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Status in 1999 of Coho Stocks Adjacent to the Strait of Georgia

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ABSTRACT

Escapements of 1996 brood coho were poor relative to 1998 and 10-year averages in areas of the Georgia Basin other than the lower Fraser. Compared to ten year averages, one lower Fraser wild indicator, Salmon River, was very poor and another, Upper Pitt, quite good. 1999 escapements were better than 1998 escapements in this area with the notable exception of the Salmon River indicator stock. In terms of the provisional limit reference point of 3 females/km, virtually all enumerated stocks in the Basin were above the limit. Escapements were the result of poor escapements in 1996 and poor marine survival. Exploitation due to release mortalities and catch in Alaska was 13.1% for ECVI and lower Fraser coho. Most of the exploitation was from release mortalities in BC, as estimated using DNA estimates of stock composition and estimates of regional escapements. If accurate, and our confidence in the escapement estimates is low, these values approximate the exploitation of wild coho. Extremely low marine survival is the driving short-term cause of poor abundances. A slight increase in 1999 everywhere except in the northern Strait provides some hope that the decline has stopped.

Based on smolt estimates at Black Creek and Salmon River and using fry densities and sizes, the 1997 brood smolt runs were probably below average in 1999 and possibly well below average on the Sunshine Coast. With marine survivals forecast to remain poor, we expect escapements in 2000 to be well below 1990's averages, similar to 1999 except in the Fraser Valley where escapements were not as depressed in 1999. Nevertheless, assuming continued near-abatement of exploitation, most monitored stocks will probably exceed the provisional limit reference point of three females per kilometre of stream as they did in 1999.

Considering the current low productivity of Georgia Basin coho, we recommend that fishing mortality remain similar to existing minimal levels in order to ensure that there is a sufficient proportion of escapements that exceed the provisional limit reference point.

The abundance of 1998 brood smolts this spring will probably be better than the 10-year average everywhere except possibly on the Sunshine Coast. Excluding this part of the Basin, fry densities were above average in 1999 in response to average to better than average escapements. Their sizes were probably sufficient to provide average winter survival with some regional variation. With inadequate data coverage, we think fry abundances were probably poor on the Sunshine Coast and winter survival, as inferred from fry size, was likely average despite lower densities. Smolt runs may be poor in this area but sample sizes were too small to conclude this with any confidence.

Fry densities at both the individual stream level and summarised over the Basin are correlated with parental escapements throughout the 1990's, which is the period of the fry survey. Fry surveys are an economical and effective way to determine trends (at least) in escapements when escapements are low to moderate. Continuing in a tactical vein, a 'full' indicator facility is needed on the Sunshine Coast where juveniles are enumerated and tagged and adults are accurately counted and sampled. Another is required in the Fraser Valley. The existing indicator of Salmon River and the escapement indicator of Upper Pitt have different escapement trends and the area requires another full indicator facility.

RÉSUMÉ

Les échappées de saumon coho de la classe 1996 dans les régions de Georgia Basin autres que le bas-Fraser étaient faibles par rapport à 1998 et aux moyennes décennales. En comparaison de ces dernières, un indicateur des stocks sauvages du bas-Fraser, soit Salmon River, était très mauvais et un autre, celui du cours supérieur de Upper Pitt, assez bon. Les échappées étaient plus abondantes en 1999 qu'en 1998 dans cette région, sauf dans le cas du stock indicateur de Salmon River. Presque tous les stocks dénombrés dans le bassin se situaient au-dessus du point de référence limite provisoire de 3 femelles/km. Ce niveau d'échappée est attribuable aux échappées faibles en 1996 et au faible taux de survie en mer. Le niveau d'exploitation attribuable à la mortalité suite à la remise à l'eau des captures et aux prises alaskiennes se chiffrait à 13,1 % dans le cas du coho de la CEIV et du bas-Fraser. La plus grande partie de l'exploitation résulte de la mortalité suite à la remise à l'eau des captures en Colombie-Britannique, telle qu'estimée d'après des analyses de la composition d'ADN des stocks et des estimations des échappées régionales. Si ces valeurs sont précises et que l'on accorde peu de confiance aux estimations des échappées, ces valeurs se rapprochent de l'exploitation du coho sauvage. Les taux de survie en mer extrêmement faibles sont à l'origine, à court terme, des abondances faibles. Une légère hausse de ces taux à tous les endroits en 1999, sauf dans le nord du détroit, donne un peu d'espoir que le déclin de l'abondance a pris fin.

D'après des estimations du nombre de smolts dans Black Creek et Salmon River, ainsi que les densités et les tailles des alevins, les remontes de smolts de la classe 1997 étaient probablement inférieures à la moyenne en 1999 et peut-être bien au-dessous de la moyenne dans la région côtière Sunshine Coast. Comme l'on prévoit que les taux de survie en mer demeureront faibles, nous nous attendons à ce que les échappées en 2000 se chiffrent bien au-dessous des moyennes observées dans les années 90 et qu'elles se comparent à celles de 1999, sauf dans Fraser Valley où les échappées n'étaient pas aussi réduites en 1999. Néanmoins, si l'on suppose que l'exploitation sera presque éliminée, la plupart des stocks contrôlés dépasseront probablement le point de référence limite provisoire de 3 femelles/km de cours d'eau, comme cela était le cas en 1999.

Compte tenu de la faible productivité actuelle du coho dans Georgia Basin, nous recommandons que le taux de mortalité par la pêche soit maintenu aux taux minimums actuels afin d'assurer que le nombre d'échappées dépasse le point de référence limite provisoire.

Ce printemps, l'abondance de smolts de la classe 1998 sera probablement plus élevée que la moyenne décennale dans tout le bassin, sauf peut-être dans la région côtière Sunshine Coast. Abstraction faite de cette partie du bassin, les densités des alevins se chiffraient au-dessus de la moyenne en 1999 grâce à des échappées se chiffrant de moyennes à supérieures à la moyenne. Les alevins étaient probablement assez gros pour qu'ils aient un taux de survie moyen en hiver variant quelque peu selon la région. Malgré la couverture inadéquate des données, nous croyons que les niveaux d'abondance d'alevins étaient probablement bas dans la région côtière Sunshine Coast et que le taux de survie en hiver, tel que déduit de la taille des alevins, était probablement moyen malgré les faibles densités. Les remontes de smolts sont peut-être mauvaises dans cette région, mais la petite taille des échantillons ne permet pas de tirer cette conclusion avec confiance.

