstream of the Coldwater confluence (< 0.3 fry/100m^2) and particularly above Nicola Lake. The same authors estimated that parr abundance for the Nicola system ranged from 152,200 to 193,100 fish, with the contribution from the Coldwater ranging from 26,900 to 50,000 fish (15-33% of the total population). A higher proportion (75% vs 25%) of anadromous to resident fish was assumed, resulting in smolt estimates ranging from 56,600 to 63,600 smolts, with an 11-18% (6,000 to 10,700 smolts) contribution from the Coldwater

From recent Coldwater River mark/recapture studies, it is estimated that steelhead smolt production ranged from 2,499 in 2004 to 10,017 smolts in 2005 (Figure 5). As was noted for coho and Chinook, steelhead parr emigrated from the Coldwater during the smolt ‘migration window’, ranging from 3,123 fish in 2005 to 26,723 fish in 2006.

Steelhead estimates are derived from mark/recapture studies of wild fish; however, alternative marking methods to fin clipping need to be explored as there is concern that it may be having an adverse effect on fish.

3.2 Exploitation and marine survival

Exploitation rates have not always been stock specific. For example, for coho, one rate was applied to all interior Fraser stocks. Marine survival estimates for these stocks are sporadic and generally difficult to determine or forecast.

3.2.1 Coho

Exploitation rate of interior Fraser coho is based on coded-wire tagged wild fish from the Eagle River and from coded wire tagged hatchery smolts from the Spius Creek Hatchery. During the 1970s and 1980s, exploitation was high and not appreciably reduced until 1998. An average 68% of the total returns was harvested between 1975 and 1985, with a peak of 88% in 1993. By 1998, the harvest rate was reduced to 7%, with severe restrictions placed on all coho fisheries; currently, the harvest rate is around 13% (Figure 6; Table 1).

As no commercial fishing for interior coho stocks is allowed, the current exploitation comprises approximately 10% by catch in US fisheries, 3% by catch in Canadian fisheries (commercial, recreational and First Nations), 0.5% for scientific research and test fisheries, and 0.3% in direct First Nations fisheries (DFO 2005). The First Nations fishing is undertaken by terminal area First Nations groups on streams having accurate escapement counts (i.e. counting fence facility) with takes permitted after escapement has reached a target threshold (Folkes et al. 2005). Prior to 1998, Thompson/Nicola coho were harvested in marine fisheries from Alaska to Washington State, with the majority taken in troll and sport fisheries off the west coast of Vancouver Island and in Georgia Strait. In addition, Thompson/Nicola coho were caught incidentally in net fisheries and historically were taken in saltwater and freshwater sport fisheries (Nelson et al. 2001).

There are indications that recent fisheries management regulations have stopped the declining trend of interior Fraser River coho stocks. Moreover, the COSEWIC designation has led to the development of an immediate recovery goal exceeding the lower benchmark of 20,000 to 25,000 wild spawners for these stocks (DFO 2005). Following an extensive data review, the Interior Fraser Recovery Team concluded that there is sufficient spawner recruitment and suitable habitat available for these stocks to recover. The Team noted that threats to coho and habitat can either be avoided or mitigated through appropriate recovery actions (Interior Fraser Coho Recovery Team 2005).

Estimates of fresh water survival are sparse for hatchery coho in the Nicola system, consisting only of two consecutive years of smolt-to-adult survival for the Coldwater River population with the smolts being produced at the Spius Creek Hatchery (1.15% and 1.74% in 1998 and 1999, respectively) (Nelson et al. 2001). Currently there are no marine survival estimates for wild coho in the Nicola River watershed.

3.2.2 Chinook

Harvest rates of Nicola Chinook have been estimated using run reconstruction techniques from annual catch data for commercial, recreational and First Nations fisheries for the Fraser River watershed and escapement records (English et al. 2007). Prior to 1994, the majority of the commercial harvest of Nicola Chinook occurred as an incidental catch in the Fraser sockeye gillnet fisheries and is believed to still occur as such during years of significant sockeye runs (Nelson et al. 2001). Between 1982 and 2004, harvest rates for Coldwater and Spius Chinook stocks fluctuated widely, ranging from 18.5% in 1991 to 72.7% in 1999; mean harvest rate for these two stocks has been virtually identical (Figure 7, Table 2).

Harvest rates for the Nicola River have been less variable ranging from 12.7% in 1985 to 42.9% in 1991. Some harvesting of Nicola River Chinook by First Nations groups does occur (Nelson et al. 2001). Other fisheries of relevance to management of the interior Fraser Chinook stocks include the West Coast Vancouver Island and Northern Troll fisheries, and the Georgia Strait and Juan de Fuca Strait sport fisheries (Nelson et al. 2001).

3.2.3 Steelhead

There is no directed commercial fishery for Thompson steelhead (part of the interior Fraser summer run group), although interior Fraser summer-run steelhead are intercepted in commercial sockeye, pink and chum salmon fisheries in the lower Fraser River and in the Strait of Juan de Fuca, Johnstone Straits and the Strait of Georgia. Changes in fishery openings and catch handling methods have been implemented in an attempt to reduce steelhead by-catch mortality. Historically, fishing mortality of interior Fraser stocks (based on theoretical simulation models including commercial, sport and First Nations catches) has been as high as 80%, but since 1996 fishing mortality has been between 10-20% (Nelson et al. 2001).

Coldwater steelhead are subjected to a catch-and-release fishery in the lower Thompson upon their return from the sea (Nelson et al. 2001). Steelhead are also harvested by First Nations for ceremonial, social and subsistence purposes (Ahrens 2004), but the amount harvested is not known as winter and spring fishing in the Thompson River and tributaries are not monitored, as is the case in many watersheds of the Fraser system (Nelson et al. 2001).

There are no direct measures of marine survival of Thompson River steelhead stocks, although trends in escapement of interior Fraser stocks and test fishery data suggest that survival rates are strongly affected by changes in their marine survival.

3.3 Adult Returns

Adult escapement for the Nicola mainstem and major tributaries has been monitored for both coho and Chinook since the mid 1970s with reasonably good precision. Monitoring of steelhead escapement has been ongoing since the early 1980s, but with less consistency and lower precision than for salmon.

3.3.1 Coho

Coho begin to return to the Nicola River in September, with peak returns generally occurring in late October/early November; spawning begins in late October and continues into December (Kosakoski and Hamilton 1982). Coho spawn in Spius Creek (mainly in Maka Creek), Coldwater River (throughout, but most heavily upstream of Juliet Creek), Guichon and Clapperton creeks, and some sporadic spawning occurs in the Nicola mainstem below the lake, as well as above the lake when sufficient flow is available. (Interior Fraser Coho Recovery Team 2005; Kosakoski and Hamilton 1982). Spawning escapement of both the lower and upper Nicola mainstem has averaged 21 spawners, while Clapperton and Guichon creeks have averaged 8 and 65 spawners, respectively (Table 3). Spawner counts are not available for all years for these streams.

The majority of coho spawning in the Nicola system occurs in the Coldwater River and Spius Creek, averaging 66% and 32%, respectively (Figure 8). During the mid 1980s to mid 1990s, the Coldwater constituted the majority of spawners, followed by a shift in the majority to Spius, and some three to four years later back to the Coldwater. Spawner escapement in all other parts of the Nicola system has been minimal (0.2-6%).

