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# 1999 Assessment of Thompson River/Upper Fraser River Coho Salmon

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## Abstract

We evaluated the effects of the 1998 fishing season on the status of upper Fraser/Thompson coho populations. Restrictions in Canadian fishery mortalities during 1998 lowered the overall exploitation rate to about 7% (~2% in Canada) although estimates are not precise. As a result of expanded efforts to estimate spawner escapements in 1998, it was determined that coho in the upper Fraser/Thompson were more abundant than previously was thought. However, while there was a slight improvement in escapements in 1998 over 1997, for much of the aggregate, returns in 1998 were less than for the brood year. Coho spawners were not seen in 27% of streams that had coho spawners observed in them 3 generations earlier. We conclude that the status of South and North Thompson coho populations remains poor. The productivity of this portion of the aggregate has declined in the last 10 years to the point where the population is only barely able to sustain itself (even in itself in the absence of fishing). Our understanding of the status of lower Thompson and non-Thompson/upper Fraser coho is weak.

Major recommendations from this paper are:

1. Since some coho populations within the North and South Thompson drainages remain at risk of extinction, fishing mortality should continue to be minimised to conserve these populations.
2. We relied upon the use of DNA technology to estimate numbers of Thompson coho in marine fisheries. To reduce our uncertainty around estimates of fishery mortalities, we recommend that the use of DNA to identify stocks of concern in fisheries be critically reviewed.
3. Freshwater habitat degradation has occurred throughout the Thompson/upper Fraser. The degree of habitat change needs to be quantified for coho bearing streams and the relationship between these changes and freshwater survival examined in detail.
4. Expanded escapement surveys in 1998 relative to previous years identified significant populations of coho that we had not been aware of. Some of these populations were in non-Thompson Fraser tributaries. Because it is not yet possible to reliably separate these fish in the marine environment from Thompson fish, estimates of Thompson fishery mortalities requires knowledge of the numbers of coho in non-Thompson as well as in Thompson drainages. We recommend that expanded escapement surveys be maintained.
5. Our review of escapement survey methodology revealed numerous inconsistencies among systems and years. Methodologies need to become more standardized, and commentaries on methodologies should be available in order to reliably use escapement data in salmon stock assessments.

**Résumé**

Nous avons évalué les effets de la saison de pêche de 1998 sur le statut des populations de saumon coho du cours supérieur du fleuve Fraser et de la rivière Thompson. Les restrictions imposées à la mortalité par pêche canadienne en 1998 ont réduit le taux global d'exploitation à environ 7 % (~2 % au Canada), bien que les estimations manquent de précision. Grâce aux efforts accrus en matière d'estimation des échappées de géniteurs en 1998, on a pu établir que le coho était plus abondant dans le cours supérieur du Fraser et la Thompson qu'on ne l'avait cru dans le passé. Toutefois, bien qu'on ait constaté une légère amélioration de l'échappée de 1998 par rapport à celle de 1997, pour une bonne partie des groupes de stocks, la remonté de 1998 a été inférieure à celle de l'année d'éclosion. Les coho géniteurs étaient absent de 27 % des cours d'eau où ils avaient été observés trois générations plus tôt. Nous en concluons que le statut des populations de coho de la North et de la South Thompson demeure précaire. La productivité de cette partie du groupe de stocks a diminué au cours des dix dernières années, à tel point que la population est a peine viable (même en l'absence de pêche). Notre compréhension du statut du saumon coho dans le cours inférieur de la Thompson et ailleurs dans le cours supérieur du Fraser est inadéquate.

Voici une liste des principales recommandations formulées dans ce document :

1. Étant donné que certaines populations de coho des bassins versants de la North et de la South Thompson sont toujours menacées d'extinction, on devrait continuer de minimiser la mortalité par pêche afin de les préserver.
2. Nous nous somme appuyés sur des techniques d'analyse d'ADN pour estimer le nombre de coho de la Thompson qui se trouvent en mer. Pour réduire l'incertitude liée à l'estimation de la mortalité par pêche, nous recommandons d'effectuer un examen critique des techniques d'analyse d'ADN utilisées pour l'identification des stocks.
3. Il y a eu une dégradation de l'habitat d'eau douce dans toute la Thompson et le cours supérieur du Fraser. Il faudrait quantifier le changement survenu dans l'habitat des cours d'eau fréquentés par le coho et étudier en détails le rapport entre ces changements et la survie du coho en eau douce.
4. L'expansion en 1998 des relevés des échappées par rapport aux années précédentes a permis de déceler des populations appréciables de coho dont l'existence était demeurée inconnue jusque là. Certaines ont été repérées dans des affluents du Fraser autres que la Thompson. Parce qu'il nous est impossible présentement de distinguer de façon fiable ces stocks de ceux de la rivière Thompson en milieu marin, il sera donc nécessaire, pour les estimations de la mortalité par pêche des poissons de la Thompson nécessitant la connaissance à la fois du nombre de saumons coho du bassin versant de la Thompson et celui des autres bassins versants. Nous recommandons donc de poursuivre le relevé élargi des échappées.

L'examen de la méthodologie employée pour le relevé des échappées a fait ressortir de nombreuses incohérences entre les systèmes et les années. Il y aurait lieu de standardiser les méthodes et de diffuser les commentaires sur la méthodologie afin de mieux utiliser les données sur les échappées pour estimer l'état des stocks de saumon.

# 1 Introduction

At the spring 1998 meeting of the PSARC Salmon Subcommittee, the status of Upper Fraser/Thompson[1] coho was reviewed (Irvine et al. 1999), and a risk assessment undertaken (Bradford 1998). The PSARC Steering Committee accepted the findings presented in these two Working Papers. They advised that Thompson River coho were extremely depressed, would continue to decline even in the absence of fishing mortality under current marine survival conditions, and that some populations were at high risk of biological extinction (Stocker and Peacock 1998). On 21 May 1998, David Anderson, Minister of Fisheries and Oceans Canada announced that “Despite significant conservation measures implemented by my department over the last three years, scientific evidence demonstrates conclusively that wild coho stocks are declining and some are at extreme risk”. Minister Anderson proclaimed a conservation objective of achieving zero fishing mortality for critical Thompson (and upper Skeena) coho stocks.

The objectives of this paper are to provide an overview of fishery regulatory changes implemented in 1998 to conserve Thompson coho, to critically examine fishery and spawner escapement data to determine the effectiveness of these regulatory changes, and to update the risk assessment undertaken in 1998.

## *1.1 Overview of Fishery Changes and Monitoring Programmes Implemented in 1998*

Regulatory changes made to salmon fisheries in 1998 to conserve threatened coho populations were probably the most significant ever implemented within the Pacific Region of Canada. No directed fisheries on wild stocks of 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). The coast of BC was divided into a series of Red and Yellow zones (Figure 1.1). 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. Prevalence was determined by the historical frequency of capture of coho of known Thompson origin determined from an analysis of coded-wire tag data from the Mark Recovery Program (MRP) database.

During 1998, only a small number of restricted experimental and test fisheries were allowed in Red zones, and these were closely monitored. In Yellow zones, the only salmon fisheries permitted were directed on salmon species other than coho. To reduce the by-catch and mortality of coho in Yellow zones, a selective fishing strategy was implemented for all commercial gear types. Logbooks were mandatory and an onboard observer program was instituted for all southern licence areas. Recreational fisheries were monitored more intensively than in previous years.

[1] The upper Fraser/Thompson region consists of four major subregions: (1) South Thompson - mainstem South Thompson River and tributaries upstream from the confluence of the North Thompson River; (2) North Thompson - mainstem North Thompson River and tributaries of it; (3) Lower Thompson - mainstem Thompson and tributaries downstream from the confluence of the North Thompson including the Nicola watershed; and (4) Upper Fraser/non-Thompson – Fraser River and tributaries upstream of the Fraser Canyon excluding the Thompson.

# 2 Data Sources

Since many of the data sources used in this paper are not described elsewhere, a detailed description of methods used to gather this information is provided in Appendix 1. A brief description follows.

Salmon fisheries in BC were closely monitored during 1998 and tissue samples for DNA analysis were taken from coho from many of the fisheries. Stock compositions were estimated post-season based on analysis of these samples (Appendix 2), as well as from historical information on catches of coded-wire tagged fish (Appendix 1). The ratio of the number of fish escaping to the Thompson and its tributaries to the number of fish escaping to the upper Fraser and Thompson was used to scale DNA stock composition estimates of upper Fraser/Thompson coho. There is greater uncertainty in our estimates of Thompson mortalities occurring in northern and central BC than in other areas of the province.

In 1998, a sport fishery occurred in Area 5 Puget Sound (Washington State), and since there were concerns about potential catches of upper Fraser coho, this fishery was evaluated by Washington Fish and Wildlife (Hagen-Breaux 1999). Tissue samples were taken for DNA analysis to estimate the proportion of the catch made up by upper Fraser coho (Appendix 2). Thompson coho catches in other US fisheries were estimated based on the ratio of cwt's reported in these fisheries and the numbers of cwt's reported in the Area 5 recreational fishery. These estimates have a high degree of uncertainty.

Coho spawning escapement estimates prior to 1998 are provided in Irvine et al. (1999). More effort was expended to estimate fish numbers during 1998 than in previous years. First Nations, contract and DFO personnel using a variety of techniques estimated escapements for 71 streams in the Thompson basin and Upper Fraser. In some instances, counts were obtained through a fence (with or without mark-recapture), while drifting a stream in a vessel or by snorkelling, on foot and from a helicopter. Wherever multiple visual surveys were completed (and fish were observed on at least three surveys), Area-Under-the-Curve (AUC) methods were used to derive escapement estimates. Regional DFO offices were visited and detailed escapement estimation histories were compiled for 1990-1998 (Appendix 3). We report both our 'best' estimates for the 1998 escapements, and estimates that we feel would have been generated by methods used in the past ("trend" estimates), to allow comparisons with previous years.

# 3 Results

## *3.1 Thompson Coho Fishery Mortalities During 1998*

### 3.1.1 Southern BC

Using our estimates of stock composition developed pre-season (generally derived using cwt data as described in Appendix 1), we calculated that ~211 Thompson-origin coho were killed in fisheries in southern BC during 1998 (Table 3.1). Final estimates developed post-season resulted in an estimate of ~205 mortalities in the same fisheries.

Differences in mortality estimates were found between the pre- and post-season methods for some of the fisheries (Table 3.1). For example, the pre-season method predicted a mortality of 36 Thompson coho in Yellow Zone recreational fisheries while our final estimate, using a combination of cwt and DNA data, determined that 96 Thompson fish had been killed. Most of these Yellow Zone coho encounters occurred along the West Coast of Vancouver Island. As cwt'ed Thompson coho had almost never been caught in fisheries near-shore, we anticipated pre-season that the catch of Thompson fish in this near-shore fishery would be almost zero. However, DNA results (Appendix 2) indicated that about 1% of the coho sampled in summer recreational and troll fisheries off the West Coast of Vancouver Island were of Thompson origin. As a consequence, our estimate of Thompson mortalities using post-season stock composition estimates was higher.

There was a large difference between pre- and post-season approaches for numbers estimated for First Nation's fisheries in the Fraser River. The pre-season stock composition estimate included the possibility of coho being caught during August when Thompson fish might make up a significant portion of the catch. As it turned out, all the First Nations coho catch occurred after late October when DNA evidence demonstrated that almost all coho caught were of lower Fraser origin. Therefore, the discrepancy between the estimates is understandable.

DNA evidence indicated a considerably greater catch of Thompson coho in experimental (including selective) fisheries in the Red Zone. We had relatively little information pre-season to forecast Thompson proportions, so this discrepancy is not surprising.

### 3.1.2 Washington, Northern BC and Alaska

We estimated that ~294 Thompson coho mortalities occurred in the Area 5 recreational fishery in Puget Sound and ~105 in northern and central B.C. fisheries (Table 3.2). A crude estimate of the number of Thompson coho killed in US fisheries outside of Area 5 (including Alaska) was ~660 (Appendix 1 – Section 12.4).

## *3.2 1998 Spawner Escapement Estimates*

A total of 71 streams in the Thompson and mid-Fraser regions were surveyed for coho escapements, yielding a total estimated return to the study area of 27,111 coho. Of these, 688 fish were taken for broodstock. Based on this, we estimate that 26,423 coho were available to spawn in surveyed Thompson and upper-Fraser/non Thompson tributaries in 1998.

Spawning escapements were estimated as 8,997 adult coho to the North Thompson, 4,675 to the South Thompson, 2,233 to the Lower Thompson, and 10,518 to upper Fraser/non-Thompson tributaries. These estimates are biased low because not all streams containing coho were surveyed.

The 1998 escapement program was considerably enhanced in comparison to programs in previous years, both in terms of the intensity of survey effort on many streams, and in terms of the coverage of the surveys. Although the number of coho that were reported in the Fraser system above Hells Gate was substantial, many of these fish would not have been counted in previous years. Significant populations of coho were found in the Nahatlatch River (estimate

7,800) and Fennel Creek (estimate 2,614). More coho than expected were observed at McKinley Creek (790) although survey effort in 1998 was higher than most previous years, but also and Eagle River (2,630) and Dunn Creek (962) where effort was not greatly increased. In contrast, surveys on 16 streams still failed to detect any coho.

### 3.2.1 Complete counts and fences associated with rigorous mark-recapture

Fence counts and fence mark-recapture estimates of coho escapements to the Thompson and mid-Fraser region are summarised in Table 3.3 and detailed in Appendix 3. Fence counts (including estimates of the numbers spawning below fences) ranged from 94 at the Salmon River (Salmon Arm) to 2,630 at the Eagle River. Counts at the Eagle and Salmon rivers, and Spius Creek are considered complete; some spawning occurred below the fences, but none of these fences were breached or topped during the 1998 escapement period. Other notable returns to fenced systems in 1998 included 790 to McKinley Creek (a Horsefly River tributary).