Les densités des alevins dans chaque cours d'eau et dans l'ensemble du bassin sont en corrélation avec les échappées de géniteurs pendant toutes les années 90, soit la période de relevé des alevins. Les relevés des alevins sont un moyen économique et efficace pour déterminer les tendances (au moins) des échappées lorsqu'elles sont faibles à modérées. Dans le même esprit tactique, une installation « pleinement » indicatrice est requise dans la région côtière Sunshine Coast, où les juvéniles seraient dénombrés et étiquetés et les adultes, dénombrés précisément et échantillonnés. Une autre installation du genre est aussi requise dans la vallée du Fraser, car l'indicateur actuel, la Salmon River, et l'indicateur des échappées de Upper Pitt, donnent des tendances différentes des échappées.

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INTRODUCTION

This is the seventh PSARC Working Paper presenting an assessment of the coho populations in the Georgia Basin and provides 1999 data to update the last report (Simpson et al. 1999). The assessment information includes juvenile abundance data, catches, escapements, survival rates and exploitation rates. We do not discuss coho stocks in the Thompson and upper Fraser drainages. We define 'Georgia Basin' for this report as Canadian drainages emptying into the Strait of Georgia, including the Fraser system as far upstream as Hope. An accompanying paper will present data for other Fraser coho stocks (Irvine et al. 2000). The status of West Vancouver Island coho is also being discussed in another paper (Dobson et al. 2000). Forecasts of the 1999 marine survival, abundance and distribution of southern BC coho have been submitted (Holtby et al. 2000).

1 METHODS

Assessment of coho from the Georgia Basin relies on using some stocks to represent other stocks in the same area (e.g. Symons and Waldichuk 1984). These 'indicator' stocks include all wild and most hatchery stocks that have reliable smolt release, catch and escapement data. The catch distributions of coded wire tagged (CWT'd) coho from 1990 to 1993 were analysed by cluster analysis in Kadowaki et al. (1995) to define stock aggregates that may be associated with indicator stocks. Melding the cluster analysis results with criteria of geographic proximity and biogeography yielded stock aggregates representing seven regions: SE Vancouver Island, Nanaimo area, Baynes Sd., Campbell River area, Powell River area, Sunshine Coast /Squamish /North Shore, and lower Fraser. Based on the between-stream covariations that can be seen in the data summarised in this report and from earlier work (e.g. Labelle 1990a), marine mortality factors appear to be sufficiently similar between stocks in a region to permit the indicator stock strategy to be a valid practical solution to the prohibitively high cost of obtaining extensive survival and exploitation rate data.

The interpretation of data obtained from indicator stocks is supplemented with extensive assessments of fry densities, which can be obtained relatively cheaply. Although not as readily obtained, we are also estimating more escapements using 'area-under-the-curve' (AUC) analyses of counts from multiple visits. The stocks discussed in Sections 1.1 and 1.2 are the nodes of our network of heightened accuracy data: what we refer to as 'indicator' stocks. The more numerous sources of data where sampling error is expected to be larger make up the 'extensive' network. This largely consists of escapement and fry data.

Black Creek and Salmon River (Langley) are the only wild populations where we have the smolt, catch and escapement data needed to estimate survival and exploitation rates. The Mesachie Creek indicator operation ended in 1996. There is a time series of medium quality estimates of coho escapements from a suite of Cowichan River tributaries and from upper Pitt River. All other indicators having what we characterise as 'intensive' data sets are hatchery stocks or enhanced streams, e.g. Chase River in Nanaimo.

1.1 WILD INDICATOR STOCKS

1.1.1 Black Creek

This creek flows into the Strait of Georgia mid-way between Courtenay and Campbell River and is a mid-sized, low gradient stream, 31 km long (Brown et al. 1996). It is the site of the longest and most complete time series of wild coho data in the Georgia Basin.

There was an adult counting fence near tidewater for six years between 1968 and 1980 and every year since 1985 (Kadowaki et al. 1995). Of the pre-1980 counts, 1975 and 1978 are considered the most accurate and are the only escapements used from this period in this report. However, the 1975 escapement may be an underestimate (the escapement includes an estimate of 450 uncounted coho during a two-day breach and the fence was also terminated early). Escapements from 1985 to 1999 were estimated using mark recapture (MR) analyses of coho tagged at the fence. However, a large proportion of the spawners were counted at the fence in most years: the MR estimate was less than 10% greater than the fence count of adults in 1986, 1987, 1992, 1993, 1995 and 1999. Only the 1985, 1997 and 1998 fence counts were less than half the MR estimate. The 1996 adult count was barely more than half the MR estimate (147/283).

We have fence counts of smolts in 1978 and 1979 and for every year since 1985. The fences caught virtually all smolts during their operation in most years. The median expansion multiplier of the fence count to obtain the estimated smolt numbers used in this report was 1.03. The proportion of tagged adults in 1985 was about half the proportion of smolts that were thought to have been tagged. Labelle (1990b) thought the most likely explanation was that the actual number of smolts was about double the original estimate, i.e. the number of uncounted and untagged smolts was underestimated. However, the proportion of tagged adults was also low in 1996, 1997 and 1998: 64.2%, 19.6% and 40.5%. Although adult runs in 1996 and 1997 were small enough that it is conceivable that the untagged adults were missed as smolts, there were fully 4,531 untagged adults estimated in 1998 – too many to be explained this way. Other possible reasons need to be examined, in particular the possibility that significant straying is occurring into Black Creek, perhaps from Oyster River nearby. For now, we will present smolt numbers not corrected for adult mark rate. This uncertainty does not affect estimates of marine survival and exploitation since only tagged coho are used in the calculations.

Black Creek smolt and adult assessments up to the spring of 1995 are published: Clarke and Irvine (1989), Fielden et al. (1989), Labelle (1990a), Bocking et al. (1991, 1992), Nass et al. (1993a,b), Nelson et al. (1994a,b, 1995, 1996), and Nelson and Simpson (1996).