The Nicola River stock, like the rest of the interior Fraser coho stocks has declined significantly in the last two decades. The interior stocks returned in modest numbers during the 1970s, peaked during the 1980s, but declined markedly in 1996. The decline was thought to be due to overfishing when harvest rates were not adjusted to match productivity declines due to changing marine conditions and freshwater habitat perturbations/losses (DFO 2002). During the last three decades, Nicola River coho escapement has ranged from 598 fish in 1996 to 11,455 fish in 2002 (Figure 6; Table 1). Since the 1996 crash in coho returns, inter-annual variability has been considerable with, for example, a peak in 2002 followed by a near tenfold decrease in returns in the following year.

During the past 30 years, Spius Creek wild coho spawner escapement has averaged 656 fish, ranging from zero fish in 1988 to 2,374 fish in 1997; including hatchery contributions, average escapement was 1,644 fish, ranging from 186 fish in 1988 to 5,585 fish in 1997. By comparison, Coldwater River wild coho escapement averaged 1,971 fish, ranging from 289 to 3,436 fish in 1996 and 2001, respectively; including hatchery contributions, escapement averaged 3,288, ranging from 394 to 7,446 fish in 1996 and

1993, respectively. Within the Nicola system, wild spawner escapement averaged 2,740 fish, ranging from 366 to 4,936 fish in 1996 and 1984, respectively. For wild and hatchery fish combined, an average of 4,480 coho spawners was recorded, ranging from 598 to 11,455 fish, respectively in 1996 and 2002.

Peak live counts, the method commonly used to estimate spawner escapement, are generally low precision, and so the estimates for the Coldwater, Spius and Nicola may be quite unreliable. Coldwater coho spawner estimates generated from a fish counting facility while in operation (1998-2001) have higher accuracy and reliability.

3.3.2 Chinook

There are two temporally and spatially separated Chinook stocks in the Nicola system. Chinook returning to the Nicola watershed are predominantly age '4sub2' fish (spend first 2 years in fresh water). The early-run component enters the Coldwater River and Spius Creek as early as May (enters the lower Fraser as early as mid March) and generally completes spawning by late August. Spawning in the Coldwater is generally above Kingsvale, whereas in Spius it occurs mainly in Maka Creek. The later component begins to enter the Nicola system in mid to late July (generally enter the lower Fraser in early May), and spawns in mid September mainly in the Nicola mainstem and lower 6 km of Spius Creek and lower 15 km of the Coldwater River (English et al. 2007; Bailey et al. 2001; Farwell et al. 1999). Up to 75% of Chinook spawning in the Nicola mainstem occurs between the confluences of Spius Creek and the Coldwater River, with the remainder generally distributed equally in the reach downstream of the Spius confluence and in the reach upstream of the Coldwater confluence to Nicola Lake. Spawning above Nicola Lake, based on fence counts, is usually minimal (<25 spawners between 1995 and 1998), but from an aerial survey in 1999, 199 spawners were recorded in the mainstem and Spahomin Creek (Bailey et al. 2000).

Nicola River Chinook escapement has fluctuated considerably since the mid 1990s, from a high of 16,400 fish in 1996 to a low of 1,211 fish in 1998, after which it gradually increased to 14,574 fish in 2003 and declined in the following year to 7,850 fish (Figure 7; Table 4). The occurrences of highs and lows in spawner escapement for both the Coldwater and Spius are similar to those noted for the Nicola.

Escapement estimates of Chinook salmon in the Fraser River watershed are from a combination of aerial and ground surveys and subsequent expansion of the counts (English et al. 2007). Some escapement data are available for the Nicola mainstem from an intensive mark/recapture program conducted from 1995-1999 (Bailey et al. 2000). Comparison of data from the two methods indicates that visual counts were 5-40% lower than mark/recapture estimates (Bailey et al. 2000).

3.3.3 Steelhead

Interior Fraser summer-run steelhead return to fresh water from late spring through autumn and sexually mature during winter in big-water habitat prior to moving into their natal stream in the following spring to spawn (Ahrens 2004). Generally, Nicola River steelhead congregate and over-winter in the Thompson River, after which they migrate into the Nicola during spring freshets (Webb et al. 2000). As observed from radio-tagged steelhead, spawning occurs in the lower Nicola mainstem, Skuhun, Shakan, Nuaitch, Spius, and Maka creeks and the Coldwater River. Some spawning has also been observed in Guichon, Prospect, and Clapperton creeks and the Nicola mainstem between the Coldwater confluence and Nicola Lake (Webb et al. 2000).

Historical anecdotal information indicates that adult returns of Thompson steelhead were as great as 25,000 fish, although empirical evidence from the 1960s indicates returns were probably closer to 10,000 fish. Since those times, adult steelhead returns have decreased dramatically ranging from <1,000 to < 5,000 fish between 1993 and 2005. These returns were considered to be low enough for the stock to be given conservation status by the MOE (Bos 2006).

With few exceptions, steelhead escapement in the Nicola since the 1980s has not exceeded 1000 fish (Figure 9; Table 5). A peak 3,284 spawners was recorded in 1985, with moderate returns of 1500-2000 fish between 1993 and 1995. Escapement to the Coldwater has ranged from 130 to 773 fish in 1992 and 1993, respectively, but more commonly has been around 250 spawners in any one year. In some years, Coldwater steelhead has provided the greatest contribution (23-42%) to escapement in the Nicola system.

Steelhead spawner escapement data for the Nicola system have been available since 1983, although the reliability of these data varies with year. Up until 1999, estimates were based on peak counts from limited helicopter and ground surveys. This approach was particularly unsuited for the Coldwater River as turbid freshet conditions often precluded deployment of visual surveys. Since 1999, escapement estimates have been based on periodic visual counts for Spius Creek and estimates for other streams of the Nicola system (including the Coldwater) are extrapolated from the distribution of a random sample of steelhead radio-tagged prior to their upstream migration in the Nicola (Nelson et al. 2001).

Steelhead spawner enumeration estimates for the Coldwater River may improve in the near future with the use of resistivity counter technology. The counter was installed and operated for the first time in 2006, and it is expected that at least two more seasons of operation and calibration may be required to obtain more precise estimates than have been possible since 1983.

3.4 Stock Enhancement

The Spius Creek Hatchery was one of six pilot hatcheries that were built to enhance the declining upper Fraser River Chinook and coho salmon stocks (Winton and Hilborn 1994). Enhancement strategies for the Nicola system began in 1981, with broodstock initially taken from the Nicola River mainstem stock. The hatchery focuses on coho and chinook supplementation in the Nicola watershed, capturing broodstock from the Coldwater (Chinook and coho), Spius (coho), and Nicola mainstem (Chinook).

3.4.1 Coho

Coho broodstock was collected from the Nicola River (1986), Spius Creek (1986-2005) and the Coldwater River (1984-2005) to ultimately produce fry for release into the Nicola mainstem, Guichon, Maka and Spius creeks and the Coldwater River. All fry released into the Nicola River and Guichon and Maka creeks were unmarked, although later both marked (coded wire tags, adipose clips or both) and unmarked fry were released into Guichon and Maka creeks. In Spius Creek and the Coldwater, both marked and unmarked fry releases were made in varying proportions annually.