Fence/mark-recapture escapement estimates ranged from 195 at Louis Creek to 691 at Coldwater River (591 fish above the fence and an estimated 100 fish spawning below the fence) (Table 3.3).

### 3.2.2 Fences associated with crude mark-recapture

A mark-recapture technique using operculum punches was used at five systems to expand fence counts, where fences were known to have been breached or topped. Escapement estimates derived via this technique ranged from 39 at Danforth Creek to 962 at Dunn Creek (Table 3.3)

### 3.2.3 Visual Surveys

Escapements to 55 streams were estimated using visual survey based methods in 1998. Of those, AUC estimates were generated for 13 systems and on the remaining 42 streams, the peak count was multiplied by an expansion factor. AUC based estimates ranged from 20 fish at Harris and Ireland creeks to 7200 fish at the Nahatlatch River (Table 3.4 and Appendix 3). Estimates derived via peak counts ranged from zero (16 systems) to 1055 for Portage Creek (Appendix 3).

### 3.2.4 Escapement Trend Analysis

Irvine et al. (1999) filtered the coho salmon escapement database for Thompson basin stocks to remove the confounding effects of inconsistent monitoring and enhancement. They presented trend data for 16 South Thompson streams (previously 19 but the Bessette Creek system is really one drainage system = Bessette Creek, Duteau Creek, Harris Creek and Creighton Creek) and 10 North Thompson streams. We added the 1998 “trend” data (i.e., based on methods similar to historical) to these time series (Figures 3.1 and 3.2).

Escapements to the South Thompson aggregate increased annually from 1996 to 1998, however, the 1998 aggregate escapement is still less than that of 1995, the parental brood year (Figure 3.1). A similar pattern exists in the North Thompson aggregate (Figure 3.2).

Comparisons of the 1995 and 1998 trend escapements to enhanced (or previously enhanced) streams yield mixed results. Certain streams such as the Salmon River and Deadman River apparently experienced marked brood over brood declines (689 to 41, and 573 to 131, respectively), whereas others such as the Eagle River, Dunn Creek and Lemieux Creek experienced significant growth (800 to 2342; 280 to 933; 300 to 586, respectively).

### *3.3 Biases in escapement estimates*

Trend escapement estimates for the 1998 escapements were compared with the estimates generated from the increased effort in 1998 (summarised by region in Table 3.5). The difference between the trend and best (i.e. estimate we feel approximates the true number of spawners) estimates for individual streams varied considerably; the range was between 0 and 100%.

In total, trend estimates of escapements to the North Thompson streams were only 37% of the values generated by the full escapement program. Similarly, trend estimates for non-Thompson Fraser River tributaries represent only 20% of the estimated escapements. Conversely, trend estimates for the South Thompson and Lower Thompson stocks were much closer to actual values (72% and 98% respectively; Table 3.5).

Previous escapements to some South Thompson streams, and particularly those in the Salmon Arm sub-district, may be over-estimated. There are many examples where Stream Inspection Logs show no fish being observed for a particular creek, yet annual escapement reports (i.e. BC16's) show fish present (e.g. Bessette Creek 1990, 50 fish; Creighton Creek 1990-1991, 25 fish; Hunakwa Creek 1995, 60 fish; and lower Shuswap 1990, 200 fish). In Harris Creek 1995, 1 fish was counted, but the reported BC16 estimate was 75 (Appendix 3).

In contrast, previous North Thompson tributary escapements may be under-estimated. Examples exist for some North Thompson tributaries where Stream Inspection Logs show more adult coho than do the BC16 reports. An escapement of 85 was reported to Barriere River in 1995, yet 86 were observed on a "spot check", and the reported escapement to Avola Creek in 1995 was 40 fish, yet 50 were recorded on one walk (Appendix 3).

### *3.4 Exploitation Rate Estimates*

A very crude estimate of fishery exploitation in 1998 can be obtained by summing the estimated catches of Thompson coho and dividing this by the sum of this number and the estimated numbers of fish returning to the Thompson. The total number of coho estimated to return was ~16,593 (15,905 spawners plus 688 fish taken for brood stock) and the total catch was 1,264 (205 [S. B.C.], 105 [N. B.C.], 294 [Wa Area 5], and 660 [rest of USA]). The total fishery exploitation rate therefore was ~7 % (i.e. 1,264/(1,264+16,593)). Within Canada, the estimated exploitation was ~2 % and the total US exploitation was ~5 %. We acknowledge that there are unaccounted for mortalities of Thompson coho, particularly in certain B.C. First Nation's fisheries. This would result in exploitation estimates being biased low, however under-reported escapements may in part balance this.

## 4 Update on Risk Assessment

In this section we update the risk assessment made in 1998 (Bradford 1998). Except where noted, we used the North and South Thompson aggregates detailed in Section 3.2.4, and considered the Eagle and Salmon Rivers separately (as did Bradford 1998). For consistency we used the "trend" escapement estimates (see Section 3.2.4) for 1998.

Last year Bradford (1998) noted that:

"..total recruitment in 1997 was still only 43% of the parent escapement. Over all 4 Thompson stocks the summed brood year escapement for 1998 returns [i.e. 1995 spawners] are 12% less than for the 1997 returns. The marine survival forecast is for similar or perhaps worse conditions than faced the 1997 returns. Therefore the most likely scenario is that recruitment of Thompson River coho in 1998 will be less than we observed in 1997. *However, there is considerable, and as yet unquantified, uncertainty in this forecast. Returns could be much better or worse than this."*

Total recruitment in 1998 exceeded the estimated 1995 parent escapement by 23%, although nearly all of the increase was due to the strong return to the Eagle River. Without the Eagle, recruitment to the sum of the Salmon, and the North and South Thompson aggregates was only 72% of the brood escapement. The 1998 escapement to the four index series was 80% more than the 1997 escapement, however, without the Eagle, total returns were about the same as last year.

To examine changes in returns per parent spawner (R/S), we plotted the full time series of *r*, (calculated as *ln*(R/S)), in Figure 4.1. Over the entire time series, the productivity of the 4 stock groups appears to fluctuate fairly coherently over time, and there has been considerable year-to-year variation. The South Thompson streams have fluctuated around zero for the last 5 years. There was a slight overall increase in the R/S in 1998 (1995 brood) over 1997 (1994 brood), which could be the result of a region-wide increase in freshwater survival, a higher than expected marine survival rate, the removal of unreported fishing mortality through the large scale fishery closures, or simply chance caused by estimation errors. It is clearly premature to suggest that the somewhat mixed, but slightly improved, return rates for 1998 indicate any sort of future trend (in any direction).

While there was a slight increase in the overall escapement in 1998, spawning in the North and South Thompson drainages follows the pattern of 1997, of being concentrated in relatively few streams. Bradford (1998) noted that 32% of streams that had fish observed in them in 1988 had reached 'none-observed' status in 1997 (i.e. 3 generations earlier); this fraction was largely unchanged (27%) for the 1998 spawning relative to the 1989 distribution. There is a great deal of uncertainty about the precision of these proportions, as reporting methods for the data have varied considerably (see Appendix 3), however, as noted earlier, even with enhanced effort to find fish in 1998, many streams were apparently devoid of spawners.

In summary, the status of the stock has changed little since 1997. Conditions do not appear to have noticeably worsened in 1998, nor has there been any overall improvement in abundance. The results of the enhanced survey effort in 1998 suggest that the overall aggregates are larger than previously thought, and this means the risk of large-scale (watershed-level) extinction is probably lower. However, since we do not understand the meta-populational dynamics of populations of the small tributaries, it is still prudent to consider streams that have very few fish in them as continuing to be at risk of local extinctions.

Holtby et al. (1999) forecast, based on time series models, that the total abundance (recruitment) of Thompson coho in 1999 will be about the same as in 1998. Marine survivals are expected to remain low. They note that spawning populations were lower in 1996 than in 1995. Bradford (1998) and Irvine et al. (1999) also noted that the 1996 and 1997 spawning populations were small, and there was concern that the reproductive potential of these broods may be lowered because of male-biased sex ratios and reductions in fecundity. Thus, we reiterate Bradford's conclusion that "unless there is a reversal in ocean conditions, the risks and conservation concerns will be even higher in 1999 and 2000 (i.e. than in 1998)."

## 5 Discussion

The escapement estimation program instituted in 1998 was an attempt to provide more reliable coho escapement estimates than previously from a large cross-section of the streams in the Interior. Estimates of escapements in 1998 were greater than expected, however, this was mainly due to increased survey effort finding fish that otherwise would not have been counted. Increased survey effort on the Nahatlatch River and Fennel Creek added over 10,000 coho to the estimated upper Fraser/Thompson total that prior to 1998, would not have been detected.

There are many areas where coho have been reported in the Interior that we have, as yet, been unable to survey. Working in co-operation with local First Nations, we would like to expand coverage of surveys in the Quesnel / Williams Lake areas to better understand the status of populations in the Chilcotin, Blackwater, and Quesnel river drainages.

The return of relatively large numbers of coho to streams above the partial blockage of the North Thompson at little Hell's Gate indicates the flexibility of these fish in taking advantage of habitat as it becomes available. There were no spawners observed in the Albreda or Blue rivers in 1995, yet over 500 were estimated in 1998 (and this estimate is probably biased low) presumably originating from fish that spawned in a lower tributary. It is this flexibility in the meta-population structure that will hopefully permit some of the now desolate streams to become re-utilised in the future assuming the overall abundance increases.

We documented considerable inconsistency in escapement surveying and estimate generation practices since 1990. There are many reasons for this including funding cutbacks and changes in roles and responsibilities within Fisheries and Oceans Canada. In general, escapements to the streams in the Clearwater sub-district appear to have been under-estimated. In contrast, escapements to many South Thompson streams may have been over-estimated. Our results suggest that estimates of escapement to the North Thompson and Fraser since 1990 have been biased low, while those to the South Thompson and Lower Thompson streams have been more accurate. The reason the 1998 estimates in the Lower Thompson were accurate is that they were derived chiefly from fence and fishway counts – many historical estimates in this region may be biased low.

There is a great deal of uncertainty around our estimates of fishery mortalities. There are relatively few data to support the gear mortality rates assumed. The fact that stock composition forecasts using information chiefly from the historical distribution of cwt's (preseason approach in Appendix 1) generally yielded similar total mortality estimates to DNA sample generated estimates is reassuring. Nevertheless, we have little confidence in the ability of either method to provide precise estimates of catches of Thompson coho for many individual fisheries. There is clearly a need for additional tissue sampling of fish from many fisheries. Given the increasing importance of using DNA to identify stocks of concern in fisheries, we recommend the approach be critically reviewed. The completeness of samples constituting the baseline (including non-Thompson/upper Fraser stocks), the ability to estimate numbers of rare stocks of fish in a mixture, the validity of precision estimates generated, and the importance of randomization in sampling need to be considered.

It is extremely difficult to estimate catches of rare animals in a fishery. Simulations indicate that if the stock of interest represents only 1% of a mixture and we wish to estimate numbers with a standard deviation of 1% or less, we need a sample size of at least 200 (J. Candy, PBS, pers. comm.). Often we had fewer than 200 animals in our samples. With small sample sizes, the effect will generally be to overestimate the numbers of rare animals since while it is not possible to estimate fewer than zero animals, it is possible to over-estimate. This effect may be reduced somewhat in the future when we are able to incorporate additional loci into the analysis (T. Beacham, PBS, pers. comm.).

Some of our estimates of Thompson coho mortality are extremely imprecise. The mortality estimate that is probably the least precise is also the highest. Our estimate of USA catches of Thompson fish outside Puget Sound Area 5 (660 fish) was developed using a simple ratio estimator and was based on only 18 Thompson fish observed with cwt's. In contrast, we are more confident in our estimates of the numbers of Thompson fish killed in the Puget Sound Area 5 sport fishery and the various fisheries in southern BC. We also have concerns about the ability of the DNA approach to generate precise estimates of Thompson coho in fisheries in northern and central BC.

Irvine et al. (1999) concluded that the status of coho populations in the South and North Thompson was less healthy than that of populations in the lower Thompson and upper Fraser, although data for the latter two areas were less reliable. We have no reason to alter this conclusion. In 1998, we estimate that almost half (~48 %; Table 3.5) of the coho returning to the upper Fraser and Thompson watersheds spawned in the Lower Thompson and in non-Thompson tributaries. Our inability to separate marine caught coho amongst the various upper Fraser/Thompson groupings restricts our ability to assess fishery impacts on these populations.

Our estimate of fishery exploitation for Thompson coho was ~7 % and although this estimate is probably low, it is nevertheless much lower than estimates for previous years. The extreme management measures undertaken in 1998 to conserve coho appear to have stemmed the decline for many populations. While some population sizes may be larger than previously thought, we are however concerned that those streams with very few fish in them continue to be at risk of local extinction. The forecast for Thompson coho is for continued poor returns (Holtby et al. 1999). Low parent spawner abundance, and poor prospects for the return/spawner rate mean that no dramatic improvements to the overall abundance of Thompson River coho are anticipated for the next 2 years. If we wish to conserve these populations, we must continue to maintain minimum levels of fishing mortality.

There remain a number of information needs which would improve our ability to understand the response of these populations to conservation efforts. A partial list includes a better understanding of: (1) the freshwater life history and critical habitat use, (2) habitat-based escapement or conservation goals, (3) the metapopulational dynamics of tributary and mainstem populations and (4) the role of habitat alteration on population declines and recoveries.

## 6 Conclusions

1. We estimate that fishing regulations in 1998 resulted in approximately a 7 % exploitation rate on Thompson watershed coho salmon (~2 % in Canada).