1.1.2 Salmon River (Langley)

Salmon River is a lowland tributary that flows northeast for 33 km before it enters the Fraser River near Fort Langley. It is one of several streams called Salmon River in British Columbia. ‘Salmon River’ in this report always refers to this stream. Its principal tributary, Coghlan Creek, joins the mainstem 14 km upstream from the Fraser River. Salmon River supports the largest coho population of any of the wild stock indicators.

Escapement estimates provided by fishery officers are available from 1951 to 1987 (Farwell et al. 1987; unpublished files). We have little confidence in the accuracy of these estimates because visual counts are difficult and the estimation procedures were not documented. These data, therefore, will not be presented here.

During 1977-1981, escapement was monitored using systematic foot surveys (Schubert 1982b; Schubert and Fleming 1989); however, estimations of accuracy and precision were largely inadequate. In 1982 and 1986, traps were installed in culverts where the river passes under the dike at the river mouth (Schubert and Fleming 1989). This technique proved unsuitable because the traps could not fish during high flows. Furthermore, tagging data showed that fish from nearby stocks would enter the trap and subsequently leave the Salmon River when the traps were removed during freshets.

Since 1987, escapement has been estimated using the single census Chapman version of the Petersen MR technique. From 1987 to 1996, coho adults were captured using an electroshocker and marked with disk tags and opercular punches. Starting and continuing since 1997, a fence installed 5 km from the mouth was used to capture fish for this purpose. The fence by itself was not thought to be able to capture all coho because of possible high water events which could pass fish by the structure without being counted; hence, our continued reliance on mark and recapture as a means of estimating the escapement. We estimate escapements by recovering and examining carcasses for marked and unmarked coho (e.g. Schubert et al. 1994a).

Smolt traps were operated in the Salmon River and in Coghlan Creek during the springs of 1978-1980 (Schubert 1982a) and 1986-1999 (Schubert and Kalnin 1990; Farwell et al. 1991; 1992a,b; Kalnin and Schubert 1991; Schubert et al. 1994a,b; R. Diewert and R. Semple, unpubl. data). Up to 1997, the Coghlan and Salmon traps, which were located in Williams Park, 14 km from the mouth, were designed solely to capture coho smolts for coded wire tag application. In 1998 and 1999 they were used to capture smolts to mark (Panjet dye and/or a fin clip) as part of a Petersen population estimate. Mark recovery took place at the new fence in the lower Salmon River, where smolts were also coded wire tagged. None of the smolt fence installations provide estimates of total smolt production because the trapping period did not encompass the entire emigration period, nor could the traps be operated during high flows. Smolt production from the river downstream of the traps was not directly assessed in any year. In the case of the lower Salmon fence, this may not be important because we feel that all of the fry production comes from upstream habitat. However, it is possible that smolts are over-wintering in the 5 km below the fence (or even elsewhere in the lower Fraser).

To index smolt trends, we used a smolt production index (SPI, Schubert et al. 1994a). The index represents Petersen estimates, scaled by a factor of 10^{-5}, using fin clipped smolts as the mark application sample and adult recoveries as the census sample. The estimates are expressed as an index because capture and tagging probably reduced smolt to adult survival, introducing an unknown positive bias in the population estimates. However, the bias is presumably similar among years. Perhaps of more concern is the possibility that the proportion of tagged adults differs from the proportion of the brood year smolt population that was tagged, like seen in recent years at Black Creek (Sect. 1.1.1) and elsewhere (e.g. Lachmach River, Lane et al. 1994). This mark recapture might then be an estimate of all juvenile emigrants, not just the smolts leaving in the April to June period, if that is the reason for the discrepancy, or may be erroneous if the cause is adult straying, for example. Whatever the cause, the effect would be to over-estimate the April to June smolt migration.

1.1.3 Upper Pitt River

The upper Pitt River originates in Garibaldi Provincial Park and flows 52 km in a southerly direction to the north end of Pitt Lake. The lower Pitt River drains Pitt Lake and enters the north side of the Fraser River near Coquitlam. The upper Pitt River flows for most of its length in a braided, shifting channel through a 1 km wide U-shaped valley. The river has a relatively high rate of bed-load transport and an overall gradient of 3.2% (Elson 1985). Tributaries enter the upper Pitt River mainstem from steep valleys and have short, flat, delta areas in the river's floodplain.

The hydrograph of the upper Pitt River reflects a dominant summer glacial melt with low flows from December to March. Daily river discharges vary widely in the fall due to frequent heavy rainfalls and freezing and thawing temperatures. Extreme autumn discharges often result in scouring and shifts in the main river channel (Elson 1985).

Coho salmon enter the upper Pitt River system as early as September and begin to spawn in mid-November. There are no obstructions to adult migration for the lower 40 km of the river but adults usually concentrate in a reach half that length (Elson 1985). The main run of adults usually remains in the upper Pitt mainstem through December with peak spawning occurring later that month (Schubert 1982b). Coho spawning is generally confined to side channels and the lower two km of tributaries. A second group of coho may arrive in the river in late January and spawn in early February.

Escapement estimates provided by fishery officers are available from 1951 to 1996 (Schubert and Fedorenko 1985; unpublished files). We have little confidence in the accuracy of these estimates because river conditions often made enumeration difficult, and the estimation procedures were not documented. These data, therefore, will not be presented here.

Systematic spawning ground surveys were carried out from 1977 to 1981 and in 1983 (Schubert 1982b, Schubert and Fleming 1989). Escapement estimates were derived subjectively based on live and dead counts in conjunction with sighting conditions, physical stream characteristics and carcass flushing rates.

In 1982 and from 1994 to 1999, escapement has been estimated using the Chapman version of the Petersen MR technique (Schubert and Fleming 1989; R. Diewert and R. Semple unpubl. data). Coho adults were captured mainly by beach seine in the lower reaches of the mainstem upper Pitt River and marked with uniquely numbered disk tags and opercular punches. Tributary spawning grounds were surveyed throughout the spawning period and the incidence of disk tagged carcasses was used to estimate the total spawning escapement.