Smolts are also reared at the hatchery and released as marked and unmarked fish in Spius Creek and the Coldwater River. In Spius Creek, between 1995 and 2005, unmarked smolt releases ranged from 1,513 (1999) to 110,294 (1996) fish, while marked smolts ranged from 22,033 (1999) to 111,077 (1995) fish. In the Coldwater River, between 1986 and 2006, unmarked smolt releases ranged from 1,500 (2001) to 145,400 (1991) fish; marked smolts ranged from 19,657 (1995) to 160,292 (2003) fish. A portion of the coho releases was coded-wire-tagged to provide data for comparison of survival from smolt-adult returns among the different release groups.

Coho hatchery releases have added substantially to both smolt and spawner populations of the recipient streams. From 2002 to 2006, wild smolts in the Coldwater constituted from 15-35% of the total output, with the total smolt population being largely sustained by hatchery releases (Mathews et al. 2007). Including hatchery contributions, total coho smolt output from this stream in 2005 and 2006 has been within the target range of 60,000 to 110,000 smolts identified in the Coldwater Recovery Plan (Nelson et al. 2001). The dependence on hatchery releases is also evident in the adult returns. On average, wild spawners constitute 67% of Coldwater escapement (range 32-100%) since enhancement began in 1984 (Table 6). Hatchery contributions for Spius Creek are similar to those of the Coldwater.

The Coldwater River Recovery Plan (Nelson et al. 2001) concluded that the coho stocking program added significantly to annual escapement and appeared to have no negative effects on wild fish survival. However, in light of recent data now available from the five-year Coldwater smolt monitoring program, Mathews et al. (2007) recommended that the effects of fry stocking on wild populations be re-evaluated to ascertain if negative impact is occurring. Several studies conclude that hatchery reared fish can have detrimental effects on their wild counterparts through predation, competition, displacement and genetic contamination reducing the fitness of wild fish (McMichael et al. 1999; Einum and Fleming 2001; Weber and Fausch 2003). This may not be of major concern for smolt releases as their stay in fresh water is limited, but for fry releases whose residency is much longer, the potential for negative effects on wild fish is much greater.

3.4.2 Chinook

Since initiation of the Nicola enhancement program, Chinook salmon broodstock has been collected from the Nicola River (1981-2005), Spius Creek (1986-2005) and the Coldwater River (1984-2004). Releases have been made in the Nicola River, Spahomin, Spius and Maka creeks and the Coldwater River. Fry releases into Maka, Spius and, Spahomin creeks and the Coldwater River have all been unmarked. Fry releases in the Nicola River have consisted of marked and unmarked fish, with unmarked totals ranging from 80 (1996) to 158,126 (1997) fish, and marked totals from 31,500 (1982) to 78,199 (1987) fish. Fry releases in the Nicola mainstem above Nicola Lake have been minimal, compared with the much greater releases below the lake.

Chinook smolt releases have occurred in the Nicola mainstem, Spius Creek and the Coldwater River, in addition to a single release of unmarked smolts in both Spahomin and Maka creeks. In an attempt to reduce the hatchery's release and production schedule by one year, initial releases were of age 0^+ smolts in the hope that the freshwater rearing phase could be shortened by releasing fry in the spring that would migrate to the ocean without overwintering in fresh water for an additional year. This was not successful, with egg-to-adult survival rates well below the target range; much greater survival was obtained for fry held for one winter in the hatchery prior to release. Subsequently, hatchery releases were of 1^+ smolts, as returns favoured first year overwintering in the hatchery before release (Winton and Hilborn 1994).

Chinook smolt releases in the Nicola River have ranged from 26,382 (2000) to 509,623 (1989) unmarked fish, and from 43,410 (2000) to 252,815 (1990) marked fish. Similarly, in Spius Creek, releases have ranged from 4,999 (1997) to 174,760 (1990) unmarked fish, and from 47,397 (1997) to 49,449 (1998) marked fish. Likewise, in the Coldwater River, releases have ranged from 1,433 (1996) to 194,270 (1988) unmarked smolts, and from 20,423 (1995) to 71,767 (1993) marked smolts.

In general, the Chinook enhancement program for the Nicola system has been regarded as a success as the releases have added substantially to the total smolt population (37 to 68% in 2002 and 63-96% in 2003). There are no wild versus hatchery Chinook spawner escapement data available for the Nicola system from which to assess the contribution of hatchery releases to the spawner population. (Budget constraints prevented the Nicola Tribal Association from researching this information). Similar to the coho situation in the Coldwater River, possible negative effects of hatchery releases on wild Chinook stocks in the longer-term should be assessed.

3.4.3 Steelhead

Unmarked steelhead fry were consistently released in Spius Creek from 1986 to 1995, ranging from 53,003 (1992) to 97,984 (1988) fish. Similarly, unmarked fry releases of Spius stock occurred in Maka Creek in 1986. Steelhead fry were consistently released in the Coldwater River from 1984 to 1995, the majority being unmarked and ranging from 36,708 (1988) to 135,000 (1986) fish. In 1985, 172,277 coded wire tagged fry were released in the Coldwater to obtain information on survival to adulthood. Unfortunately, there does not appear to have been a follow-up assessment program subsequent to the release of the marked fish.

It is difficult to determine the success or impact of steelhead hatchery releases on the wild smolt populations in the Nicola system as enhancement stopped long before the mark/recapture estimates were made. Enhancement did allow anglers to retain hatchery marked steelhead after the 1989 regulations of catch and release of all wild populations came into effect. Escapement contribution from hatchery releases remains unknown. The steelhead enhancement program was discontinued in the mid 1990's as stock managers wanted to be in the position of evaluating the status of wild stocks (most hatchery releases were unmarked).

3.4.4 Future Enhancement Programs

DFO has indicated that both Chinook and coho hatchery programs will continue in the Nicola system with a focus on smolt releases. Fry stocking programs of coho will continue for the Coldwater system only; any other fry stocking programs will either be the result of fish surplus to the smolt program or BKD screening of adults (eggs from any female broodstock with positive BKD test results will only be used for fry releases). Spius Creek coho enhancement will no longer continue due to budget cuts. There are no plans to resume steelhead enhancement strategies in the Nicola system (Dennis Graf, DFO, pers. comm.).

4 Key Information Gaps

In a recent-round table discussion, Nicola Tribal Association, LGL Limited and DFO representatives discussed objectives for a future Coldwater/Nicola Salmonid Research Program. It was decided that any ongoing work should remain focused on filling key information gaps on the Coldwater River salmonid stocks. They include the need for: 1) greater confidence in wild coho and Chinook smolt population estimates currently generated by mark and recapture data using marked hatchery fish, 2) improved understanding of early life histories (migration and rearing) for Coldwater coho, Chinook and steelhead and determination of the relative contribution that rearing in the Coldwater, lower Nicola and lower Thompson makes to adult recruitment to the Coldwater, and 3) estimates of marine survival of wild coho and Chinook (currently marine survival estimates are based on hatchery marked fish).

The coho smolt mark/recapture study on the Coldwater relies on hatchery releases of adipose clipped pre-smolts upstream of the rotary screw trap. Two key assumptions of this design are 1) that the adipose marked hatchery fish mix completely with the wild population of migrating pre-smolts, and 2) that hatchery coho and wild coho are equally vulnerable to re-capture. These assumptions have not been tested and raise concerns regarding study design and reliability of smolt population estimates.

There is much scientific evidence that survival of wild and hatchery salmon can differ significantly. To properly monitor the recovery of these wild fish stocks, marine survival of these fish must be confidently known. Sufficient numbers of wild coho and Chinook pre-smolts are needed for mark and recapture studies in the Coldwater for determination of smolt and marine survival.