2. As a result of increased survey effort, we found that the upper Fraser/Thompson stock aggregate is much larger than was previously thought, as is the proportion made up by non-Thompson/upper Fraser fish.

3. Based on consistent methods of escapement estimation there was only a slight improvement in escapements in 1998 over 1997, and the status for South and North Thompson coho populations remains poor. Poor spawning escapements in 1996 imply that returns in 1999 will also be low.

4. The productivity of the South and North Thompson aggregates has declined in the last 10 years to the point where many populations have intrinsic rates of growth near zero (i.e. are only barely able to sustain themselves in the absence of fishing).

## 7 Recommendations

1. Since some coho populations within the North and South Thompson drainages remain at risk of extinction, fishing mortality should continue to be minimised to conserve these populations.

2. We relied upon the use of DNA technology to estimate numbers of Thompson coho in marine fisheries. To reduce our uncertainty around estimates of fishery mortalities, we recommend that the use of DNA to identify stocks of concern in fisheries be critically reviewed.

3. Freshwater habitat degradation has occurred throughout the Thompson/upper Fraser. The degree of habitat change needs to be quantified for coho bearing streams and the relationship between these changes and freshwater survival examined in detail.

4. Expanded escapement surveys in 1998 relative to previous years identified significant populations of coho that we had not been aware of. Some of these populations were in non-Thompson Fraser tributaries. Because it is not yet possible to reliably separate these fish in the marine environment from Thompson fish, estimates of Thompson fishery mortalities requires knowledge of the numbers of coho in non-Thompson as well as in Thompson drainages. We recommend that expanded escapement surveys be maintained.

5. Our review of escapement survey methodology revealed numerous inconsistencies among systems and years. Methodologies need to become more standardized, and commentaries on methodologies should be available in order to reliably use escapement data in salmon stock assessments.

## 8 Acknowledgements

We acknowledge the contributions of technical staffs of Shuswap Nation Fisheries Commission, Nicola Watershed Stewardship and Fisheries Authority, the Okanagan Nation, and Fishery Officers from the Salmon Arm, Clearwater and Lillooet offices in undertaking field studies to estimate coho escapements. In 1998, D. Michie and D. Allen co-ordinated field assessment programs, and visually surveyed coho returns to many streams. They also reconstructed the escapement histories with assistance of staff in the field offices. The genetics lab at PBS analysed fishery samples in a timely fashion, and Terry Beacham and John Candy provided stock composition estimates. Brenda Adkins (DFO, PBS) provided preliminary information from the DFO Catch and MRP databases and Laurie Peterson (Washington Dep. Fish & Wildlife, Olympia Washington) kindly provided preliminary information on the Puget Sound sport fishery. Review comments by T. Gjernes and K. Wilson were appreciated.

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**Table 3.1** Coho encounters and estimated mortalities in southern BC during 1998.[1]

| | Total Coho Encounters | Estimated Coho Mortalities | Prelim. Est. of[2] Coho Thompson Mortalities | Final Est. of Coho Thompson Mortalities |
|---|---|---|---|---|
| **YELLOW ZONE FISHERIES** | | | | |
| **Commercial** | 21268 | 8887 | 41 | 52 |
| **Recreational** | 88136 | 8814 | 36 | 96 |
| **First Nations (Fraser R.)** | 191 | 115 | 40 | 0 |
| **Test Fisheries** | 3657 | 1011 | 6 | 8 |
| **Experimental** | 19107 | 2047 | 0 | 0 |
| **Yellow Total** | 132359 | 20874 | 123 | 157 |
| **RED ZONE FISHERIES** | | | | |
| **Test Fisheries** | 3253 | 934 | 50 | 30 |
| **Experimental** | 12913 | 1223 | 38 | 17 |
| **Red Total** | 16166 | 2157 | 88 | 48 |
| **Yellow + Red Total** | 148525 | 23030 | 211 | 205 |

[1] Estimates biased low because of incomplete First Nations catch estimates.
[2] Calculated using pre-1998 season estimates of stock compositions

**Table 3.2** Estimates of Thompson Coho Mortalities during 1998 In Washington State (Puget Sd Area 5 Sport) and Northern and Central British Columbia.

| | Area | Gear Type | Coho Encounters | Coho Mortalities | Percent Thompson | Thompson Mortalities |
|---|---|---|---|---|---|---|
| Washington | | | | | | |
| | 5-period 1 | Recreational | 10844 | 10844 | 1.3 | 137 |
| | 5-period 2 | Recreational | 9601 | 9601 | 0.9 | 87 |
| | 5-period 3 | Recreational | 3165 | 3165 | 2.2 | 70 |
| Total Puget Sd Area 5 Sport | | | 23610 | 23610 | | 294 |
| North + Central British Columbia | | | | | | |
| | 1 | Recreational | 131000 | 13100 | 0.3 | 33 |
| | 2E | Recreational | 200 | 20 | 0.1 | 0 |
| | 2W | Recreational | 1500 | 150 | 0.3 | 0 |
| | 3&4 | Recreational | 5268 | 527 | 0.0 | 0 |
| | 6 | Recreational | 6240 | 624 | 0.0 | 0 |
| | 7 | Recreational | 4782 | 478 | 0.0 | 0 |
| | 8 | Recreational | 6000 | 600 | 0.0 | 0 |
| | 2W | Troll | 61479 | 7439 | 0.3 | 19 |
| | 2W | Seine | 38 | 10 | 0.3 | 0 |
| | 2E | Gill Net | 916 | 550 | 0.1 | 0 |
| | 2E | Seine | 2000 | 500 | 0.1 | 0 |
| | 3 | Gill Net | 13543 | 8126 | 0.0 | 0 |
| | 3 | Seine | 10665 | 2666 | 0.2 | 5 |
| | 6 | Gill Net | 4367 | 2620 | 0.0 | 0 |
| | 6 | Seine | 34762 | 8691 | 0.5 | 47 |
| | 7 | Gill Net | 711 | 427 | 0.0 | 0 |
| | 7 | Seine | 16071 | 4018 | 0.0 | 0 |
| | 8 | Gill Net | 5683 | 3410 | 0.0 | 0 |
| | 8 | Seine | 54400 | 13600 | 0.0 | 0 |
| Total North + Central British Columbia | | | 359625 | 67554 | | 105 |
| Total Puget Sd Area 5 Sport plus BC | | | 383235 | 91164 | | 399 |

**Table 3.3**. Escapements to fenced coho systems in the Thompson and Mid-Fraser, as determined by fence counts (f, * indicates topped or breached), fishways (fw), fence and rigorous mark-recapture (fmr),), fence and rigorous mark-recapture plus estimate of below fence spawners (fmr-bf), fence and operculum mark-recapture (fop), and fence counts plus estimates of below fence spawners (fbf)).

| System | Location | Study Type | Spawning Escapement | Total Return (inc brood / morts) |
|---|---|---|---|---|
| Bessette (whole system) | S. Thompson | fop | 167 | 167 |
| Danforth Creek | S. Thompson | fop | 39 | 39 |
| Duteau (trib. to Bessette) | S. Thompson | f* | 41 | 59 |
| Eagle | S. Thompson | fbf | 2512 | 2630 |
| Huihill Creek | S. Thompson | f | 1 | 1 |
| Momich River | S. Thompson | fop | 115 | 115 |
| Salmon River | S. Thompson | fbf | 80 | 94 |
| Bonaparte River | Lwr. Thompson | fw | 67 | 67 |
| Coldwater River | Lwr. Thompson | fmr-bf | 691 | 781 |
| Deadman River | Lwr. Thompson | f | 131 | 171 |
| Spius Creek | Lwr. Thompson | f | 1271 | 1535 |
| Upper Nicola River | Lwr. Thompson | f | 29 | 29 |
| Dunn Creek | N. Thompson | fop | 962 | 1010 |
| Lemieux Creek | N. Thompson | fmr | 605 | 652 |
| Louis Creek | N. Thompson | fmr | 195 | 226 |
| Mann Creek | N. Thompson | fop | 245 | 263 |
| McKinley Creek | Mid-Fraser | fbf | 790 | 790 |
| Total | | | 7941 | 8629 |

**Table 3.4** Thompson and Upper Fraser 1998 coho escapement estimates, derived using AUC

| Stream | Where | Survey method | Estimate |
|---|---|---|---|
| Avola Creek | N. Thompson | Walk | 88 |
| Blue River | Upper N. Thompson | float/heli | 494 |
| Bridge River | Mid-Fraser | Walk | 548 |
| Cayoosh Creek | Mid-Fraser | Walk | 114 |
| Creighton Creek (Bessette trib.) | S. Thompson | Walk | 33 |
| E. Barriere River | N. Thompson | Walk | 99 |
| Fennel Creek | N. Thompson | Walk | 2,614 |
| Harris Creek (Bessette trib.) | S. Thompson | Walk | 20 |
| Ireland Creek | S. Thompson | Walk | 20 |
| Lion Creek | N. Thompson | Walk | 2,299 |
| Nahatlatch River | Mid-Fraser | Float | 7,800 |
| Raft River | N. Thompson | walk/heli | 603 |
| Salmon River | S. Thompson | walk (below fence only) | 39 |

**Table 3.5** Summary of differences between 1998 escapements to Upper Fraser and Thompson coho streams and 1998 "trend escapement estimates" to those streams

| | North Thompson | South Thompson | Lower Thompson | Upper Fraser |
|---|---|---|---|---|
| Estimate | 8997 | 4675 | 2233 | 10518 |
| Trend Estimate | 3287 | 3344 | 2186 | 2054 |
| No of streams in trend estimate | 20 | 20 | 5 | 6 |
| % of estimates(overall) | 37% | 72% | 98% | 20% |
| Mean % of estimates | 49% | 69% | 88% | 35% |
| Max. % of estimate | 98% | 100% | 100% | 52% |
| Min. % of estimate | 0% | 0% | 38% | 0% |