1.1.4 Cowichan River System

Cowichan River drains Cowichan Lake and flows east for 50 km to Duncan and Cowichan Bay. It is a large system for Vancouver Island, draining 842 km^2. Its mean annual discharge is about 44 m^3/sec (Armstrong and Argue 1977). It was recognised as one of the seven most important coho systems in the province (Aro and Shepard 1967) and is still a large producer (mean 1990-97 escapement of 10,500; see also Holtby, 1993).

The Fisheries Research Board of Canada operated a hatchery and adult counting fence from 1938 to 1944 on Oliver Creek, which enters Cowichan River just below Cowichan Lake. They also surveyed several other creeks, including Mesachie Creek in four of those years. Holtby (1993) has reconstructed the probable Mesachie escapement so we have escapement estimates for both creeks in this period. Several other assessments have occurred since, most notably a CWT program in 1975 and 1976 (Armstrong and Argue 1977; Argue et al. 1979) and CWT recovery and escapement estimates from 1976 to 1979 (Lister et al. 1981). Mesachie Creek was a full indicator stream with an upstream/downstream fence from 1986 to 1996 and is described by Holtby (1993).

AUC estimates of coho escapements have been made in six or seven tributaries of the Cowichan River since 1989. The tributaries are: Mesachie Creek, Robertson River side channel, Patricia Creek and Shaw Creek (all of which are tributaries of Cowichan Lake); Oliver Creek at the outlet of Cowichan Lake; and Rotary Park side channel and Richards Creek which are in and near Duncan, respectively. All are wild to the extent that no fry or smolt releases occur, although some fry salvaging has taken place in the past. The spawning habitat in Robertson and Rotary side channels has deteriorated so much we no longer count coho there.

1.2 HATCHERY AND ENHANCED INDICATOR STOCKS

Coded-wire tagged hatchery stocks provide much of the critical data for determining catch distribution, survival and exploitation rates. Hatchery stocks have been tagged since the late 1960’s and thus have a long time series of data. Generally, hatchery coho do not survive as well as adjacent wild stocks, but their survival, exploitation rate and catch distribution pattern correlate well with wild stock patterns. Hatchery indicator information is valuable to supplement intensive wild indicator data within a year and to provide data before wild monitoring began in the mid-1980’s.

The following hatcheries are used because they have complete escapement information. Data from hatcheries with absent or incomplete escapement data can only be used for catch distribution.

1.2.1 Vancouver Island

Goldstream River Hatchery, on the southern end of Vancouver Island, will be used as an indicator in subsequent assessments. This stock has been tagged since the 1996 brood and an enumeration fence now exists.

Big Qualicum. Big Qualicum River is 11 km long and runs from Horne Lake into the Strait of Georgia, 60 km north of Nanaimo. The Big Qualicum Project was the first of the modern enhancement projects to be undertaken in British Columbia. The project consists of a counting fence, chum spawning channels, incubation and rearing facilities for chinook, coho, steelhead and cutthroat, and complete flow control of the river.

Big Qualicum provides the longest time series of data for Strait of Georgia coho marine survival and exploitation rate trends. This stock is used as an indicator of survival trends and distribution for mid-Vancouver Island and Sunshine Coast coho stocks. Smolt releases have been consistently marked since the 1969 brood with adipose clips and coded-wire tags. Returning adults and jacks are enumerated and sampled for marks at the counting fence, located approximately one km from the estuary. Some fish are placed above the fence after sampling and allowed to spawn naturally. Less than 5% of the returns are estimated to spawn below the fence. These fish are not sampled for marks.

The 1995 brood coho were mass marked with a pelvic clip. Since then, smolts have been mass marked with an adipose clip. Tagging levels have doubled since the 1995 brood. For 1995 brood, 40k coho were tagged and marked with an adipose clip and 40k were tagged and marked with an adipose-left pelvic clip. For 1996 brood onward, 40k were tagged and marked with an adipose clip (Ad-CWT) and 40k were tagged but not clipped (CWT-only). Comparison of the different groups will help to determine survival rate differences due to clipping and the effects, if any, of any selective mass marked fisheries. In 1998, freshwater sport fisheries in the Big Qualicum River were mark selective fisheries. In 1999, the terminal marine area was mark retention only while the in-river fishery was open for both marked and unmarked coho between the beginning of October and mid-November. The fishery began in an area north of Big Qualicum River as a mainly shore-based fishery and expanded into the river in mid-October. A single observer patrolled the various access points along the beach daily throughout the fishery and interviewed fishers for catch and effort information. Once the river fishery opened, interview effort was split between the river access at Big Qualicum Hatchery and the beach accesses.

Electronic detection equipment was installed in 1999 to permit detection of coded-wire tags in the escapement.

Quinsam. The Quinsam River is a tributary of the Campbell River, which enters Discovery Passage in the town of Campbell River. The hatchery is located 3 km above the confluence of the Quinsam and Campbell Rivers, which is 3.5 km from the estuary. The project consists of a diversion fence and incubation and rearing facilities for coho, chinook, pink and steelhead.

Quinsam stock is used as an indicator of survival trends, exploitation rate and distribution for north Vancouver Island and mainland inlet coho stocks. Smolt releases have been consistently marked with adipose clips and coded-wire tags since the 1974 brood. Returning adults and jacks are enumerated and sampled for marks at the diversion fence. Some fish are placed above the fence and allowed to spawn naturally. Wild smolts from brood years 1972 to 1976, 1984 and 1985 were also marked. Five to ten percent of the returns are estimated to spawn naturally below the fence. These fish are not sampled for marks. Additionally, some fish do pass above the fence unsampled, the number depending on flow conditions in the river. Attempts are made to quantify the unsampled number.

The 1995 brood Quinsam coho were not mass marked, due to disease concerns and the timing of the decision to mark. From 1996 brood onward, smolts have been mass marked with an adipose clip. As for Big Qualicum, representative groups of Ad-CWT and CWT-only coho were released.

In 1998 and 1999, the diversion fence was topped during high water events. Concerns were raised about the possibility of coho that were released above the fence dropping back below the fence and returning to the hatchery. In 1999, some fish were marked with operculum punches in an effort to determine the return rate. A number of marked fish did return to the hatchery. Since the fish are released around a bend just upstream of the fence, it was felt that during periods of high flow the fish are being carried downstream below the fence before they can recover and orient themselves after being transported. Estimates of fish above the fence were adjusted to account for recaptures, but the release strategy should be reviewed for future years.