5 Proposed Strategy to Close Information Gaps

The strategy to close the above mentioned information gaps involves both field and laboratory work. First, it will be important to determine if sufficient numbers of wild[1] coho and Chinook pre-smolts can be captured in the upper Coldwater River (Objective 1). If sufficient numbers of wild coho and/or Chinook can be captured, then future mark and recapture studies on the Coldwater can be stratified by wild and hatchery outplants and opportunities may exist to coded-wire tag pre-smolts to estimate marine survival.

To determine what portion of coho, Chinook and steelhead returns to the Coldwater come from juveniles that have reared in the Coldwater, lower Nicola, and lower Thompson, it is proposed to test if micro elemental signatures on otoliths from spawned-out fish in the Coldwater correlate with the presence of trace elements in the different rearing environments occupied by the fish during their gradual migration between the Coldwater and Fraser River. This would provide a means of determining the relative contribution of the different rearing components to adult returns of these fish stocks (Objective 2).

Should it be determined that meeting one or both of the objectives is feasible, a long term program for monitoring freshwater production and adult recruitment to the Coldwater could be pursued.

5.1 Specific Objectives and Proposed Methodology

Objective 1
Coho
Evaluate the feasibility of capturing sufficient numbers of wild coho pre-smolts (~50-70 mm fork length) in various areas of the upper Coldwater River by baited minnow trapping during early May 2007. The information gathered would be used to assess if it is feasible to capture sufficient numbers of fish for future mark and recovery study to estimate smolt population and marine survival.

Large numbers of minnow traps baited with salmon roe would be fished in various productive coho sites in the Coldwater River, including off-channel sites. To distinguish between wild and hatchery coho captured in the minnow traps, all hatchery releases into the Coldwater in the current year (presmolts) would be adipose-clipped for identification. The minnow trapping operation would progressively move upstream in the various areas sampled, so as not to disturb unsampled areas and to avoid recaptures of released fish. The main output of this sampling would be an estimate of Catch-Per-Unit-Effort (CPUE) over time, expressed as number of coho captured per trap per day. The results would be used to calculate how much trapping effort and over what period would be required to meet marking objectives for reliable (± 20%) and unbiased estimates of outgoing wild coho smolts and survival to returning adults.

[1] Wild refers to any coho or Chinook progeny of river spawners, be they of hatchery or wild parents.

Chinook
Evaluate the feasibility of capturing sufficient numbers of early-run Chinook 1^+ smolts with a rotary screw trap operated upstream of Brodie Y, or some other suitable site, on the upper Coldwater River during early May 2007. The information gathered would be used to assess if it is possible to capture sufficient numbers of fish by this method for future coded wire tagging operations to obtain estimates of early-run Chinook 1^+ smolts in the Coldwater River through recaptures at a smolt trap (RST) operated on the lower Coldwater at Merritt.

Early-run Chinook smolts in the Coldwater begin to emigrate around mid April and continue to do so until at least mid May. A rotary screw trap would be installed at a suitable site on the Coldwater mainstem in early May. This would be a trial year to examine catch rates and resolve various logistical problems associated with the trapping site, varying flows, handling of fish, and other issues. All Chinook smolts would be counted and released downstream. This sampling would provide an estimate of Catch-Per-Unit-Effort (CPUE) over time, with CPUE expressed as number of Chinook captured per day. The results would be used to calculate how much trapping effort and over what period would be required to meet marking objectives for reliable (± 20% at 95% confidence limits) and unbiased estimates of wild Chinook smolt output and marine survival.

Objective 2
Coho, Chinook, steelhead
Evaluate the feasibility of using natural elemental signatures on otoliths of coho, early-run Chinook and steelhead collected from spawned-out salmon and steelhead carcasses recovered on the spawning grounds in the Coldwater River. Laser ablation analysis of otoliths would be used to assess if elemental signatures can be used as a means of determining the relative contribution that rearing habitats in each of the Coldwater, lower Nicola and lower Thompson make to adult returns in the Coldwater River. The use of natural elemental signatures to differentiate fish movements between streams has recently been shown to work for slimy sculpin and Arctic grayling populations in several tributaries of the Williston Reservoir (Clarke et al. 2004, 2007).

Water samples would be collected from various sites in the Coldwater, lower Nicola, and lower Thompson during late summer low flows for analysis of trace element concentrations, which would be used to characterize the water chemistry of the different rearing environments of significance to these salmonids. Water samples would also be collected from Spius Creek as some coho carcasses in the Coldwater are likely to be of hatchery origin. The samples would be analyzed with an Optical Emission Spectrometer at the University of Northern British Columbia to determine the concentrations of specific trace elements.

Otiliths would be collected from Chinook and coho spawned-out fish on the spawning grounds in the Coldwater. Also, otoliths from occasional steelhead carcasses could be opportunistically taken earlier in the season. Information recorded from each of the carcasses would include species, fork length and sex, and in addition scale and fin ray samples would be taken from each fish for additional life history information. The otolith analysis would be done with the use of laser ablation equipped with the latest technology in Optical Emission Spectrometry, located at the School of Earth and Ocean Sciences, University of Victoria. This instrument has the capability of providing information on approximately each 10 days of fish life from otolith daily growth rings – thus, if a fish remains in a specific water type for at least that period, the trace elements from that water deposited on the otoliths would be detected.

The main outputs from this objective would be 1) an assessment of trace element concentrations in the different rearing environments along the freshwater migration corridor of Coldwater coho, Chinook and steelhead, and 2) an assessment of the use of laser ablation to discern differences in trace element depositions on otoliths among adult salmon and steelhead. If successful, the findings of this objective could give rise to a new method for stock discrimination of salmon and steelhead species in Fraser River fisheries. In addition, improved knowledge of the significance of specific freshwater rearing areas for salmonids in the Nicola watershed would assist in guiding development of the Nicola Water Use Plan.

6 Conclusions and Recommendations

- The Coldwater River is an important key indicator system for the production of coho, Chinook and steelhead populations;
- Several significant community-based initiatives are underway to restore these salmonid populations;
- There is a need for a long-term monitoring program of wild smolt production and marine survival for more effective management of these salmonid stocks;
- There is a need to fill three information gaps (ie, wild smolt production; relative contributions of rearing components between the Coldwater and the sea to adult returns; and marine survival of these fish stocks) before proceeding further with attempting to restore these threatened stocks;
- If these information gaps can be filled, then a long-term program of stock restoration can be confidently pursued.

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Figure 1. Map of Nicola River system, with inset showing location of watershed in British Columbia.