## 11 Figures

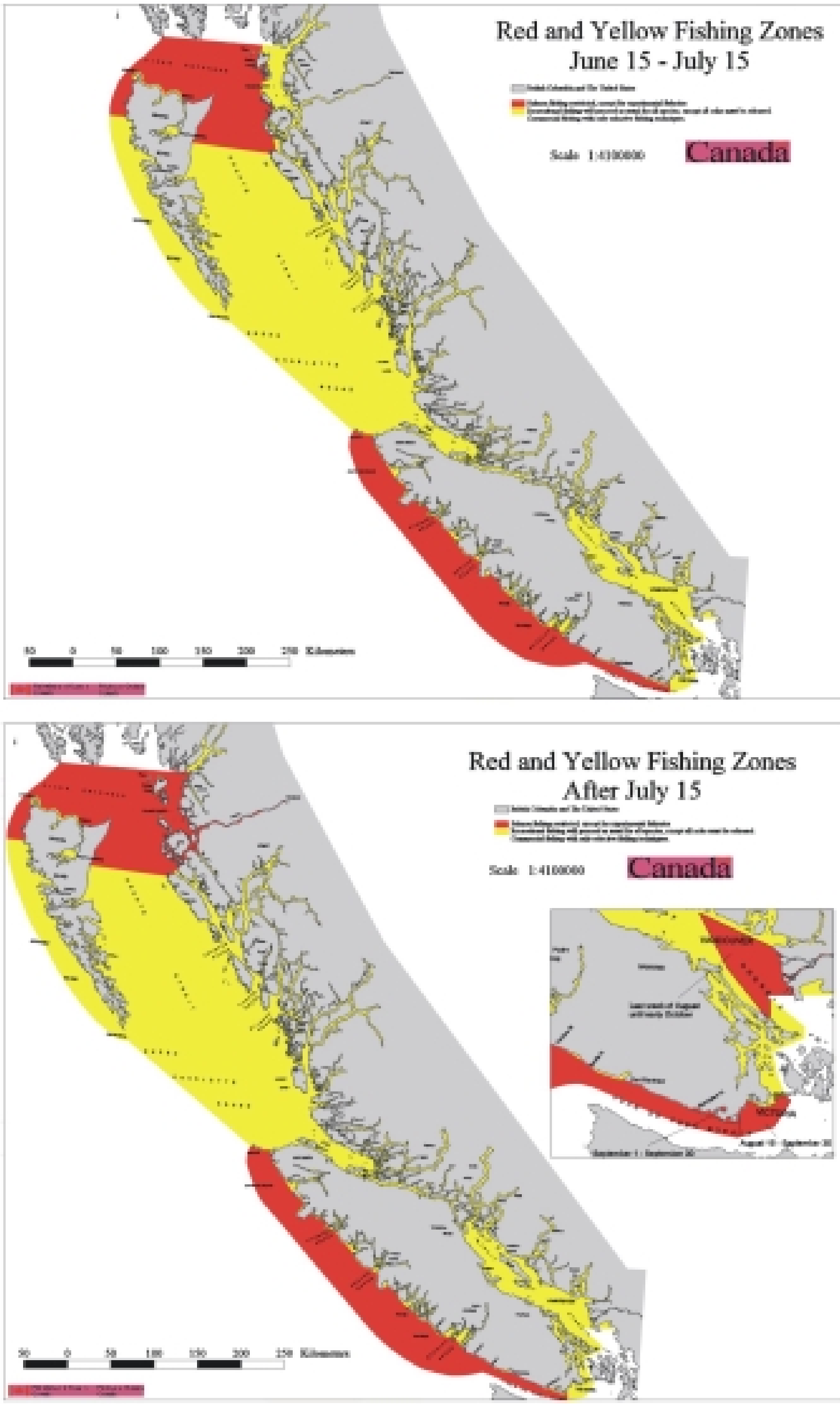
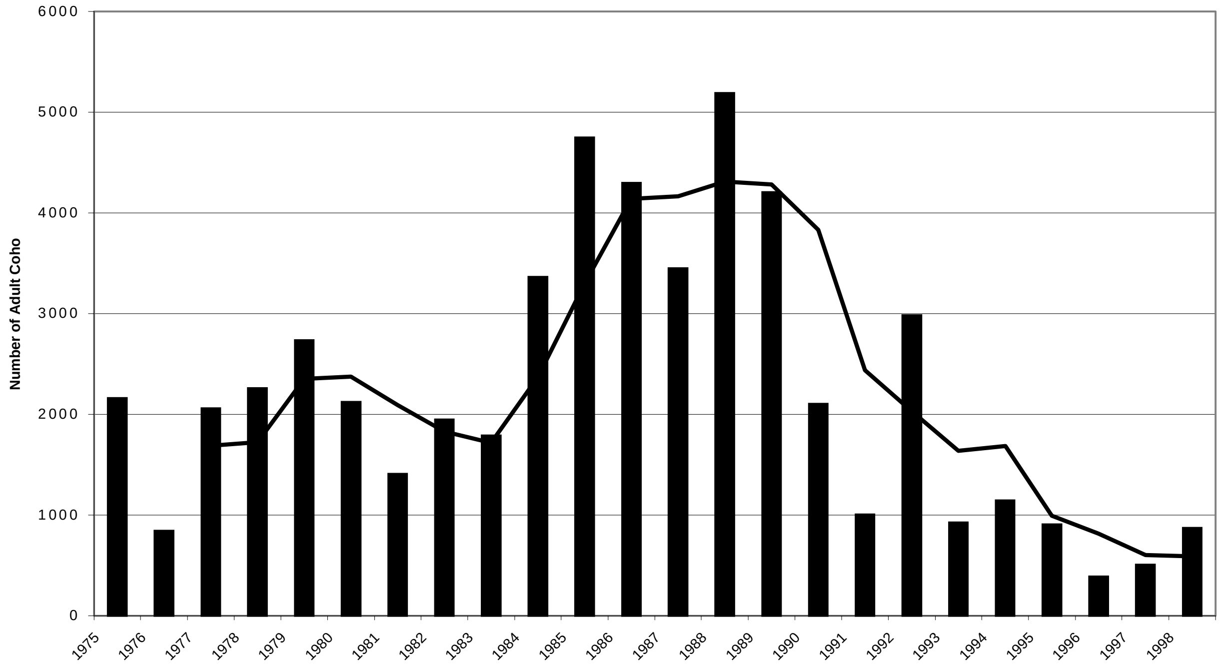
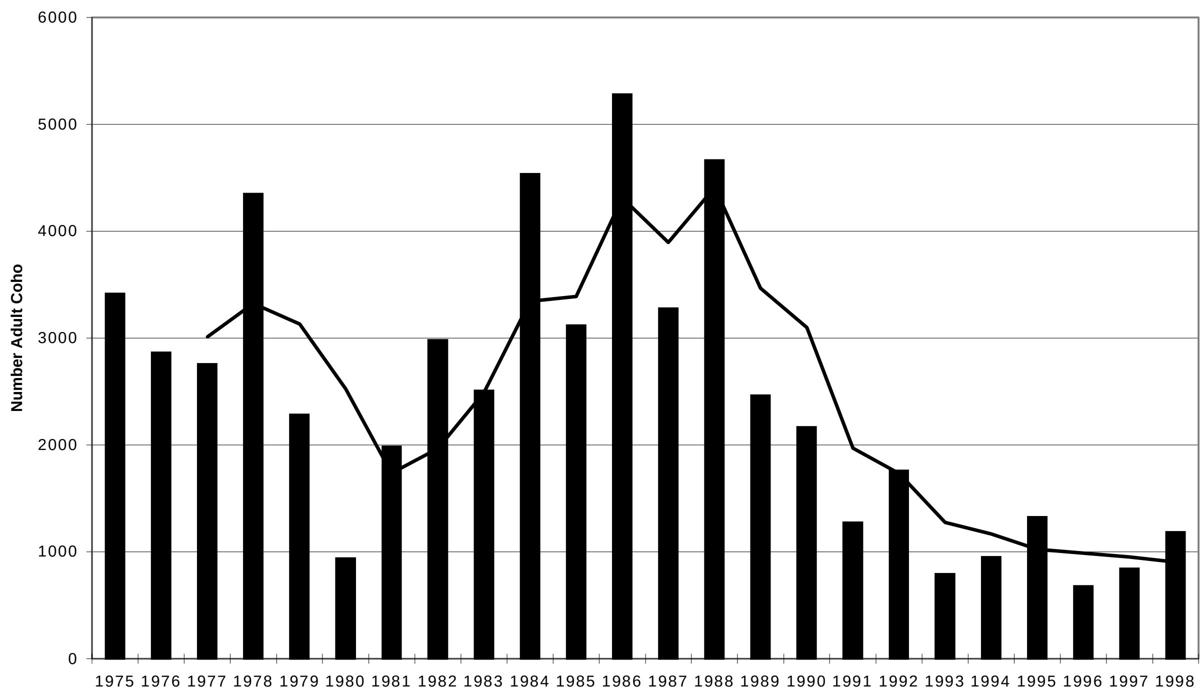



**Figure 1.1** Major Red and Yellow zones during the 1998 fishing season in coastal BC. (NB Some areas indicated as yellow were in fact experimental fisheries and should have been indicated as red (e.g. around Langara Island)).




**Figures 3.1 and 3.2**. Aggregate coho escapement to 16 South Thompson (above) and 10 North Thompson streams (below) (1975-1998). Trendlines are 3 yr moving averages.



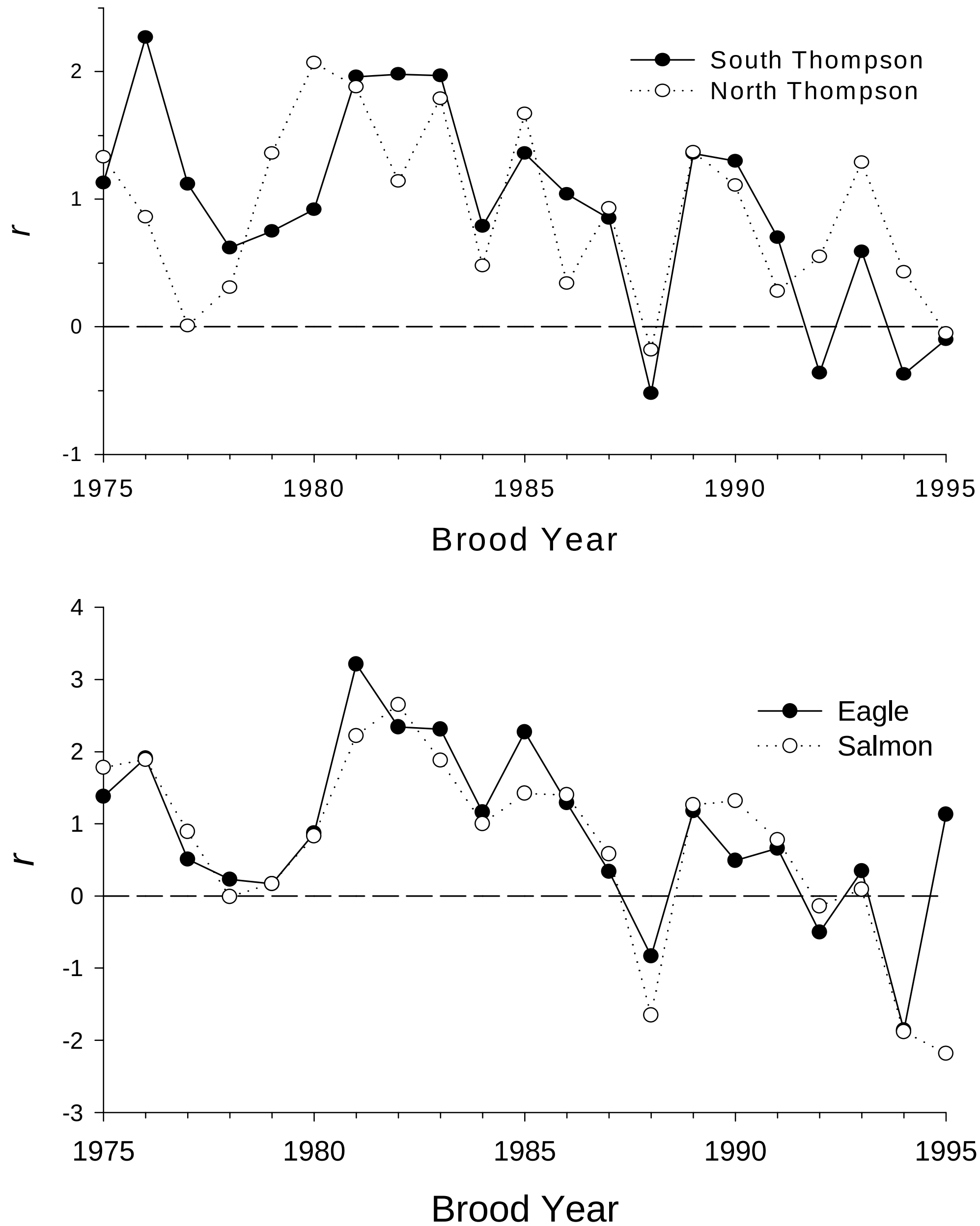



**Figure 4.1** Time series of the intrinsic rate of growth, *r*, for 4 stock groups of Thompson coho salmon. When $r < 0$, populations are unable to sustain themselves even in the absence of fishing. *r* is calculated as *ln*(Returns $_{t+3}$/Escapement $_t$), where Returns $_{t+3}$ = Escapement $_{t+3}$ /(1-h); h is the exploitation rate.

# 12 Appendix 1. Methods

## *12.1 Coho Catches and Mortalities in Southern B.C.*

In 1998, DFO implemented an extensive on grounds catch monitoring program of commercial, recreational, and aboriginal fisheries (Thomas 1999a and 1999b, Archipelago Marine Research 1999, and D&D 1999). In addition, test and experimental fisheries were closely monitored. The commercial fisheries included Area B seine, Areas D and E gillnet and Areas G and H troll. All commercial and first nations fisheries occurred only in the yellow zone areas. However, recreational, test and experimental fisheries were conducted in both yellow and red zones. The monitoring program consisted of mandatory logbooks, mandatory phone in of the catches and encounter data on a daily basis, participation in the on-grounds observer program, involvement of the charter patrol hail program, monitoring the landings at specific landing sites by contractors, and creel surveys. Through the mandatory phone-in data, fisheries managers were able to track overall catches and encounter rates of non-target species on a daily basis during the season. The charter patrol hail program provided an independent verification of the catch monitor program. Observers were able to assist the fishers with validating and recording catch and encounter data and phoning in the data in addition to their other duties of biological sampling. Logbooks were mailed into DFO either in-season or after fishery closures. This information provided a complete data set to the larger catch and encounter data base. The coho encounter data provided to fisheries managers were collated on a daily basis for each fishery that occurred in the yellow and red zones.

Coho mortalities were determined by applying gear mortality estimates from catch and release experiments to the encounter data:

| Gear | Mortality (%) | References |
|---|---|---|
| Purse Seine | 25 | Based on previous work with observers (W. S. Shaw, unpub.) |
| Gillnet | 60 | From PSC (1995 and 1997) |
| Troll | 26 | From WDFG (1993) |
| Sport | 10 | Gjernes (1990), Gjernes et al. (1993) |

Other gear mortality estimates used in-season for beach seine, fishwheel, trapnet and tangle net ranged from 1 to 10%. Calculation of the Thompson coho mortalities was based on the proportion of Thompson River coho described in Sections 12.2 and 12.3. As fisheries progressed through the season, a timing component based on the date when the encounters occurred was applied. This provided a temporal assessment of the Thompson mortalities for particular fisheries. In the end, all encounters and mortalities were summarized separately into the Red and Yellow zones (Table 3.1). We recognize that additional work is required to verify the appropriateness of the gear mortality rates used.

### *12.2 Pre-Season Estimation of Southern BC Fishery Stock Compositions*

Before fishing began in 1998, procedures were developed to estimate the proportions of coho caught of Thompson origin. This was necessary to evaluate the implications to Thompson coho of various fishery proposals pre-season, and to assist with inseason monitoring.

For years prior to 1998, from the DFO catch database, we had catch estimates of coho by catch region, but we did not know how many of these coho were of Thompson origin. From the MRP database, we had estimates of the numbers of coded-wire tagged (cwt'ed) Thompson origin coho caught in various fisheries, but we did not know how to expand these numbers to estimate the total (hatchery and wild) numbers of Thompson fish represented by these cwt'ed coho.

Two main methods were used to forecast the proportions of coho caught in marine fisheries that would be of Thompson origin: 1) Expansion of smolt numbers; and 2) An exploitation rate analysis approach. For fisheries in the lower Fraser River, results from DNA analysis were used.

We estimated the proportion of coho smolts leaving the Thompson watershed that were cwt'ed in various years. Annual smolt and fry release estimates from enhancement facilities in the Thompson, separated into fish that had been cwt'ed and fish that had not been cwt'ed, were obtained from HEB staff. We assumed that 20% of the coho released as fry would survive to the smolt stage.

To estimate wild smolt production, we worked from spawner escapement data provided in Appendices 1-3 in Irvine et al. (1999). Non-Thompson Fraser tributaries were ignored because we had no evidence that they were endangered. When an escapement estimate was not available for a particular stream-year combination, we used the mid-point of adjacent estimates for that stream. With the exception of the Salmon River and Eagle River, we expanded North and South Thompson escapement estimates by 1.52, the mean expansion factor determined from fence counts at Louis and Lemieux creeks. We did not modify escapement estimates for the Salmon and Eagle rivers in the South Thompson, or streams in the lower Thompson, as we had no reason to believe these estimates to be seriously biased.