Electronic detection equipment was installed in 1999 to permit detection of coded-wire tags in the escapement.

Chase River. This stream which enters the Nanaimo River estuary on the south side of Nanaimo is described by Irvine et al. 1994. It drains four regional district reservoirs and is about 11 km long; 4.5 km of which is accessible to coho and chum salmon. One salmon-bearing tributary enters the mainstem 2.8 km from the mouth. The range in discharge is approximately 0.2 to 35 $m^3 \cdot sec^{-1}$. Most spawning occurs from the mouth to the tributary at 2.8 km.

The Malaspina University College Hatchery was built in 1985 and hatchery smolt releases began in 1987. Releases have ranged from 8,616 to 28,948 with no trend evident (Figure 12). The mean release is 14,434. Coded wire tagged smolts were released from 1989 to 1997.

Spawner populations were estimated by mark-recapture from 1988 to 1995 and by AUC calculations using visual counts from 1990 to 1995 and in 1998 and 1999. Malaspina University College made the estimates in conjunction with DFO (Irvine et al. 1994).

1.2.2 Mainland

We do not have a hatchery (or wild) indicator on the mainland coast of the Strait of Georgia north of the Fraser River. Powell River (Lang Cr.) and Capilano River data were not used because they are summer run stocks and are not regarded as representative of other stocks in the region. Capilano also has a large unassessed sport and aboriginal fishery. Tenderfoot Hatchery (Squamish R. system) may be used in future assessments. Its data must be reviewed and incorporated into the analysis if desirable.

Chilliwack. Chilliwack River flows northwest into Sumas River near the confluence with the Fraser River, near the town of Chilliwack. The hatchery is situated at Slesse Creek, approximately 35 km upstream from the mouth. It consists of a fishway and incubation and rearing facilities for coho, chum, chinook and steelhead. Enhancement began in 1980.

Coho have been released mainly as yearling smolts and have been tagged consistently from 1980 to the present. Hatchery returns are counted at the fishway and escapement estimates are made for several tributaries each year. A possibly substantial portion of the run used to be unaccounted for, due to a large freshwater sport fishery that has developed on the river. Catch estimates were approximately 2,000, 15,000 and 15,000 in 1985, 1986 and 1988 respectively (Hickey et al. 1987, Whyte et al. 1987, Whyte and Schubert 1990). Most of the catch was hatchery-origin. This fishery was not assessed between 1988 and 1998. The catch estimate for 1998 was 12,000 jack and adult coho [revision pending] and the preliminary 1999 estimate is 6,337 adults and 51 jacks (pers. comm. V. Palermo, DFO, 100 Annacis Parkway, Delta BC). Although the freshwater recreational catch is generally underestimated for a number of systems, the magnitude of the sport catch of Chilliwack Hatchery coho means that it's important to estimate.

The 1995 brood Chilliwack coho were mass marked with a pelvic clip and subsequent broods were adipose clipped. For the 1995 brood, both pelvic and adipose-pelvic groups of tagged fish were released. The application of 40k adipose-CWT had already occurred when we decided to mass mark. Therefore, an additional 40k Ad-CWT and 40k Ad-CWT-left pelvic were applied during the mass marking process, to ensure that comparisons could be made between the different groups of marks. The 1996 brood is represented by 40k Ad-CWT and 40k CWT-only. Freshwater sport fisheries in the Chilliwack River and most tributaries of the lower Fraser were mark selective fisheries in 1998 and 1999.

In 1998, electronic detection equipment was installed at the hatchery for testing. The equipment was fully functional in 1999.

Inch. Inch Creek is a small groundwater-fed tributary of Nicomen Slough, near Dewdney. The hatchery is situated at the head of the creek and consists of incubation and rearing facilities for chum, coho, chinook, cutthroat and steelhead. Chum enhancement began in 1970 and coho were added in 1979. The hatchery enhances a number of coho stocks, including Norrish, Stave and Inch. Other stocks have been enhanced in the past.

The Inch Creek coho stock has been released mainly as yearling smolts and has been tagged consistently since 1982. Most of the coho return to the hatchery to spawn. Returns to the hatchery are enumerated and sampled for marks and a dead-pitch is conducted to enumerate and sample natural spawners. The creek is short and groundwater-fed, making conditions good for accurate enumeration and sampling. Typically, few marked fish are observed spawning in the river. Inch Creek is the best indicator for exploitation rates of lower Fraser stocks, since almost the entire return can be enumerated and sampled. Some concerns have been raised, however, as to how well this stock represents other lower Fraser stocks.

The 1995 brood was mass marked with a pelvic clip. Subsequent releases from 1996 brood onward have been mass marked with an adipose clip. As at Big Qualicum, tagging levels were doubled for the 1995 and 1996 broods. For 1995 brood, 40k coho were tagged and marked with an adipose clip and 40k were tagged and marked with an adipose-left pelvic clip. For 1996 brood, 40k were tagged and marked with an adipose clip and 40k were tagged but not clipped. , Freshwater sport fisheries on the three stocks enhanced at Inch Hatchery were open for marked and unmarked fish retention in 1998, unlike many other lower Fraser tributaries. These fisheries were mark retention only in 1999.

1.3 FISHING MORTALITY

1.3.1 Catch Monitoring

Recreational and commercial catch estimates for 1970-1997 are from the salmon stock assessment catch database (Catch Database Spreadsheet System ver 3.4) accessed through the ALPHA computer at PBS.