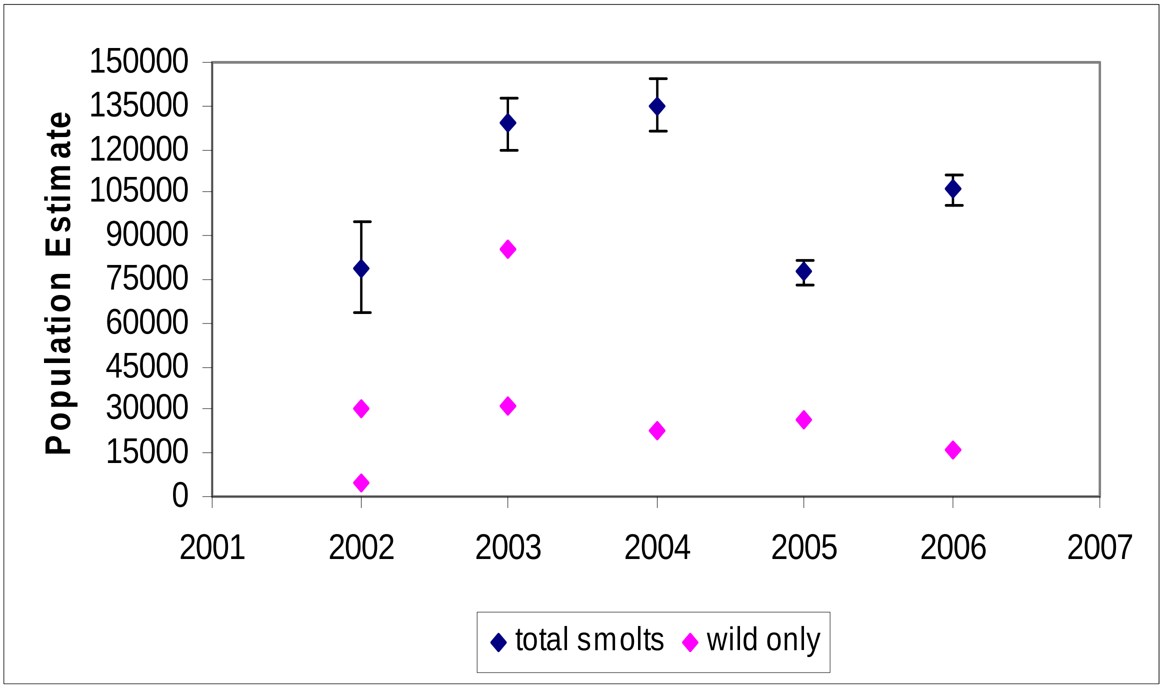

Figure 2. Estimates of coho total smolts (wild and hatchery combined) and wild only smolts from the Coldwater River, 2002-2006 (2002 & 2003 include range of wild smolt numbers). Data are means ± 95% confidence limits.

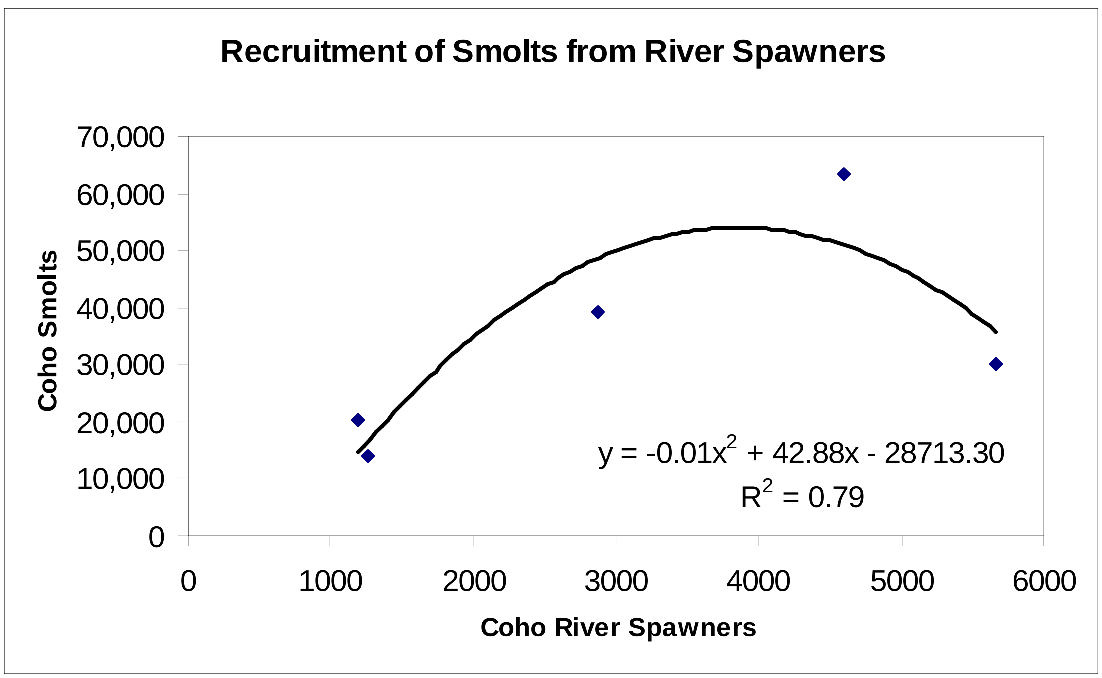

Figure 3. Recruitment of coho smolts from river spawners in the Coldwater River from spawner/smolt data collected from 2002-2006.

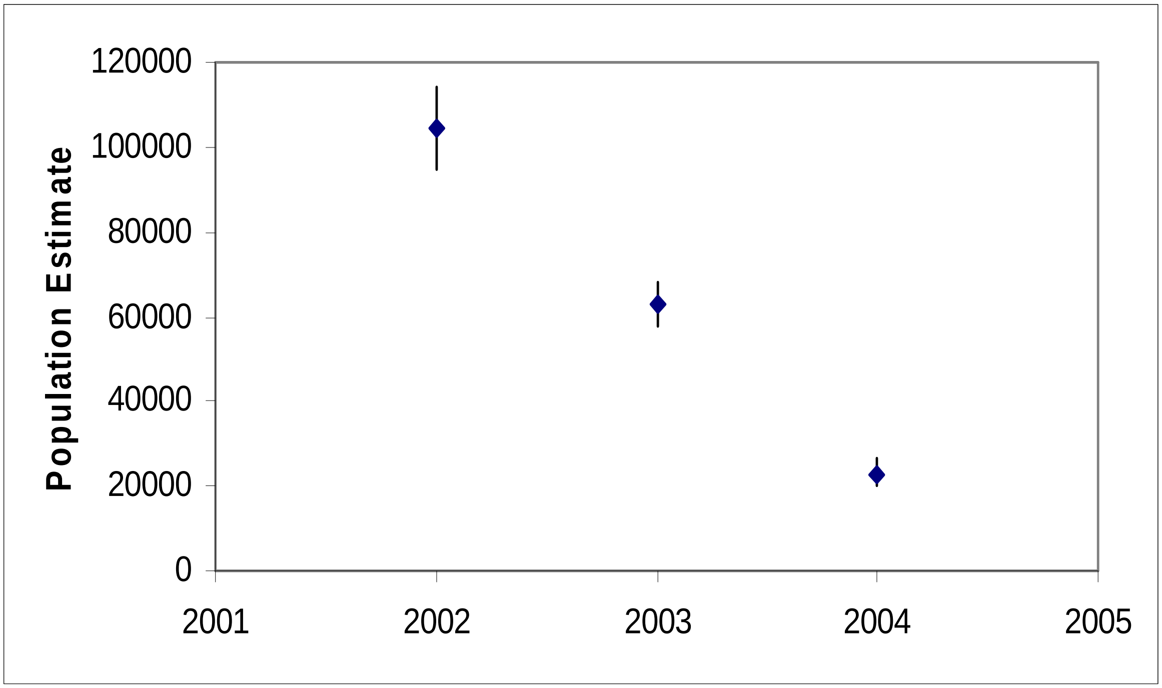

Figure 4. Estimates of Chinook total smolts (wild and hatchery combined) from the Coldwater River, 2002-2004. Data are means ± 95% confidence limits.