To calculate natural smolt production, we assumed the proportion of females to be 0.466 and the fecundity to be 1600. Data on survival from eggs to smolt are lacking for Thompson coho so we assumed a freshwater survival of 3%, within the range known for coastal coho populations. Annual estimates of wild smolt production were added to our estimates of unmarked hatchery smolts to yield estimates of unmarked smolts.

Expansion factors (the inverse of the proportion of the total numbers of smolts leaving the Thompson watershed estimated to be cwt'ed) were calculated (Table A1-1) for recent years of outside distribution[2].

In our second approach, we used annual exploitation rate estimates for coho returning to the Thompson (Irvine et al. 1999) and escapement data compiled as described above.

[2] Kadowaki and Holtby (1998) predicted a strong likelihood of a high distribution of coho outside the Strait of Georgia in 1998.

Thompson coho stock size (SS) on an annual basis was determined by:

SS = esc/1-exploit

where esc = total Thompson escapement and exploit = mean annual exploitation rate

(i.e. catch divided by catch plus escapement)

Then,

catch = SS - esc

Expansion factors (exp) were computed by dividing annual catch by the total numbers of estimated cwt's (est tags) in Canadian fisheries (Table A1-1):

exp = catch/est tags

We calculated annual (1991, 1994, 1995, 1996, and 1997, recent outside distribution years) catches of Thompson coho for major southern BC fisheries by multiplying estimated cwt's in each fishery and catch region by each of the two annual expansion factors (Table A1-1). Estimates of Thompson coho caught were expressed as a percentage of the total coho caught by catch region from the catch database. The mean annual percentage of coho catches of Thompson origin by catch region was computed (outside years only), along with confidence intervals. To be risk adverse, we used 75th percentiles; i.e. 75% of the time, the catch of Thompson coho would be less. The means of these values are provided (Table A1-2) for major southern BC marine fisheries and catch region. We emphasize that there is a large amount of uncertainty around these multipliers.

These multipliers were used pre-season to forecast, and inseason to monitor projected catches of Thompson origin coho. For example, if 300 coho were caught (or predicted to be caught) in a sport fishery in Juan de Fuca (JFSP), to estimate the numbers of these fish that would be of Thompson origin, one would multiply 300 * 0.01199 = 3.6 Thompson fish. In some instances, we adjusted our multipliers based on temporal patterns of cwt recoveries (Irvine et al. 1999, Section 4.2.3).

Results from the smolt and exploitation analyses for the Area 29 (Fraser Gill Net) fishery were not used for fisheries in the lower Fraser because they included samples for the entire Area 29 which extends well out into the Strait of Georgia. Numbers of Thompson coho in Fraser River fisheries were estimated using the relative compositions determined from the genetic analysis of 1997 samples (Irvine et al. 1999, Table 5.2).

### *12.3 Post-season Estimation of Southern BC Fishery Stock Compositions*

An alternative approach was sometimes used post-season to estimate Thompson/upper Fraser coho catches. During 1998, tissue samples were taken from coho caught in various fisheries. A hole punch was used to sample coho caught, and these samples were sent to the molecular genetics lab at PBS for analysis. Analytical procedures are documented in Small et al. (1998). Estimated stock compositions (Appendix 2) were applied to estimates of 1998 coho mortalities to calculate the number of Thompson/upper Fraser coho mortalities. Because we were interested in the number of Thompson origin mortalities (i.e. we wished to exclude non-Thompson Fraser fish), we applied the ratio of the number of coho escaping to these areas (Section 3.2). Approximately 60% of the coho returning to the Thompson/upper Fraser River in 1998 returned to the Thompson portion of this aggregate so estimates of numbers of Thompson/upper Fraser mortalities were scaled appropriately.

It needs to be stressed that DNA sample sizes used to generate the stock compositions for some fisheries were small, and the estimated precision around these estimates was sometimes large (Appendix 2). Sampling was not random so we have no guarantee that samples were representative. We do not advocate that fisheries should be managed solely on the basis of these results. For fisheries in southern BC where we also had pre-season estimates of stock composition, we developed a protocol based on sample size to assist in determining whether to use the stock composition estimate developed pre-season, or the estimate based on the 1998 DNA evidence.

When either the pre-season or DNA sample size for a fishery/time strata exceeded 100, we used the estimated proportion of Thompson fish from that sample. If both samples exceeded or were less than 100, we used the average of the two estimated proportions. In instances where samples were not available from the most appropriate fishery/time strata, we used samples from nearby fisheries. In some instances, weighted averages of estimated stock compositions were used when samples sizes were deemed to be inadequate for particular fishery/time strata.

### *12.4 Thompson/Upper Fraser Coho Catches and Mortalities Outside of Southern BC*

Coho catches were permitted in the sport fishery in Area 5 in Puget Sound, Washington between 11 Aug and 7 Sep 1999. Washington Fish and Wildlife sampled the catch with an intensive, dockside creel census (Hagen-Breaux 1999). Catch and effort was estimated for coho (and other species). Because of concerns that upper Fraser/Thompson coho might constitute a significant portion of this catch, tissue samples were collected from this fishery on three separate occasions and analysed for stock composition. Area 5 sport catches were stratified into three timing periods (11 – 20 Aug., 21-30 Aug., and 31 Aug – 7 Sept). Estimates of the proportion of Thompson/upper Fraser coho contributing to these fisheries were multiplied by 0.6 to estimate Thompson mortalities (Table 3.2).

Sport catches of coho in other areas of Puget Sound were sampled as part of a less intensive sampling design (Laurie Peterson, Washington Dept. of Fish and Wildlife, pers. com., 9 April 99). Some coho were also taken in a commercial sockeye fishery in Puget Sound. This fishery was closed 21 Aug in an attempt to reduce possible Thompson coho bycatches. Coho catch estimates from these Puget Sound fisheries were not available at the time of writing.

Preliminary estimates indicate that approximately 24,000 coho were caught by sport fishermen in other areas of Washington during 1998, mostly along the outside coast, from as far south as the mouth of the Columbia River (Brenda Adkins, DFO, pers. comm. 6 April 99). We have no DNA samples from this fishery but we do know the number of cwt's of Thompson origin from this and other US fisheries. During 1998, one cwt'ed Spius Creek (lower Thompson/Nicola) coho turned up in the Oregon sport fishery (Astoria sport Area 2), four were recovered in Puget Sound sport

Area 5, 11 were found in other marine areas of Washington State, and two were turned in from Alaska.

In comparison, during 1997 there were 74 recoveries of cwt'ed coho in Washington from the Thompson. Of these, 28 had been sport-caught, and 18 of these were caught in Puget Sound. During 1996, 50 recoveries of Thompson-origin coho were reported in Washington, of which 45 were sport-caught, and 23 from Puget Sound.

To generate a crude estimate of the number of Thompson coho killed during 1998 in the USA (excluding the Area 5 recreational fishery in Puget Sound) including Alaska, we assumed that the ratio of the number of Thompson cwt's in the Area 5 recreational fishery to the total number of Thompson cwt's caught in the US was equal to the ratio of the catches of Thompson coho in these same areas. We used estimated recoveries (observed recoveries multiplied by the catch:sample ratio). Since expansion factors were not available for most Washington sport recoveries, we used an expansion factor of four (assuming that 4 cwt'ed coho were caught for each tagged coho recovered). Similar expansion factors have been used in the same fisheries for earlier years (Irvine et al. 1999).

The number of Thompson coho estimated killed in the US outside the Area 5 recreational fishery (N) was:

N = (est. Thomp. cwt's elsewhere* Area 5 Thom. mortalities/est. Thom. cwt's in Area 5)

Therefore, $N = (36*294/16) \cong 660$

For northern and central BC, stock composition estimates (Appendix 2) were scaled to represent Thompson coho and applied to estimates of coho catches in northern BC during 1998 (Table 3.2). In a few instances, weighted averages of estimated stock compositions were used when samples sizes were deemed to be inadequate for particular fishery/time strata. The sampling of many northern fisheries for DNA was opportunistic and we are less confident in the discriminatory powers of this method (with respect to Thompson coho) because the northern baseline may be less well represented than the southern baseline. There is greater uncertainty in the results for northern and central BC (Table 3.2) than for the Washington Area 5 recreational fishery results or our estimates for southern BC (Table 3.1).

### *12.5 Escapement Methodology During 1998*

First Nations, contract and DFO personnel using a variety of techniques estimated escapements for 71 streams in the Thompson basin and Upper Fraser. In some instances counts were obtained through a fence (with or without mark-recapture), while drifting a stream in a vessel or by snorkelling, on foot and from a helicopter. Wherever multiple visual surveys were completed (and fish were observed on at least three surveys), Area-Under-the-Curve (AUC) methods were used to derive escapement estimates.

### 12.5.1 Fence and Fishway Counts

Seventeen fences and one fishway were operated during the 1998 coho return. Escapements to three systems, Coldwater River (Nicola drainage), Louis Creek, and Lemieux Creek (North Thompson) were estimated using fence counts and statistically rigorous, upstream mark-recapture studies. For Coldwater River, an estimate of the number of fish spawning below the fence was also obtained.

Crude mark-recapture estimates (operculum punches only combined with sporadic carcass recovery) were used on five systems (Bessette Creek, Danforth Creek, and Momich River (South Thompson) and Dunn Creek, and Mann Creek (North Thompson) ). The escapement to the Bonaparte River was estimated from a fishway count alone, and escapements to six other systems where the fences were not topped or breached, were estimated from fence counts alone (Duteau Creek and Huihill Creek (South Thompson), Deadman River and upper Nicola River (Lower Thompson)), or from fence counts and estimates of the numbers of coho spawning below the fences (Eagle River, Salmon River(South Thompson) , Spius Creek (Lower Thompson) and McKinley Creek (Upper Fraser)). The Lang Channel count was added to the aerial estimate to generate the estimated escapement to the Middle Shuswap River, and the Upper Nicola fence count (above Nicola lake) was added to the aerial estimate for the Nicola River below the lake to generate a Nicola River estimate.

#### 12.5.1.1 Fence-based Mark Recapture Estimates

Rigorous mark recapture studies were conducted at Louis and Lemieux creeks in the North Thompson (see Atagi et al. 1999 for detailed description) and at the Coldwater River (Nicola River tributary). Adult coho passing the counting fences were tagged with uniquely numbered Petersen disk tags, and given a sex-specific secondary mark on the left operculum (one or two 0.5 cm punches). The entire accessible portions of the streams were walked at least weekly throughout the run to recover carcasses of post-spawned coho, and also to record the numbers of live adult coho observed. All recovered carcasses were measured for post-orbital hypural (POH) length, cut open to confirm sex and determine spawning success, and examined for the presence of Petersen disk tags and/or operculum punches. Scales were taken from all recovered carcasses for age determination and heads were retained from carcasses that were adipose fin-clipped. After examination, all carcasses were cut in half to prevent resampling.

Escapements and 95% confidence intervals, stratified by sex were estimated using Petersen formulae (Chapman modification) (Ricker 1975). Simple Petersen mark recapture procedures were employed to estimate escapements above fences at Bessette Creek, Danforth Creek, Dunn Creek, Mann Creek and Momich River. An operculum punch was applied to fish passing the fences, and carcasses were recovered by stream walks and from the fences as carcasses drifted downstream. Recovered carcasses were examined for the presence of operculum punches and cut in half to prevent resampling.

### 12.5.2 Visual Surveys

Visual surveys of spawner abundance were conducted by a variety of means. Most visual surveying was conducted by observers walking upstream (in the water) , gently dislodging coho from under cover with 2 M dowels. Observers wore polarised sunglasses.

Surveys of some rivers were conducted by drift counting from whitewater rafts or pontoon boats. Raft counts employed one or two rafts with one observer and a separate person controlling the raft. Surveyors drifted downstream, and each crew counted fish on their side of the river. Crews discussed their observations as they drifted, and at the end of each section, determined a “best” estimate for that reach.

Blue River and Mahood River were surveyed using a pontoon boat. For those surveys, a single observer guided the craft downstream, retarding its progress in the current with oars. All coho observed were recorded and the counts noted by reach.

Helicopter-based visual surveys were conducted on relatively large or inacessible rivers including Mitchell River (Quesnel Lake tributary), the Upper Adams River and the lower and Shuswap rivers. A Bell 206B helicopter, equipped with “counting bubbles” on the left side front and rear doors was used. The helicopter flew at an elevation of about 50 M, either downstream or upstream, depending on light and wind conditions. Speeds varied from almost hovering to 50 Km/hr. Two observers seated on the left side of the machine counted fish, and discussed their totals continuously. At the end of each section, totals were recorded and a “best” estimate determined.

#### 12.5.2.1 AUC

Wherever three or more visual estimates of spawner abundance were conducted and spawning coho were observed on each survey, we attempted to generate AUC estimates of escapement. AUC escapement estimates require periodic estimates of the abundance of spawners in the system, an estimate of the efficiency of counting fish (*observer efficiency*) and an estimate of the average amount of time that the fish spend visible to the surveyors (*survey life*).

For the estimates of 1998 spawner returns, we assigned the arrival time of the first fish into the system and the date that the last fish died based on local fences, stream conditions and visual survey records. We used survey life information derived from the Lemieux Creek mark-recapture and streamwalk study.

We constructed AUC estimates for 15 systems (13 other than Lemieux and Duteau creeks). Twelve AUC estimates were “complete” system estimates; and one estimated abundance below the Salmon River fence. We were unable to construct AUC estimates on some other systems due to a failure to observe fish on at least one of the surveys.

For visual surveys used to construct AUC estimates, we assumed observer efficiency to be 75% for streamwalks, and for raft float counts and helicopter surveys, we assumed observer efficiency to be 50%.