Recreational catch estimates in the Strait of Georgia up to 1976 were based on subjective assessments and local creel surveys. The statistics from 1972 to 1976 were revised by Argue et al. (1977) using CWT recoveries. The Strait of Georgia creel survey began in 1980 and continues. However, starting in 1993, budget limitations have reduced the temporal coverage. In addition, there has been erosion in the number of fisher interviews during the survey period. Prior to 1993, the creel survey was conducted 12 months of the year but it was gradually reduced to 6 months by 1996-98 (April-September). Part of October was covered in the Victoria area in 1998. In 1999 creel surveys in the Strait of Georgia, West Coast Vancouver Island and Johnston Strait covered April-October, June-September and mid-June to mid-September, respectively. Recreational catches are not estimated elsewhere except in the lower Fraser. The lower Fraser survey was done in the mainstem in 1995 and 1996 but it was not designed for coho catch monitoring and terminated in September each year, before most returning coho were available in the river. Nor did the 1995-6 surveys cover the intense local sport fishery directed at Chilliwack Hatchery coho in the Chilliwack/Vedder River. However, there were separate creel surveys there in 1985, 1986 and 1988, and they have been conducted since 1998. Nicomen/Norrish, Harrison, Chehalis and Stave systems were also covered in 1998 and 1999.

Other recreational catch monitoring activities were instituted in 1998 and 1999 (logbooks and independent observers) in some areas. The objective was to augment the on-going catch and release information and to provide better and more timely in-season coho management. A release mortality of 10% was applied to the number of coho encounters in the sport fishery to estimate hooking mortality. The overall goal of these programs was to avoid coho by-catch and reduce the mortality associated with catch and release.

Up to 1997, most commercial catch was well estimated through the commercial sales slip system. However in 1998 and 1999 severe coho conservation measures were imposed to protect upper Skeena and Thompson stocks at times and places where they were prevalent. Because of non-retention restrictions imposed in most fisheries in these years, the mortality associated with releasing coho was assessed by mandatory logbook programs (both written and phone-in) and through observer programs that directly monitored and verified the encounter and release information provided by fishermen in the logbook program. Fishing mortalities are based on kept coho, where permitted, plus encounters multiplied by assumed release mortality rates of 26%, 25% and 60% for troll, seine and gillnet fisheries.

Aboriginal catches of coho are not well recorded before 1999 but coverage improved greatly last year.

1.3.2 Coded Wire Tag Recoveries

Estimates were made two ways; the first using catch as determined from coded wire tag recoveries. This has been the standard method but it does not include estimates of the mortality of coho that were released after capture. The resultant under-estimation of exploitation becomes significant in relative terms when catch is small and retention restrictions increase release rates, as in 1998 and 1999. It also causes underestimates of survival. This gap is most significant for Black and Salmon coho; none of which were marked and all went undetected in fisheries. Holtby et al. (2000) assumed the number of unmarked coho from Black Creek that were encountered by sport fishermen was at least equal to the retention (catch) of marked Quinsam coho groups. Black and Quinsam coho have shared the same catch distribution in the past (Figure 10). Since virtually all Canadian exploitation was from sport fisheries, many of which were mark selective fisheries, they calculated a minimum fishing mortality of Black coho equal to the exploitation in Alaska plus 10% of the Canadian exploitation (10% being the assumed release mortality). Exploitation in Washington was not included because this data is not available yet. We have extended this to Salmon River, comparing it to Inch Hatchery marked coho, which have had virtually the same ocean catch distribution in earlier years of 'outside' distribution as well as earlier 'inside' years (Figures 9 and 10). These mortality estimates are incomplete because the encounters of marked coho that were released are not known.

Coded wire tag recoveries were obtained from the MRP Reporter, version 3.9, accessed through the ALPHA computer at PBS. All recoveries were for 'adults' only, i.e. age .1 or brood year + 3 coho. Off-site hatchery releases were excluded. Estimated recoveries (observed recoveries multiplied by the catch: sample ratio) were used for wild stock analyses and expanded recoveries (estimated recoveries divided by the tagged proportion of the total hatchery release) were used for hatchery stocks. Estimated and not expanded recoveries were used for wild stocks because the numbers of unmarked smolts were unknown in wild stocks. Recoveries by catch region were not filtered to exclude strata with few recoveries where the sampling rate was low (causing a large number of recoveries to be estimated from a few recoveries with correspondingly large confidence limits on the estimate).

1.3.3 DNA Stock Composition

The following method is an attempt to assess the magnitude of the release mortalities that were not part of 1999 catch estimates, i.e. an attempt to assess actual fishing mortalities. We present both the traditional CWT analysis and this method because errors associated with the latter are potentially large and its use for areas other than interior Fraser has not been reviewed. We also wanted to continue the historic CWT time series (recognising that the relative error of not accounting for release mortalities has increased in the last two years of very limited permitted catch).

We applied stock composition estimates developed from a DNA-based approach to estimates of coho killed in all marine fisheries, most of which were non-retention for coho and were not sampled for coded wire tags. CWT data were not available from WA fisheries in time for this report, so the DNA-approach was used here as well.

Observers were present for most fisheries in BC and coho encounter rates were estimated similar to that described for 1998 (Irvine et al. 1999). Monitoring of First Nation's fisheries in 1999 was more thorough than the previous year. Coho encounter data for WA fisheries were obtained from Washington Department of Fish and Wildlife personnel.

Coho mortalities in BC fisheries were determined by applying standard gear mortality estimates (sport 10%, gill net 60%, troll 26%, and seine 25%) from catch and release experiments to the encounter data. Similar values, provided by American colleagues, were used to estimate the numbers of coho mortalities in mark selective fisheries in Areas 5 and 6 in WA.

Tissue samples were taken from coho caught in most fisheries. A single hole paper punch was used to sample coho caught, and these samples were sent to the molecular genetics lab at the Pacific Biological

Station for analysis. For the mixed stock analysis, 4 microsatellite loci (Oki1, Oki10, Oki100, and Oki101) and 2 Mhc loci (alpha1 and alpha2) were used. For details on sample preparation and DNA extraction of these samples for microsatellite analysis see Small et al. (1998). Microsatellite loci were sized on an ABI Prism 377 sequencer (B.E. Biosystems). The Mhc loci were analyzed using DGGE (Denaturing Gradient Gel Electrophoresis) methods presented in Miller et al. (1999). The coho salmon coast-wide DNA data baseline consists of approximately 22,000 fish from 139 stocks ranging from southeastern Alaska to the Columbia River in the south.[1]

Maximum likelihood estimates of stock grouping contributions were produced using Statistics Program for Analyzing Mixtures (SPAM). Mixtures and the baseline were bootstrapped 100 times to generate standard deviations about each point estimate.