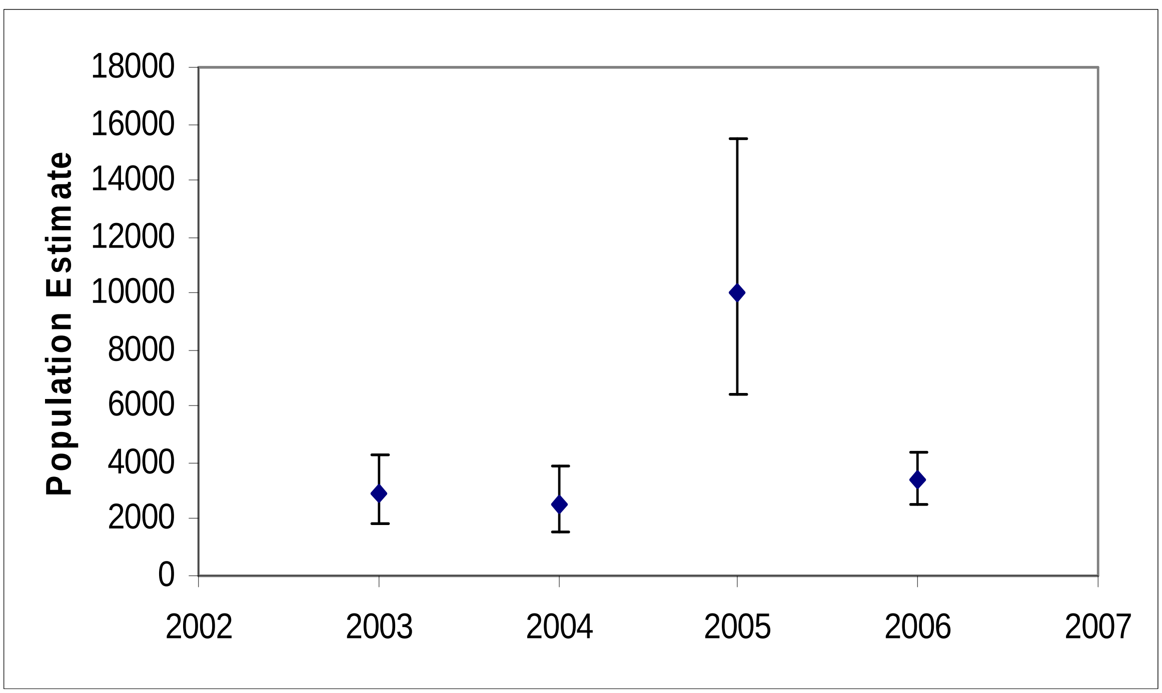

Figure 5. Estimates of steelhead smolts (FL>90mm) from the Coldwater River, 2003-2006. Data are means ± 95% confidence limits.

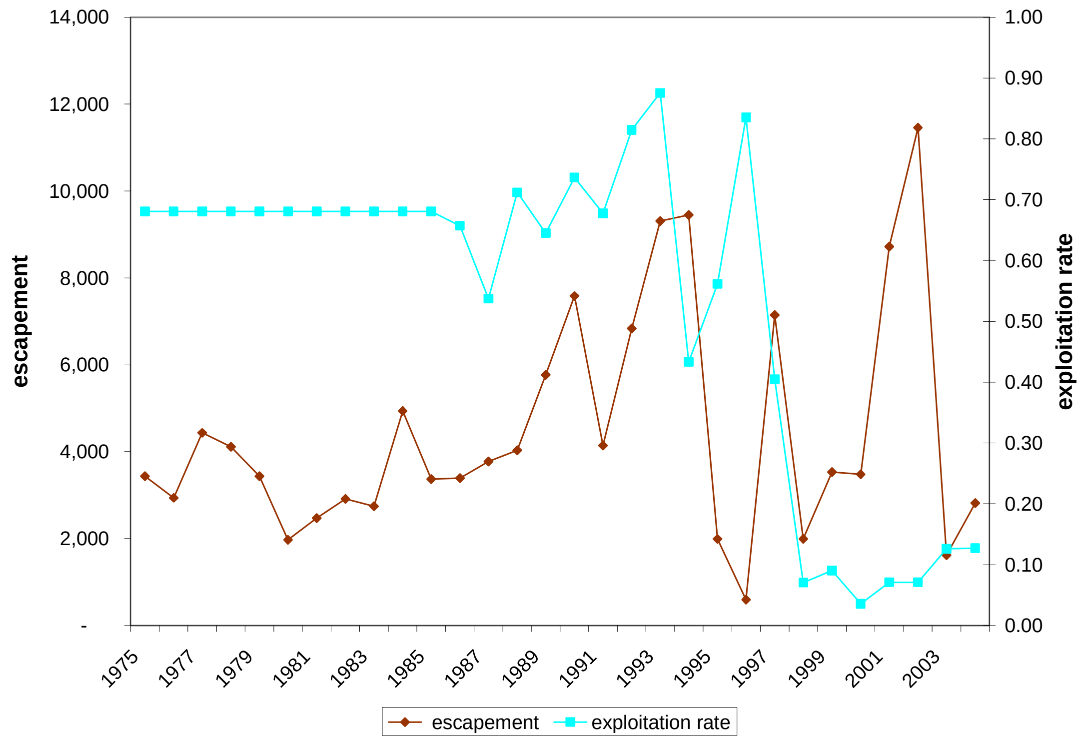

Figure 6. Nicola River coho escapement and exploitation rate, 1975-2004.

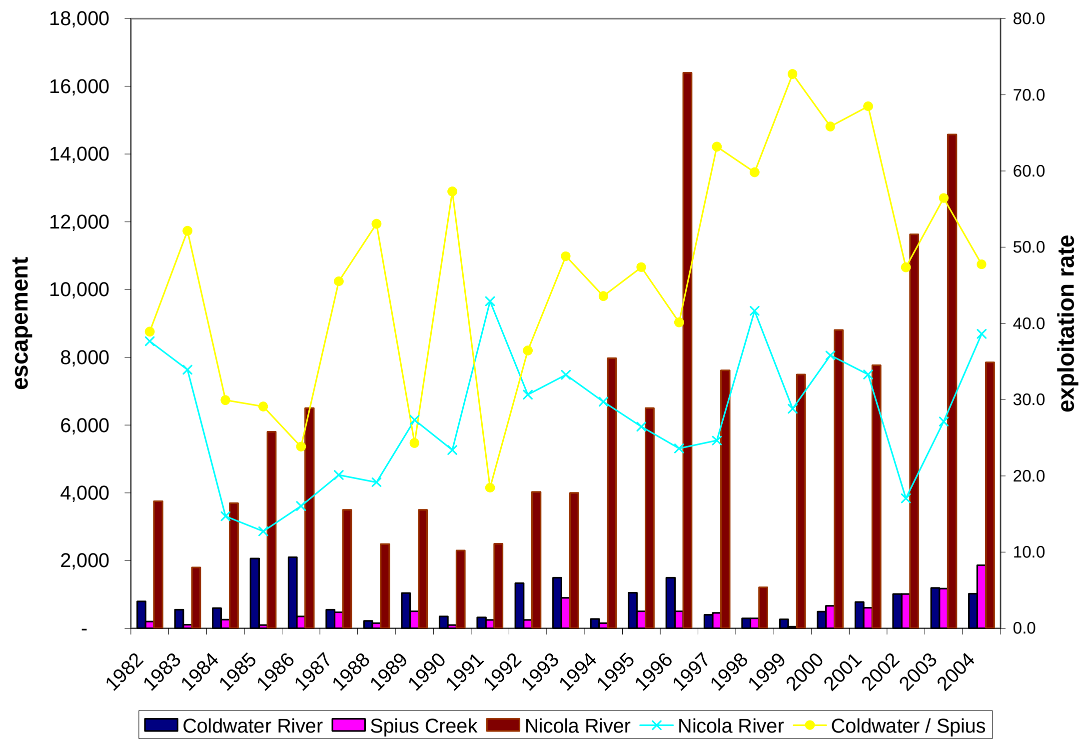

Figure 7. Chinook escapement and exploitation rates of the Nicola River, Coldwater River and Spius Creek stocks, 1982-2004 (note, Coldwater and Spius exploitation rates are roughly similar over time).