### 12.5.2.2 Expanded visual surveys

Escapements to the remaining streams were estimated using information from one or two visual surveys conducted on foot, afloat, or from helicopters. Visual surveys ranged from "spot checks" of limited areas of systems to complete system surveys on foot, floating, or from helicopters. Observed peak counts were multiplied by expansion factors derived from comparisons of peak observations to AUC estimates (including observer efficiency corrections). In all cases, we have attempted to be conservative.

### 12.5.2.3 Calibration Studies

Estimation of Survey life: Lemieux Creek

To estimate escapement using AUC, periodic estimates of abundance are required along with an estimate of survey life within the survey area. The number of spawners, *Esc* is estimated as:

*Esc = Area under the spawner curve / survey life .*

Alternately, the survey life may be estimated when an alternate estimate of escapement is available. In that case, survey life is estimated as:

*Survey life = Area under the spawner curve / Esc.*

Escapement to Lemieux Creek was estimated using a counting fence and stratified Petersen mark-recapture techniques. Five hundred and eighty six fish were tagged and secondary marked, and released upstream of the counting fence. An additional 34 fish were taken at the fence for broodstock. Two hundred and twenty five carcasses were examined for tags of which 218 were tagged. After screening for fence and handling-induced mortalities, the total spawning escapement (mark-recapture estimates stratified by sex, upstream of the fence) was estimated as 605 fish.

Foot survey observations were divided by 0.75 to correct for observer efficiency, and then assembled to form a spawner-curve. We assumed that the first fish into Lemieux Creek entered on October 10 (date of first passage through fence), and the last fish died on Jan 03, 1999). The area under the resulting spawner curve was estimated to be 5517 fish days.

Dividing the area under the spawner curve (5517 fish days) by the mark-recapture estimate yielded an estimate of survey life for Lemieux Creek of 9.1 days. Based on this, we chose to use 9 days as our estimate of survey life for foot survey generated AUC estimates. This value is similar to values reported by others for similar sized watersheds (Chase River: range 7-11 days - Irvine et al. 1994, Bailey, unpublished data), and somewhat lower than values observed at Black Creek (typically 10-14 days). Duteau Creek data were not used to develop survey life estimates because the Duteau Creek fence was briefly breached (~5 hrs) and no upstream mark-recapture program was carried out, thus it is possible that the Duteau fence count may be biased low, and the resultant calculated survey life estimate, biased high. Louis Creek data were not used because the streamwalks used to recover carcasses were not representative of visual surveys used elsewhere to develop AUC estimates.

System survey lives for coho counted from raft drifts were estimated using “tags-out” times from coho mark-recapture studies at Lemieux Creek (G. Tisdale, Tisdale Environmental Consulting Ltd., unpublished data). Mean “tags-out time” is the average time between tagging a fish at the fence (as it enters the system) and subsequent recovery of that tagged fish as a carcass. Because we counted both holding (in deep pools) and spawning fish during drift surveys, we assumed that use of survey life estimates as previously described would result in over-estimation of the total population. Therefore, we used the tags-out time as an estimate of the total time fish may reside in the spawning tributary. Using recovery data from 1995 to 1998, the mean Lemieux Creek “tags-out” time was approximately 18 days.

To determine appropriate expansion factors for raw visual count data, on systems where we were unable to estimate escapement by more robust, multiple survey methods, we determined relationships between observed (raw) peak-live counts and expanded (for observer efficiency) AUC total estimates of escapement, on systems where we were able to calculate AUC estimates. We then averaged these estimates by area and gross stream size to produce expansion factors that included observer efficiency corrections. The calculated expansions are presented in Table A1-3.

### *12.6 Escapement History Reconstruction*

In 1998, much additional effort was expended to estimate coho escapement compared to previous years. However, Irvine et. al. (1999) presented a time series of data for Thompson coho stocks, constructed from the BC 16 database. Due to the expansion of effort in 1998, many of the resultant estimates of escapement are not directly comparable with those reported for previous years. To permit extension of our time series of escapement data, we also report escapement values that would likely have been obtained, should the escapement programs of previous years been undertaken in 1998.

To better understand previous escapement estimates of coho for Thompson basin and Upper Fraser stocks, we assembled detailed stream survey histories for each system since 1990 (Appendix 3). Regional offices were visited, and for all coho escapement surveys from 1990 to 1997, the “Stream Inspection Log” datasheets were examined, and summarised, along with resultant estimates of escapement. Where feasible and documented, the processes used to estimate the escapements from the field observations were also listed.

#### 12.6.1 Trend Estimate Generation

Based on the stream escapement histories (Appendix 3), we constructed “trend” (i.e. 1998) escapement estimates for each system, using the following procedures:

1. Whenever the escapement estimation methodology was relatively consistent over time, we used this method to generate the trend estimate.

2. When condition 1 was not met, wherever possible, we applied the estimation procedures used in 1995 (parental brood year) to field observations collected during the 1998 field season.

3. If conditions 1 and 2 were not met, wherever feasible, we applied the estimation procedures used in 1997 (previous year) to field observations collected during the 1998 field season.

Otherwise we attempted to duplicate procedures used in either 1996 or prior to 1995, and where multiple years of estimates were available, we chose the procedure that we could best apply to the 1998 data.

Details of the derivation of the individual 1998 “trend” estimates are provided by stream in Appendix 3.

Fence count data used for historical comparisons were reported as counts of fish passed over the fences, even if it was known that the fence had been topped or breached. Trend estimates of fence counts were reported for Louis Creek, Lemieux Creek, Mann Creek, Dunn Creek, Salmon River, Eagle River, Bessette Creek, Deadman River and the Bonaparte River fishway.

Most recent visual survey estimates of escapement for Thompson basin / Upper Fraser coho stocks appear to be based on one or two “spot checks” in the vicinity of road crossings, although more thorough survey data are available for some stocks. In some cases, these data were then expanded by a variety of means to produce estimates of escapement. In other cases, raw counts were summed and reported as the escapement estimate. Generally, the frequency and intensity of surveys decreased between 1990 and 1997, and there was little consistency in the methods employed to generate estimates across systems or years.

**Table A1-1** Expansion factors (inverse of the proportion of the total numbers of smolts leaving the Thompson watershed estimated to be cwt'ed) as determined by the smolt expansion and the exploitation rate methods.

| Brood Year | Catch Year | Smolt Expansion | Exploitation Expansion |
|---|---|---|---|
| 1988 | 1991 | 5.58 | 6.56 |
| 1991 | 1994 | 5.97 | 4.25 |
| 1992 | 1995 | 5.74 | 11.35 |
| 1993 | 1996 | 4.15 | 7.99 |
| 1994 | 1997 | 5.68 | 9.54 |

**Table A1-2.** Pre-1998 cwt based multipliers used to project marine fishery catches of Thompson origin coho.

| Catch Region | Multiplier | n[1] | n[2] |
|---|---|---|---|
| SCTR | 0.00086 | 112 | 7 |
| GSTR | 0.00557 | 539 | 19 |
| SWTR | 0.01017 | 2401 | 1312 |
| NWTR | 0.00577 | 1014 | 266 |
| JSN | 0.00796 | 119 | 27 |
| JFN | 0.01072 | 271 | 139 |
| SWVN | 0.00413 | 8 | 4 |
| GSPN | 0.00745 | 815 | 53 |
| GSPS | 0.02434 | 219 | 24 |
| JFSP | 0.01199 | 174 | 97 |
| WSPT | 0.00823 | 31 | 16 |

[1]Number of Thompson cwt's observed in each fishery (1990 – 1997 inclusive).
[2]Number of Thompson cwt's observed in each fishery (outside distribution years only; i.e. 1991, 1994, 1995, 1996, and 1997).

**Table A1-3.** Observed relationships between observed "peak" estimates and AUC estimates

| Stream Category | Streams | | Escapement to Peak-Live ratio |
|---|---|---|---|
| Foot Surveys | | | |
| North Thompson / Lillooet (larger) | Bridge River | | 4.0 |
| | Cayoosh Creek | | 5.4 |
| | Fennel Creek | | 6.8 |
| | Lemieux Creek | | 4.4 |
| | Lion Creek | | 5.6 |
| | | Overall | 5.2 (rounded down to 5.0) |
| Other foot surveyed streams | Avola | | 2.8 |
| | Cayoosh | | 3.4 |
| | Creighton | | 2.8 |
| | East Barriere | | 3.8 |
| | Harris | | 4.9 |
| | Ireland | | 3.3 |
| | Duteau | | 3.4 |
| | Salmon | | 2.9 |
| | | Overall | 3.4 (rounded down to 3.0) |
| Float surveys (used also for Aerial survey expansion) | Blue River | | 2.9 |
| | Nahatlatch River | | 4.7 |
| | | Overall | 3.8 (rounded down to 3.0) |

## 13 Appendix 2. Coho DNA results from 1998 sampling (Source: PBS Genetics Lab., John Candy and Terry Beacham, May 1999). NB To determine the percent of Thompson fish in a sample, multiple the Thompson/UPFR percent by 0.6.

| Area 20 PSC Gillnet Test fishery | | | | | | | Area 20 PSC Seine Test fishery | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Regions** | July 3-15 | **SD** | July 16-31 | **SD** | August 1-16 | **SD** | July 24-31 | | August 1-7 | **SD** | August 8-16 | **SD** | August 17-25 | **SD** |
| **N** | 114 | | 105 | | 76 | | 455 | | 189 | | 193 | | 196 | |
| **WCVI** | 15.1% | 5.5% | 23.7% | 6.7% | 29.2% | 8.9% | 3.8% | 2.3% | 6.5% | 4.3% | 9.2% | 3.7% | 4.6% | 3.3% |
| **ECVI** | 11.6% | 6.1% | 18.6% | 5.7% | 3.5% | 6.1% | 12.1% | 3.3% | 9.3% | 4.9% | 14.1% | 4.5% | 17.4% | 5.2% |
| **S.Mainland** | 13.1% | 5.4% | 9.7% | 5.4% | 4.6% | 5.4% | 12.3% | 3.0% | 6.6% | 3.7% | 10.8% | 3.6% | 2.2% | 3.1% |
| **Lower Fraser** | 8.7% | 4.7% | 6.3% | 5.4% | 12.0% | 6.5% | 23.9% | 3.5% | 19.5% | 5.1% | 10.0% | 5.3% | 2.3% | 3.6% |
| **Thompson/UPFR** | 1.0% | 1.0% | 1.1% | 1.8% | 0.0% | 1.3% | 0.5% | 0.5% | 2.4% | 1.4% | 0.7% | 0.8% | 2.2% | 1.6% |
| **Total Canada** | 49.5% | 6.3% | 59.4% | 8.0% | 49.2% | 8.6% | 52.7% | 4.2% | 44.2% | 6.2% | 44.7% | 5.7% | 28.6% | 6.5% |
| | | | | | | | | | | | | | | |
| **Puget S.** | 34.4% | 6.4% | 21.3% | 6.7% | 34.1% | 9.1% | 39.3% | 4.2% | 43.1% | 6.3% | 44.5% | 6.0% | 56.3% | 6.1% |
| **J. de F.** | 0.0% | 2.2% | 5.2% | 3.9% | 0.0% | 1.1% | 0.0% | 1.5% | 0.6% | 2.2% | 3.9% | 2.6% | 0.0% | 1.6% |
| **Coastal** | 11.5% | 4.6% | 10.1% | 4.8% | 15.3% | 6.5% | 8.0% | 2.4% | 8.0% | 3.8% | 5.5% | 2.6% | 11.1% | 4.2% |
| **Columbia** | 4.7% | 3.4% | 4.1% | 2.5% | 1.4% | 1.5% | 0.0% | 0.5% | 4.2% | 2.5% | 1.4% | 1.3% | 4.0% | 1.9% |
| **Total US** | 50.5% | 6.3% | 40.6% | 8.0% | 50.8% | 8.6% | 47.3% | 4.2% | 55.8% | 6.2% | 55.3% | 5.7% | 71.4% | 6.5% |

| Recreational fisheries (Canadian) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Area14 | | Area17 | | Area19 | | Area20 | | Area28 | | Area29 | |
| | Oct 2- 29 | **SD** | July 29-31 | **SD** | July 5-Sept 27 | **SD** | July 26-Sept 9 | **SD** | July1-July16 | **SD** | July 15- Oct19 | **SD** |
| **N** | 68 | | 12 | | 74 | | 44 | | 42 | | 17 | |
| **WCVI** | 12.0% | 6.8% | 10.7% | 12.1% | 12.3% | 6.7% | 18.7% | 10.3% | 3.2% | 5.8% | 6.0% | 14.2% |
| **ECVI** | 78.1% | 9.6% | 16.0% | 17.0% | 23.0% | 7.9% | 32.8% | 9.8% | 19.6% | 10.8% | 19.0% | 13.0% |
| **S.Mainland** | 0.0% | 3.1% | 7.5% | 8.8% | 9.8% | 6.9% | 10.2% | 6.6% | 40.6% | 13.5% | 50.9% | 18.1% |
| **Lower Fraser** | 0.0% | 3.1% | 53.7% | 19.4% | 11.4% | 6.0% | 7.9% | 5.1% | 6.4% | 6.9% | 13.6% | 9.7% |
| **Thompson/UPFR** | 0.0% | 0.0% | 0.0% | 0.1% | 7.4% | 3.7% | 10.4% | 5.4% | 3.5% | 2.9% | 0.0% | 0.1% |
| **Total Canada** | 90.1% | 7.4% | 87.9% | 14.9% | 63.8% | 8.7% | 80.0% | 9.1% | 73.2% | 11.8% | 89.4% | 13.2% |
| | | | | | | | | | | | | |
| **Puget S.** | 2.9% | 5.0% | 8.5% | 13.5% | 28.4% | 7.8% | 12.9% | 6.5% | 2.4% | 7.7% | 5.3% | 9.6% |
| **J. de F.** | 0.0% | 2.5% | 3.6% | 5.9% | 0.0% | 2.8% | 2.2% | 3.9% | 0.0% | 1.4% | 0.0% | 2.4% |
| **Coastal** | 7.0% | 4.9% | 0.0% | 0.9% | 7.7% | 5.3% | 0.0% | 4.1% | 24.4% | 9.1% | 5.3% | 9.0% |
| **Columbia** | 0.0% | 0.2% | 0.0% | 1.3% | 0.0% | 0.8% | 5.0% | 2.9% | 0.0% | 4.0% | 0.0% | 3.3% |
| **Total US** | 9.9% | 7.4% | 12.1% | 14.9% | 36.2% | 8.7% | 20.0% | 9.1% | 26.8% | 11.8% | 10.6% | 13.2% |