Estimated stock compositions (Irvine et al. 2000) were applied to estimates of 1999 coho mortalities to calculate the number of coho mortalities for the following populations: Thompson; non-Thompson interior Fraser (Ufr); lower Fraser (below Hells Gate); East Coast Vancouver Island (Vancouver Island portion of Area 13, Area 14, and Areas 17-19); Southern Mainland (Areas 12 and 13, excluding Vancouver Island; Areas 15 – 16; Area 28); North Coast Vancouver Island (Area 27 and Vancouver Island portion of Area 12), and West Coast Vancouver Island (Areas 20 – 26). We used stock composition results from 1999 samples whenever possible. If we did not have an adequate sample size from the same or a nearby 1999 fishery during the same or similar time period, we used stock composition estimates from 1998 sampling (Appendix 2 in Irvine et al. 1999). Our target sample size was 200.

DNA sample sizes used to generate the stock compositions for some fisheries were still sometimes less than adequate, and the estimated imprecision around these estimates was sometimes large. 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.

1.4 FRY SURVEYS

Data obtained from indicator stocks are supplemented and their interpretation evaluated using extensive annual assessments of fry and escapements. The rationale and general methods of the fry survey were presented by Kadowaki et al. (1995). Fry data are used in two ways in this report: to use extensive fry densities to assess the adequacy of our small sample of escapement time series in representing regional trends in escapement; and to use fry densities and sizes to qualitatively estimate the size of smolt runs in the region in 1999 and speculate on the same for 2000.

Streams were sampled in the early fall, one site per stream in about two thirds of the streams and usually two sites elsewhere. Streams were selected that were small enough to allow reaches to be isolated with nets, that had road access, and that had no enhancement (although some enhancement activities had been directed at some populations). We tried to sample the same sites each year although there have been some deletions and additions to the survey.

Site selection was not random: accessible reaches were selected that were judged to be coho habitat (we favoured lower gradient areas with pool and cover habitat). Although the fry survey methodology will be reviewed and some form of stratified random design may be deemed necessary for new analysis requirements, random selection has not been considered necessary for the first purpose of the data which is to aggregate densities to provide an index of inter-annual variations in abundance. This goal of

[1] See Irvine et al. (2000) for a more detailed explanation.

detecting annual trends and perhaps discerning regional differences requires several years of data. The Georgia Basin fry survey began in 1991.

Most sampled reaches were 20 to 35 m long. The reach was isolated with barrier nets and the abundance of coho fry was estimated using a removal technique, usually three pass, with equal shocking and netting effort in each pass (Seber and LeCren 1967). The area and length of the reach was measured to calculate fry densities, with the area of water greater than 10 cm deep being recorded as well as total wetted area. Areas of riffles, glides and pools were also distinguished. The only other habitat measures taken were water temperature and since 1995, water conductivity. Calculated densities include age 1. or 2. parr. Most catches consist of >95% underyearlings (age 0. fry). Densities were expressed in this report as numbers of fry per m of reach length. This measure removes the annual variation in stream width due to discharge variations and it allowed us to directly use the first data year, 1991, when we did not measure the area of water greater than 10 cm deep ('pool' area). Number per pool area is the other favoured measure of coho density.

Fork lengths were recorded from all coho and scales taken from coho that may have been older than underyearlings. Where the catch in the measured section was less than 100 fry, we usually extended sampling immediately upstream and/or downstream from the density reach to obtain a larger sample. We did not do this if catches were so poor that obtaining an adequate sample was not practical. The catches in the extended reach areas were not used to calculate density and the sample data were recorded separately from the sample data in the density reach. Kent Simpson and Rick Semple have the fry density and size data from non-Fraser and lower Fraser streams, respectively.

All data are shown but spatial and temporal comparisons were made using a sub-sample of sites. Data were selected for the sub-sample largely on the basis of having no or very little fish supplementation. A few were rejected due to sampling problems, e.g. the site frequently drying into isolated pools.

1.5 ESCAPEMENTS

1.5.1 Data Collection

Approximately weekly foot surveys have been made through the main coho spawning period (October to between the end of December and mid-January) in six tributaries in the Cowichan River system, in 17 other Vancouver Island streams and in 18 streams (in 1998) between Squamish and Hope (lower Fraser/Lower Mainland or LFLM). In 1999 the number of streams surveyed in the LFLM was reduced to 15 because of perceived "noise" from stray coho mainly originating from Capilano Hatchery. Numbers of streams surveyed in 1999 on East Coast Vancouver Island and Mainland Georgia Strait increased, mainly due to a new survey in Area 13.

Coho have been counted in the Cowichan streams since 1989. Virtually all other streams (including the LFLM) were only covered thoroughly enough to generate useful AUC estimates beginning in 1998. Charter patrolmen and stewardship and Native groups outside the LFLM collect escapement information on other streams but the amount of data is inadequate to estimate a coho escapement and some stocks are heavily enhanced. Hatchery-reared fry were also planted in nine of the 17 Vancouver Island streams that we surveyed for the first time in 1998, with six plants possibly contributing to more than 25% of the escapement, assuming they survived about as well as wild fry.

The census was conducted as follows. Two workers waded or snorkelled in the creek prodding into cover for hiding fish, obtaining an observed and estimated count of jacks and adults, live and dead. In all cases, most or all the length of stream utilised by spawners was covered and the same reach was (or will be) surveyed each year. Crews were asked to record their estimate of the actual number of spawners present in the reach on each visit as well as the observed number in order to subjectively compensate for weekly differences in observation efficiency.

1.5.2 Area under the Curve Analysis

Area under the curve (AUC) abundance estimates are calculated using the estimated numbers and survey lives (e.g. Irvine et al. 1993). In 1998 survey lives (SL's) used on Vancouver Island streams were based on measurements in the Cowichan system and elsewhere. The primary data sources from the Cowichan were recoveries of coho tagged near the time of their entry into a moderate sized stream (Shaw Creek), seven years of spawner observations by the senior author in seven to nine other Cowichan tributaries and especially from tagging studies conducted at the Mesachie Creek fence (Holtby 1993). Often difficult to measure accurately, SL's appear to be correlated with stream size – coho tend to occupy larger streams longer. The estimates for Vancouver Island streams provided in last year's report (Simpson et al. 1999) used SL's graduated by stream size.