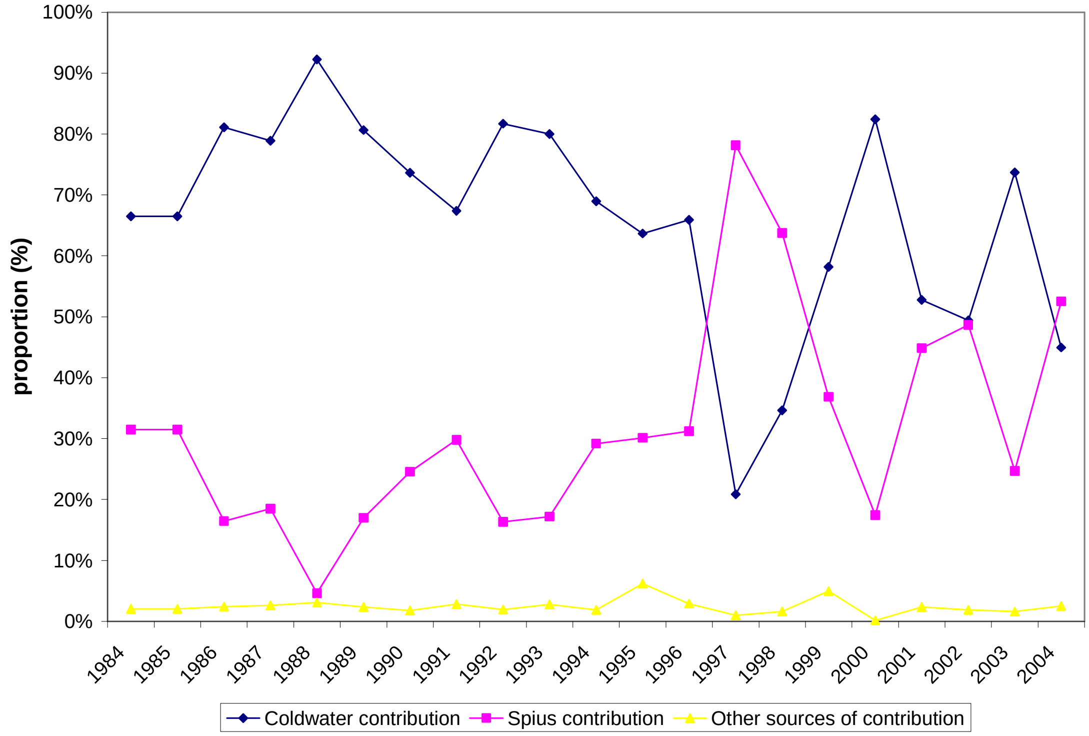

Figure 8. Comparison of coho escapement contributions from Coldwater River, Spius Creek, and other sources, 1984-2004.

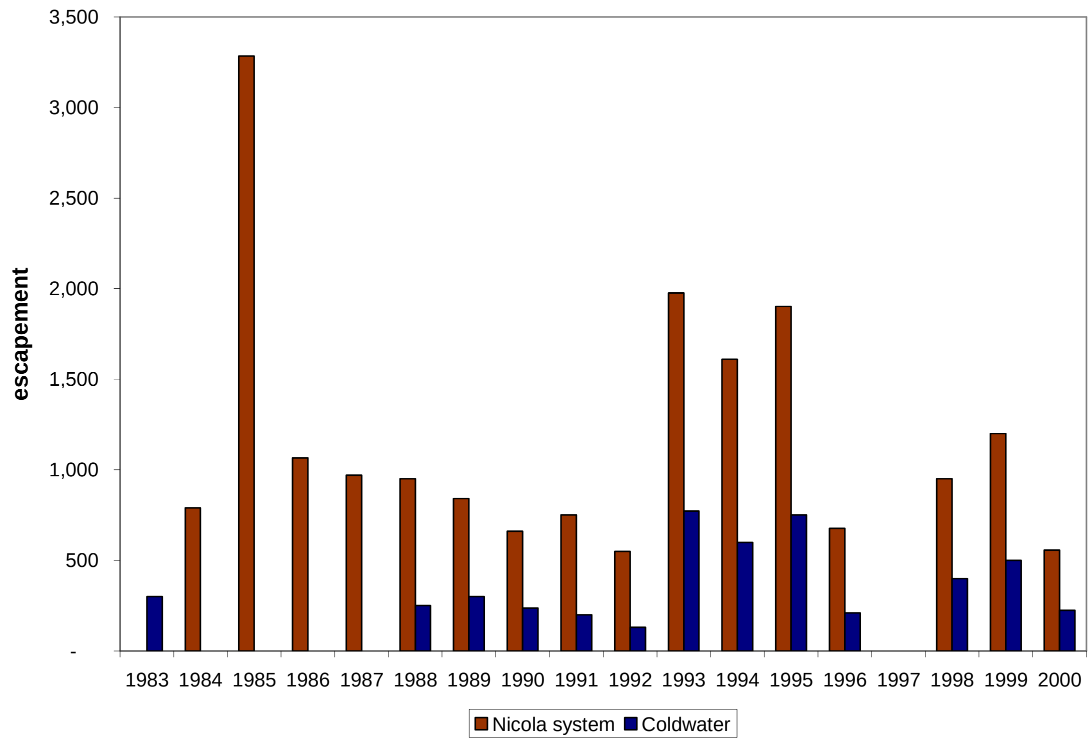

Figure 9. Estimates of steelhead escapement for the Nicola and Coldwater rivers, 1983-2000

Appendix

Table 1. Nicola River system coho escapement, exploitation rate, catch and total returns, 1975 -2004.

	escapement[1]	exploitation rate	catch[2]	total return[3]
1975	3,436	0.68	7,319	10,755
1976	2,940	0.68	6,261	9,201
1977	4,433	0.68	9,441	13,874
1978	4,112	0.68	8,758	12,870
1979	3,434	0.68	7,314	10,748
1980	1,975	0.68	4,206	6,181
1981	2,472	0.68	5,265	7,737
1982	2,915	0.68	6,209	9,125
1983	2,747	0.68	5,851	8,598
1984	4,936	0.68	10,514	15,450
1985	3,369	0.68	7,176	10,546
1986	3,390	0.66	6,498	9,889
1987	3,775	0.54	4,382	8,157
1988	4,035	0.71	9,973	14,008
1989	5,770	0.65	10,492	16,262
1990	7,582	0.74	21,199	28,781
1991	4,143	0.68	8,703	12,846
1992	6,834	0.81	30,038	36,872
1993	9,306	0.88	65,450	74,756
1994	9,450	0.43	7,226	16,676
1995	1,990	0.56	2,549	4,539
1996	598	0.83	3,028	3,626
1997	7,145	0.40	4,860	12,005
1998	1,994	0.07	151	2,145
1999	3,532	0.09	350	3,883
2000	3,483	0.04	128	3,611
2001	8,717	0.07	666	9,383
2002	11,455	0.07	875	12,331
2003	1,620	0.13	234	1,854
2004	2,818	0.13	410	3,228
mean	4,480	0.53	8,518	12,998
min	598	0.04	128	1,854
max	11,455	0.88	65,450	74,756

[1] Nicola River system escapement includes hatchery contributions

[2] catch = (exploitation rate * escapement) / (1-exploitation rate)

[3] total return = escapement + catch

Source data: Department of Fisheries and Oceans

Table 2. Nicola River, Coldwater River and Spius Creek Chinook harvest rates, 1982-2004.