**Appendix 2** (Continued)

| Recreational fisheries(Washington Area 5) | Aug-16 | SD | Aug-23 | SD | Sep-05 | SD |
|---|---|---|---|---|---|---|
| **N** | 147 | | 149 | | 146 | |
| **WCVI** | 9.5% | 4.8% | 6.1% | 3.7% | 2.6% | 4.0% |
| **ECVI** | 9.1% | 5.4% | 20.9% | 5.0% | 4.9% | 4.4% |
| **S.Mainland** | 7.7% | 4.2% | 8.3% | 4.1% | 13.7% | 5.2% |
| **Lower Fraser** | 11.5% | 5.2% | 8.3% | 4.5% | 16.4% | 5.9% |
| **Thompson/UPFR** | 2.1% | 1.5% | 1.5% | 1.1% | 3.7% | 1.6% |
| **Total Canada** | 40.0% | 6.6% | 45.0% | 6.2% | 41.3% | 7.0% |
| | | | | | | |
| **Puget S.** | 44.7% | 6.9% | 48.2% | 6.5% | 52.9% | 6.9% |
| **J. de F.** | 2.4% | 2.6% | 1.0% | 2.3% | 2.4% | 3.4% |
| **Coastal** | 9.7% | 3.8% | 3.5% | 2.8% | 3.4% | 3.1% |
| **Columbia** | 3.3% | 2.0% | 2.3% | 2.6% | 0.0% | 1.3% |
| **Total US** | 60.1% | 6.6% | 55.0% | 6.2% | 58.7% | 7.0% |

| Troll fisheries - southern BC | Area 12 July 24-31 | SD | Area12 Aug 1-7 | SD | Area12 Aug 8 -16 | SD | Area12 Aug 17-25 | SD | Area11 July 26-Aug8 | SD | Area13 Aug 1-7 | SD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **N** | 196 | | 68 | | 285 | | 45 | | 47 | | 8 | |
| **QCI** | 4.3% | 1.4% | 6.3% | 1.6% | 1.4% | 0.8% | 14.7% | 3.6% | 10.5% | 2.6% | 30.7% | 10.7% |
| **Skeena/Nass** | 3.8% | 1.6% | 4.4% | 3.5% | 0.7% | 0.9% | 8.4% | 3.9% | 12.8% | 4.0% | 14.4% | 3.9% |
| **Central Coast** | 5.4% | 1.8% | 3.7% | 3.5% | 10.9% | 2.1% | 7.2% | 4.1% | 4.1% | 2.4% | 0.0% | 0.5% |
| **Vancouver Isl** | 49.4% | 3.8% | 44.2% | 5.4% | 39.4% | 3.4% | 35.5% | 7.5% | 24.2% | 5.7% | 0.0% | 7.0% |
| **South Main** | 18.3% | 3.0% | 4.7% | 4.1% | 25.9% | 3.5% | 14.7% | 4.6% | 11.2% | 4.2% | 0.0% | 2.8% |
| **Lower Fraser** | 7.1% | 1.9% | 7.1% | 3.9% | 7.9% | 1.5% | 11.4% | 4.5% | 27.7% | 4.4% | 36.7% | 15.0% |
| **Thompson/UPFR** | 1.5% | 0.5% | 1.6% | 0.6% | 2.8% | 0.5% | 2.7% | 1.1% | 0.0% | 0.8% | 0.5% | 13.8% |
| **Canada** | 89.5% | 3.0% | 72.0% | 5.8% | 88.9% | 2.0% | 94.6% | 4.7% | 90.5% | 6.3% | 82.2% | 9.3% |
| | | | | | | | | | | | | |
| **Juan de Fuca** | 0.1% | 0.9% | 0.0% | 1.4% | 0.0% | 0.3% | 5.4% | 3.5% | 0.0% | 1.4% | 0.0% | 2.1% |
| **Puget Sound** | 4.8% | 2.1% | 16.1% | 4.4% | 6.5% | 1.5% | 0.0% | 2.4% | 6.9% | 5.0% | 0.0% | 1.5% |
| **Coastal** | 3.7% | 1.6% | 12.0% | 3.4% | 2.5% | 1.6% | 0.0% | 0.7% | 0.4% | 2.8% | 0.0% | 6.7% |
| **Columbia** | 1.1% | 1.2% | 0.0% | 0.3% | 0.0% | 0.4% | 0.0% | 0.4% | 0.0% | 0.7% | 17.8% | 7.4% |
| **US** | 9.6% | 2.7% | 28.0% | 5.7% | 9.0% | 1.9% | 5.4% | 4.3% | 7.3% | 6.3% | 17.8% | 9.3% |

**Appendix 2** (Continued)

**Recreational and Troll fisheries - WCVI**

| | Troll Areas 124 - 127, Rec. Areas 23 - 25 Aug 1 -7 | SD |
|---|---|---|
| **N** | 700 | |
| **WCVI** | 25.1% | 4.3% |
| **ECVI** | 13.0% | 4.1% |
| **South Main** | 18.5% | 4.6% |
| **Lower Fraser** | 7.2% | 3.2% |
| **Thompson/UPFR** | 1.6% | 0.9% |
| **Canada** | 65.4% | 4.6% |
| | | |
| **Juan de Fuca** | 1.5% | 1.8% |
| **Puget Sound** | 25.0% | 4.9% |
| **Coastal** | 8.1% | 2.5% |
| **Columbia** | 0.0% | 50.0% |
| **US** | 34.6% | 4.6% |

**Seine/Gillnet fisheries Southern BC**

| | Seine Area 12 Aug 1-8 | SD | Seine Area 13 Aug 1-8 | SD | Gillnet Area 12 July 24-31 | SD |
|---|---|---|---|---|---|---|
| **N** | 108 | | 18 | | 27 | |
| **QCI** | 3.4% | 2.5% | 0.0% | 1.5% | 11.7% | 5.2% |
| **Skeena/Nass** | 6.4% | 2.7% | 0.0% | 1.7% | 9.4% | 5.0% |
| **Central Coast** | 10.0% | 2.7% | 17.3% | 7.1% | 23.1% | 9.8% |
| **Vancouver Isl** | 36.4% | 4.3% | 21.5% | 11.1% | 3.3% | 11.3% |
| **South Main** | 25.8% | 4.5% | 21.8% | 6.9% | 17.2% | 10.6% |
| **Lower Fraser** | 5.7% | 1.8% | 4.3% | 7.4% | 10.9% | 5.8% |
| **Thompson/UPFR** | 2.9% | 0.4% | 8.3% | 2.7% | 0.0% | 2.0% |
| **Canada** | 90.5% | 3.5% | 73.2% | 6.6% | 75.6% | 9.0% |
| | | | | | | |
| **Juan de Fuca** | 0.0% | 0.0% | 0.0% | 0.4% | 0.0% | 2.2% |
| **Puget Sound** | 3.9% | 2.8% | 26.8% | 6.6% | 12.6% | 7.5% |
| **Coastal** | 4.7% | 2.3% | 0.0% | 0.0% | 11.8% | 5.4% |
| **Columbia** | 0.0% | 0.8% | 0.0% | 1.9% | 0.0% | 0.0% |
| **US** | 8.6% | 3.5% | 26.8% | 6.6% | 24.4% | 9.0% |

**Seine/Gillnet fisheries Southern BC Cont'**

| | Seine Area21 Oct 17-24 | SD | Seine Barkley Sound Sept9-11 | SD | Gillnet Area21 Sept28-Oct8 | SD |
|---|---|---|---|---|---|---|
| **N** | 147 | | 100 | | 8 | |
| **WCVI** | 51.5% | 7.9% | 78.0% | 6.4% | 58.3% | 23.1% |
| **ECVI** | 8.1% | 7.4% | 13.1% | 5.7% | 27.1% | 24.2% |
| **S.Mainland** | 9.6% | 6.0% | 2.6% | 4.5% | 2.1% | 17.8% |
| **Lower Fraser** | 4.3% | 3.6% | 5.0% | 3.9% | 0.0% | 9.3% |
| **Thompson/UPFR** | 0.0% | 0.6% | 0.0% | 0.0% | 0.0% | 5.5% |
| **Total Canada** | 73.5% | 5.9% | 98.6% | 3.3% | 88.7% | 13.1% |
| | | | | | | |
| **Puget S.** | 14.2% | 5.1% | 1.4% | 3.0% | 12.6% | 12.8% |
| **J. de F.** | 0.4% | 2.6% | 0.0% | 0.6% | 0.0% | 0.0% |
| **Coastal** | 8.6% | 4.2% | 0.0% | 1.1% | 0.0% | 5.2% |
| **Columbia** | 3.3% | 2.2% | 0.0% | 0.4% | 0.0% | 0.0% |
| **Total US** | 26.5% | 5.9% | 1.4% | 3.3% | 12.6% | 13.1% |

**Round Island test fishery**

| | July 16-31 | SD | Aug1-13 | SD |
|---|---|---|---|---|
| **N** | 59 | | 27 | |
| **QCI** | 10.0% | 2.6% | 0.5% | 2.5% |
| **Skeena/Nass** | 17.4% | 3.6% | 4.4% | 4.7% |
| **Central Coast** | 3.8% | 3.3% | 23.0% | 6.0% |
| **Vancouver Isl** | 55.6% | 5.2% | 29.5% | 7.6% |
| **South Main** | 5.1% | 3.8% | 0.0% | 5.0% |
| **Lower Fraser** | 2.7% | 1.8% | 14.6% | 5.7% |
| **Thom/UPFR** | 0.0% | 0.0% | 0.4% | 2.0% |
| **Canada** | 94.5% | 4.0% | 72.5% | 6.8% |
| | | | | |
| **Juan de Fuca** | 0.0% | 1.7% | 0.0% | 1.2% |
| **Puget Sound** | 3.8% | 2.8% | 14.7% | 4.3% |
| **Coastal** | 0.1% | 1.8% | 12.9% | 5.0% |
| **Columbia** | 0.0% | 0.1% | 0.0% | 1.2% |
| **US** | 3.9% | 3.8% | 27.6% | 6.7% |

## **Appendix 2** (Continued)

| Recreational fisheries - North coast | | | | | Commerical fisheries - northern BC | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Seine and Troll | | Gillnet | | Seine | | Seine | | Seine | |
| | Area3 | | Area4 | | Areas 1 and 2W | | Area2E | | Area2E | | Area 3 | | Area3 | |
| | July 25-Aug23 | | July 25-Aug 15 | | July 25- Aug 29 | | Sep 19-Oct 10 | | Sep 19-Oct 10 | | July 18 - Aug 1 | | Aug-08 | |
| | | **SD** | | **SD** | | **SD** | | **SD** | | **SD** | | **SD** | | **SD** |
| **N** | 77 | | 67 | | 286 | | 123 | | 260 | | 153 | | 498 | |
| **QCI** | 11.1% | 4.8% | 12.6% | 5.1% | 10.9% | 2.6% | 62.2% | 5.7% | 73.6% | 4.7% | 0.0% | 1.5% | 3.6% | 1.4% |
| **Skeena/Nass** | 32.6% | 6.8% | 12.0% | 5.2% | 6.9% | 2.6% | 4.1% | 5.4% | 0.9% | 1.2% | 29.1% | 6.1% | 33.8% | 3.4% |
| **Central Coast** | 34.2% | 8.4% | 34.9% | 10.9% | 15.0% | 3.9% | 4.7% | 3.4% | 5.1% | 3.0% | 12.6% | 5.2% | 16.6% | 3.1% |
| **Vancouver Isl** | 14.5% | 8.4% | 12.5% | 7.9% | 41.0% | 6.0% | 22.2% | 5.8% | 14.4% | 4.7% | 25.2% | 5.9% | 21.5% | 3.5% |
| **South Main** | 1.9% | 4.1% | 20.7% | 9.4% | 8.7% | 3.7% | 0.4% | 2.1% | 1.4% | 1.9% | 3.4% | 3.2% | 12.6% | 2.9% |
| **Lower Fraser** | 0.3% | 3.7% | 2.3% | 4.2% | 2.6% | 2.5% | 0.0% | 1.9% | 2.1% | 1.6% | 11.8% | 4.1% | 1.4% | 2.0% |
| **Thompson/UPFR** | 0.0% | 0.5% | 0.4% | 1.0% | 0.4% | 0.6% | 0.9% | 1.1% | 0.1% | 0.5% | 0.9% | 0.9% | 0.1% | 0.4% |
| **Canada** | 96.7% | 5.3% | 95.4% | 5.8% | 85.7% | 3.8% | 94.5% | 3.2% | 97.6% | 96.3% | 83.0% | 5.5% | 89.5% | 3.0% |
| | | | | | | | | | | | | | | |
| **SE Alaska** | 1.8% | 3.2% | 0.0% | 2.5% | 4.8% | 2.4% | 1.0% | 1.6% | 0.7% | 1.0% | 14.1% | 4.3% | 4.8% | 1.7% |
| **Juan de Fuca** | 0.0% | 1.0% | 0.0% | 1.5% | 3.1% | 1.8% | 0.0% | 0.8% | 0.0% | 0.5% | 0.8% | 1.9% | 1.3% | 1.0% |
| **Puget Sound** | 3.5% | 3.7% | 4.5% | 4.1% | 4.2% | 2.4% | 3.4% | 2.6% | 0.8% | 1.5% | 0.0% | 1.9% | 1.8% | 1.6% |
| **Coastal** | 0.0% | 2.1% | 0.1% | 2.8% | 2.3% | 1.8% | 0.5% | 1.0% | 1.0% | 0.8% | 2.2% | 2.2% | 2.4% | 1.3% |
| **Columbia** | 0.0% | 0.0% | 0.0% | 0.8% | 0.0% | 0.3% | 0.6% | 0.9% | 0.0% | 0.0% | 0.0% | 0.7% | 0.2% | 0.6% |
| **US** | 5.4% | 5.3% | 4.6% | 5.8% | 14.4% | 3.8% | 5.5% | 3.2% | 2.4% | 2.1% | 17.0% | 5.5% | 10.5% | 3.0% |

| Commerical fisheries - northern BC Cont' | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Seine | | Gillnet | | Gillnet | | Seine | | Gillnet | | Seine | | Seine | |
| | Area3 | | Area3 | | Area4 | | Area6 | | Area6 | | Area7 | | Area8 | |
| | Aug 15-Aug 31 | | July 11- Aug 22 | | July18-July25 | | July18-Aug22 | | July25-Aug29 | | Aug30-Sept12 | | July18-Aug29 | |
| | | **SD** | | **SD** | | **SD** | | **SD** | | **SD** | | **SD** | | **SD** |
| **N** | 92 | | 25 | | 8 | | 605 | | 73 | | 22 | | 131 | |
| **QCI** | 3.8% | 3.3% | 7.8% | 5.8% | 3.8% | 10.5% | 3.7% | 1.3% | 2.1% | 2.3% | 4.0% | 5.6% | 1.5% | 2.0% |
| **Skeena/Nass** | 25.0% | 9.8% | 14.5% | 7.6% | 14.7% | 13.4% | 9.8% | 2.7% | 1.7% | 7.3% | 19.3% | 11.5% | 1.0% | 2.6% |
| **Central Coast** | 22.2% | 9.0% | 36.1% | 12.1% | 34.8% | 22.3% | 50.3% | 4.4% | 49.9% | 11.5% | 13.7% | 13.0% | 59.5% | 9.0% |
| **Vancouver Isl** | 26.8% | 8.8% | 7.8% | 11.2% | 46.7% | 26.4% | 12.6% | 4.0% | 10.9% | 6.1% | 47.2% | 16.7% | 7.4% | 6.7% |
| **South Main** | 2.6% | 5.4% | 4.9% | 10.0% | 0.0% | 5.5% | 12.0% | 3.6% | 12.0% | 6.7% | 7.2% | 10.1% | 22.4% | 6.6% |
| **Lower Fraser** | 2.0% | 3.3% | 0.0% | 1.3% | 0.0% | 0.8% | 2.6% | 1.6% | 1.6% | 5.0% | 5.9% | 7.2% | 1.6% | 1.3% |
| **Thompson/UPFR** | 0.5% | 1.1% | 0.0% | 2.5% | 0.0% | 6.2% | 0.9% | 0.6% | 0.0% | 0.7% | 0.0% | 4.6% | 0.0% | 0.4% |
| **Canada** | 82.7% | 8.2% | 71.1% | 12.9% | 100.0% | 15.3% | 91.8% | 2.4% | 78.3% | 9.6% | 97.2% | 6.4% | 93.4% | 3.3% |
| | | | | | | | | | | | | | | |
| **SE Alaska** | 0.7% | 3.5% | 24.5% | 11.2% | 0.0% | 0.0% | 4.9% | 1.5% | 9.5% | 7.2% | 0.0% | 0.5% | 0.5% | 1.9% |
| **Juan de Fuca** | 0.0% | 0.3% | 0.0% | 1.7% | 0.0% | 0.0% | 0.2% | 0.9% | 0.5% | 3.0% | 0.0% | 3.8% | 0.2% | 1.1% |
| **Puget Sound** | 3.6% | 6.0% | 0.0% | 5.6% | 0.0% | 15.1% | 2.4% | 1.6% | 2.2% | 4.7% | 0.0% | 0.0% | 2.0% | 2.3% |
| **Coastal** | 13.1% | 5.8% | 4.4% | 4.6% | 0.0% | 1.8% | 0.5% | 1.3% | 0.3% | 4.2% | 2.8% | 5.2% | 3.9% | 2.3% |
| **Columbia** | 0.0% | 1.5% | 0.0% | 0.0% | 0.0% | 0.0% | 0.2% | 0.6% | 9.3% | 6.7% | 0.0% | 1.3% | 0.0% | 0.5% |
| **US** | 17.3% | 8.2% | 28.9% | 12.9% | 0.0% | 15.3% | 8.2% | 2.4% | 21.7% | 9.6% | 2.8% | 6.4% | 6.6% | 3.3% |

**Appendix 2** (Continued

| Fraser River | | | | | | |
|---|---|---|---|---|---|---|
| | gillnet | | gillnet | | Cottonwood | |
| | Aug 1-7 | | Aug 17-25 | | Aug26-Sept17 | |
| | | **SD** | | **SD** | | **SD** |
| **N** | 10 | | 12 | | 49 | |
| **Lower Fraser** | 100.0% | na | 80.6% | na | 51.7% | 9.6% |
| **Thompson/UPFR** | 0.0% | na | 19.3% | na | 48.2% | 9.4% |

**Fraser River Test Fisheries**

| **Tangle net** | Prior to Sept. 22 | | Sept 23 - Oct 02 | | Oct 03 - 08 | |
|---|---|---|---|---|---|---|
| **N** | 59 | **SD** | 122 | **SD** | 79 | **SD** |
| **Lower Fraser** | 73.4% | 7.0% | 86.5% | 3.2% | 95.7% | 2.8% |
| **Thompson/UPFR** | 26.6% | 7.0% | 13.5% | 3.2% | 4.3% | 2.8% |

| **Tangle net** Continued | | | | | | |
|---|---|---|---|---|---|---|
| | Oct 09 - 15 | | Oct 16 -22 | | Oct 23-Nov 15 | |
| **N** | 247 | **SD** | 254 | **SD** | 146 | **SD** |
| **Lower Fraser** | 96.8% | 1.5% | 99.6% | 0.8% | 99.4% | 1.0% |
| **Thompson/UPFR** | 3.2% | 1.5% | 0.4% | 0.8% | 0.6% | 1.0% |

| **Albion** | Prior to Sept. 22 | | Sept 23-Oct 8 | | Oct 9- Oct 19 | |
|---|---|---|---|---|---|---|
| **N** | 33 | **SD** | 37 | **SD** | 42 | **SD** |
| **Lower Fraser** | 69.0% | 10.0% | 99.5% | 4.4% | 100.0% | 3.2% |
| **Thompson/UPFR** | 31.0% | 10.0% | 0.5% | 4.4% | 0.0% | 3.2% |

## 14 Appendix 3. List of Thompson Basin and Upper Fraser River tributary streams for which escapement survey histories and subsequent escapement estimates are available, 1990 - 1998.

| North Thompson | South Thompson | Lower Thompson | Upper Fraser/non Thompson |
|---|---|---|---|
| Albreda River | Adams River | Bonaparte River | Bridge River |
| Avola Creek | Ansty River | Clapperton Creek | Cayoosh Creek |
| Barriere River | Bessette Creek | Coldwater River | Gates Creek |
| Blue River | Blurton Creek | Deadman River | Nahatlatch River |
| Brookfield Creek | Bolean Creek | Guichon Creek | Portage Creek |
| Cedar Creek | Canoe Creek | Nicola River | Seton River |
| Clearwater River | Cayenne Creek | | Stein River |
| Cook Creek | Celista Creek | | Yalakum River |
| Crossing Creek | Crazy Creek | | |
| Dunn Creek | Creighton Creek | | |
| E. Barriere River | Danforth Creek | | |
| Fennell Creek | Duteau Creek | | |
| Finn Creek | Eagle River | | |
| Goose Creek | Fortune Creek | | |
| Haggard Creek | Harris Creek | | |
| Lemieux Creek | Hunakwa Creek | | |
| Lion Creek | Ireland Creek | | |
| Louis Creek | Johnson Creek | | |
| Madd River | Kingfisher Creek | | |
| Mann Creek | Lower Shuswap River | | |
| McTaggart Creek | Mid-Shuswap River | | |
| Mahood River | Mcnomee Creek | | |
| N. Thompson River | Momich River | | |
| Raft River | Noisy Creek | | |
| Reg Christie Creek | Onyx Creek | | |
| Shannon Creek | Owlhead Creek | | |
| TumTum Creek | Ross Creek | | |
| Wire Cache Creek | Salmon River | | |
| | Scotch Creek | | |
| | Seymour River | | |
| | Sinmax Creek | | |
| | Tappen Creek | | |
| | Trinity Creek | | |
| | Tsuius Creek | | |
| | Upper Adams River | | |
| | Wap Creek | | |

**Appendix 3** (Continued)

Should readers require complete escapement histories (1990-1998) for any stock listed above, please contact Richard Bailey, Chinook and Coho Biologist, Department of Fisheries and Oceans, Stock Assessment Division, 1278 Dalhousie Dr., Kamloops, B.C., V2C 6G3; email baileyri@pac.dfo-mpo.gc.ca.

Example of escapement survey history and subsequent escapement estimates to Albreda River, North Thompson River and tributaries; 1990 – 1998.

Abbreviations used: "N/R" – Not Recorded; "N/O" – None Observed; "(#)" – Number of coho counted; "N/I" – Not Inspected; "L" – Live fish; "D" – Dead fish

Sub - District 29J Clearwater **Albreda River 04 - 7800**

| **Section surveyed** | **1990** | **1991** | **1992** | **1993** | **1994** |
|---|---|---|---|---|---|
| C.N.R. bridge / Sand Cr. | 1 Spot ch. ( 381 ) | | | 2 Spot ch. ( 12 / 67 ) | |
| C.N.R. culverts | | 1 Spot ch. (12 ) | | 2 Spot ch. ( 0 / 0 ) | |
| Mouth to Swamps | | 1 Aerial ( 32 ) | | | |
| C.N.R. culverts upstream 1 km. | | | 2 Walk (137 / 23 ) | 1 Spot ch. ( 0 ) | |
| Mouth to Clemina Cr. | | | | 2 walk ( 48 / 0 ) | |
| | | | | | |
| Escapement estimate | 800 | 50 | 200 | 100 | N/R |
| Index Factor applied | N/R | N/R | N/R | N/R | N/R |
| Coho : arrival ; end of spawn | Nov. 01 - Dec. 15 | Nov. 01 - Dec. 10 | Oct. 25 - Dec. 10 | Nov. 02 - Dec.01 | N/R |

| **Section surveyed** | **1995** | **1996** | **1997** | **1998** | **1998 Trend est.** |
|---|---|---|---|---|---|
| Transmountain pipeline | | | | 1 Spot ch. ( 2 ) | |
| C.N.R. bridge / Sand Cr. | | | 1 Spot ch. ( 0) | | |
| C.N.R. culverts | | | 1 Spot ch. ( 0 ) | | |
| Mouth to swamps | | | | 1 Aerial ( 2 ) | |
| C.N.R. culverts upstream 1 km | | | | 1 spot ch. ( 0 ) | |
| Mouth to Clemina Cr. | | 1 Spot ch. ( 0 ) | 1 Spot ch. ( 0 ) | | |
| | | | | | |
| Escapement estimate | 0 | 0 | 0 | 14 | 10 |
| Index Factor applied | N/R | N/R | N/R | L + D x 5 + Redds x 2 | See Comment |
| Coho : arrival : end of spawn | N/R | Oct. - Dec. 04 | N/R | Oct. 20 - Dec. 10 | |

Total accessible length of spawning area (meters) 30800 ( 30.8 km )

**Comments**

**1990** - Spot check survey conducted on Nov. 22, countability recorded at 50%.

**1991** - Aerial survey conducted on Nov. 26 recorded countability as 30%. Spot check survey on Nov. 2 with countability recorded as 30%.

**1992** - Surveyed by stream walk on Oct. 28 with countability at 80%, Nov. 11 was also by streamwalk and recorded 70% countability.

**1993** - Spot check surveys conducted on Nov. 09, 11, 19, 26 And Dec. 01, countability ranging from 15% to 60%. Stream walks were conducted on Nov. 02 and 22, countability ranged from 15% to 60%.

**1994** - A spot check was completed on Nov. 17, but section inspected were not recorded and no Coho were observed.

**1995** - Survey by method of spot check on Nov. 16, 28 and Dec. 08, unfortunately sections inspected were not recorded.

**1996** - Spot check was conducted on Dec. 11, countability was recorded at 50%.

**1997** - Nov. 11 spot checks were conducted in various locations, countability was recorded at 50%.

**1998** - Spot check surveys conducted on Nov. 03 and 18. Aerial survey conducted on Dec. 12, observer efficiency assumed to be 75%. Estimate based on peak live ( 1 ) + dead ( 1 ) x 5 + redds ( 2 ) x 2.2.

**1998 Trend estimate** - Because additional survey effort was expended in many streams during 1998, in some cases it was not valid to compare with previous years. When this was the case, a separate estimate was generated with the probable number of fish that would have been estimated if survey effort would have been the similar to other recent years. *1998 Trend estimate based on limited data from spot checks. It is probable, that an estimate of 10 Coho would have been recorded using 1997 surveys.*