	Nicola River	Coldwater River	Spius Creek
1982	37.7	38.9	38.9
1983	33.9	52.1	52.1
1984	14.7	29.9	30.0
1985	12.7	29.1	29.1
1986	16.0	23.8	23.8
1987	20.1	45.5	45.5
1988	19.2	53.1	53.1
1989	27.3	24.3	24.3
1990	23.4	57.3	57.5
1991	42.9	18.5	18.4
1992	30.7	36.4	36.5
1993	33.3	48.8	48.8
1994	29.7	43.6	43.6
1995	26.5	47.4	47.4
1996	23.6	40.1	40.1
1997	24.6	63.2	63.2
1998	41.7	59.8	59.8
1999	28.8	72.7	72.7
2000	35.8	65.8	65.8
2001	33.3	68.5	68.5
2002	17.1	47.4	47.4
2003	27.1	56.4	56.5
2004	38.6	47.8	47.8
mean	27.8	46.5	46.6
min	12.7	18.5	18.4
max	42.9	72.7	72.7

Source data: English, K.K., Bailey R. and D. Robichaud. 2007.

Assessment of Chinook salmon returns to the Fraser River watershed using run reconstruction techniques, 1982-04.

Prepared for: Fisheries and Oceans Canada Pacific Biological Station

Table 3. Nicola River mainstem and tributary coho escapement estimates, 1984 – 2004.

	lower Nicola mainstem	upper Nicola mainstem	Clapperton Ck	Guichon Ck
1984	18	17	7	58
1985	12	12	5	39
1986	15	14	6	47
1987	18	17	7	57
1988	22	22	9	72
1989	24	23	10	78
1990	24	23	10	78
1991	21	20	9	67
1992	24	23	10	77
1993	46	45	19	149
1994	32	31	13	103
1995	7	91	3	22
1996	2	7	1	7
1997	15	7	0	48
1998	3	29	0	0
1999	7	3	0	165
2000	6	0	0	0
2001	56	21	29	101
2002	55	23	30	111
2003	3	0	0	23
2004				71
mean	21	21	8	65
min	2	0	0	0
max	56	91	30	165

Source data: Department of Fisheries and Oceans

Table 4. Nicola River, Coldwater River and Spius Creek Chinook escapement data, 1982-2004.

	Nicola River	Coldwater River	Spius Creek
1982	3,750	800	200
1983	1,800	547	102
1984	3,700	598	256
1985	5,800	2,061	100
1986	6,500	2,100	350
1987	3,500	550	475
1988	2,490	220	150
1989	3,500	1,040	500
1990	2,300	350	100
1991	2,500	325	248
1992	4,028	1,332	250
1993	4,000	1,500	900
1994	7,970	275	150
1995	6,500	1,050	500
1996	16,400	1,500	500
1997	7,614	400	450
1998	1,211	300	300
1999	7,495	267	52
2000	8,808	497	668
2001	7,771	781	603
2002	11,628	1,012	1,012
2003	14,574	1,195	1,170
2004	7,850	1,023	1,866
mean	6,160	858	474
min	1,211	220	52
max	16,400	2,100	1,866

Source data: English, K.K., Bailey R. and D. Robichaud. 2007.

Assessment of Chinook salmon returns to the Fraser River watershed using run reconstruction techniques, 1982-04.

Prepared for: Fisheries and Oceans Canada Pacific Biological Station

Table 5. Nicola River and Coldwater River steelhead escapements, 1983-2000.

	Total Nicola	Coldwater River
1983	--	300
1984	790	--
1985	3,284	--
1986	1,066	--
1987	970	--
1988	950	250
1989	841	300
1990	660	237
1991	750	200
1992	549	130
1993	1,975	773
1994	1,609	600
1995	1,901	750
1996	676	209
1997	--	--
1998	950	400
1999	1,200	500
2000	556	225

Source data: Nelson, T., Bocking, R. and M. Gaboury. 2001.

Coldwater River watershed recovery plan. Prepared for Pacific Endowment Fund

Table 6. Nicola River, Spius Creek, and Coldwater River coho escapement estimates of wild only spawners and total spawners (including hatchery contributions), 1975-2004. Proportion of wild spawners to total population is included.

	Spius (hatch)[1]	Spius (no hatch)[2]	Spius wild	Coldw. (hatch)[1]	Coldw.(no hatch)[2]	Coldw. wild	Nicola all (hatch)[1]	Nicola all (no hatch)[2]	Nicola all wild
1975							3436	3436	100%
1976							2940	2940	100%
1977							4433	4433	100%
1978							4112	4112	100%
1979							3434	3434	100%
1980							1975	1975	100%
1981							2472	2472	100%
1982							2915	2915	100%
1983							2747	2747	100%
1984	1554	1554	100%	3282	3282	100%	4936	4936	100%
1985	1060	1060	100%	2240	2240	100%	3369	3369	100%
1986	558	558	100%	2750	2750	100%	3390	3390	100%
1987	698	698	100%	2979	2859	96%	3775	3656	97%
1988	186	0	0%	3723	1195	32%	4035	1321	33%
1989	981	316	32%	4654	2164	47%	5770	2615	45%
1990	1862	599	32%	5585	3155	57%	7582	3891	51%
1991	1234	448	36%	2792	1899	68%	4143	2464	59%
1992	1117	803	72%	5585	2050	37%	6834	2985	44%
1993	1601	1061	66%	7446	3373	45%	9306	4693	50%
1994	2757	887	32%	6516	2456	38%	9450	3522	37%
1995	600	193	32%	1267	1263	100%	1990	1579	79%
1996	187	60	32%	394	289	73%	598	366	61%
1997	5585	2374	43%	1489	1477	99%	7145	3921	55%
1998	1271	76	6%	691	627	91%	1994	736	37%
1999	1302	260	20%	2055	1093	53%	3532	1529	43%
2000	607	225	37%	2870	1946	68%	3483	2177	63%
2001	3910	880	23%	4600	3436	75%	8717	4523	52%
2002	5575	1076	19%	5661	2700	48%	11455	3995	35%
2003	400	161	40%	1194	515	43%	1620	701	43%
2004	1480	476	32%	1267	621	49%	2818	1168	41%
mean	1644	656	45%	3288	1971	67%	4480	2740	58%
min	186	0	0%	394	289	32%	598	366	33%
max	5585	2374	100%	7446	3436	100%	11455	4936	100%

[1] Escapement estimates include hatchery contributions (calculated as biostandard survival if no marks applied)

[2] Escapement estimates do not include hatchery contributions

Source data: Department of Fisheries and Oceans