This year we updated the review by Perrin and Irvine (1990) of SL estimates and the results are presented in Appendix 1. One conclusion of the analysis is that the best SL to assume is 14 d, at least for the size of streams being surveyed in this area. Second, the data do not negate the universal and critical assumption that AUC estimates, if not necessarily accurate estimates of absolute abundance, are at least indicators of annual trends.

Based on this review, the South Coast Salmon Section used a standard SL of 14 d for all Georgia Basin streams where existing data did not exist. AUC's were repeated for the 1998 data using 14 d if another value had been used and data did not exist to support that value. Only a few streams have existing data in the Georgia Basin (e.g. Cowichan tributaries and Chase River/Beck Creek). The few available estimates were not applied to other streams in the area of each estimate.

A different approach was used in the Fraser River Salmon Section in 1998 and 1999, which led to use of a shorter survey life in LFLM streams. Where the AUC estimate is a quotient, with fish-days being the numerator and SL the denominator, an estimate of SL is possible if there is an independent estimate of spawner abundance. The mark recapture estimate of abundance in Salmon River was used this way in conjunction with frequent visual estimates of abundance to derive stream life estimates of 7.4 and 6.8 days in 1998 and 1999. Other estimates using this method are reviewed in Appendix 1. This SL estimate was used to calculate all the AUC estimates in the LFLM area.

As long as AUC estimates are only used to index annual trends (usually under the assumption of small annual variation in survey life within streams), different methods of arriving at a survey life estimate are of no consequence. However, other analyses which use the escapement estimates, rather than changes in the estimates, should recognise the possibility of biases. For example, future comparisons between escapements in LFLM streams and other Georgia Basin streams should be made cautiously because the differences in survey lives used may reflect method more than reality. When we compare the two data sets, we use AUC estimates for LFLM streams, which are calculated with a 14d SL.

More problematical will be the use of escapement LRP's that depend on absolute measures of escapement, e.g. females per kilometre. This illustrates the need for regional analytical guidelines for collection and analysis of visual escapement data.

Hatchery fish contributions to escapements in Vancouver Island and some Mainland streams were estimated assuming a 15% fry to smolt survival to assess fry plant contributions to smolts, to which was applied the smolt to adult survival of Black Creek coho for that year. Streams selected for escapement counts in the LFLM are basically unenhanced.

1.6 SURVIVALS AND EXPLOITATIONS

All our survival and exploitation analyses follow the convention of excluding age .0 catches and escapements (jacks). Analyses of hatchery data are for marked coho (CWT-ad's). Minimum fishing mortality estimates for the Salmon and Black wild stocks were estimated as explained in Sect. 1.3.2 and the tagged components of their escapements were determined using hand-held CWT detectors (wands). All fence captures and all spawning ground carcasses and captures were wanded at Black Creek. The spawning ground sample included coho that had not been sampled at the fence when the fence was inoperable (as indicated by the absence of a fence tag or mark). The proportion of CWT coho in this spawning ground component plus the fence sample was applied to the mark recapture estimate of total escapement to estimate the tagged escapement. A portion of the fence captures at Salmon River were wanded to obtain the tag rate, which was applied to the mark recapture estimate to get tagged escapement.

Before 1999 significant freshwater sport catches of Chilliwack adult coho were not quantified so survivals of Chilliwack coho were estimated using marine exploitations of Inch Hatchery coho as described in Simpson et al. (1999). River catches of adults were available this year (Sect. 1.2.2) removing this necessity.

2 STOCK STATUS UPDATE

2.1 JUVENILE ABUNDANCE

2.1.1 Fry

Fry densities (Table 1) were highest in the 1990 brood year (BY), the first year of the survey, then centred around 5.5 to 7.5 fry/m from 1991 to 1995 BY's and dropped to about 4 fry/m in 1996 and 1997 BY's (Figure 1). Densities rebounded last year except on the Sunshine Coast where increases were modest. It is difficult to make conclusions about the mainland area due to small sample sizes, especially Area 28 where only one stream was surveyed. Over the Basin, densities were about equal to the 1995 brood year.

Summarised over the Basin, the size of fry changed little through this period except in the 1996 BY when mean fry sizes were larger, coincident with their low density (Table 2, Figure 2). This brood year returned in 1999. It is a common observation that over-winter survival of fry is positively correlated with their fork length in the fall (e.g. Holtby 1988). Size is negatively correlated with density in 28 of 35 sites where there were >4 annual estimates. Therefore, low fry densities in the 1996 BY may not have carried through to reduced smolt outputs. In fact, this brood survived very well in the Black Creek system (sect. 2.1.2). Of course, density is not the only determinant of fry size and the 1997 brood, which returns this year, was back to the pre-1996 fry size range, even though they were almost as sparse as the 1996 brood fry. The mid-summer to mid-fall of 1998 was especially dry, which may have retarded growth. The possible effect on smolt outputs in 1999 is discussed in the next section.

Fry were relatively abundant in 1999 but only slightly smaller than average on the East Coast of Vancouver Island and in the lower Fraser valley. We think its likely that smolt production this spring will be large (by 1990's standards) in those areas. The sampling sites in Areas 15 and 16, all but one of which are along the Strait of Georgia shore, did not have these high densities consistently and we do not predict large smolt numbers. There is insufficient data from the mainland inlets of these Areas and from Area 28 to draw conclusions.

StAD intends to review the fry survey methodology and more thoroughly analyse its results. For example, its use in predicting smolt yields will be examined. However, a preliminary examination of the use of fall fry densities for estimating parental escapements as a partial alternative to costly, time consuming and sometimes ineffective spawner enumerations shows the survey has some merit. AUC spawner enumerations on the south coast cost about 4 times as much as fry assessments per stream. We calculated a crude index of coho escapements in the Basin by taking the median AUC estimates from the Cowichan system and the mark-recapture estimates from Black Creek and Salmon River. As will be seen in the escapement section following, each shows a different escapement pattern but there is some evidence to support the hope that each is representative of a portion of the Basin. We scaled each 1990-99 data series by dividing each year's escapement by the average escapement for the system in that period. The three scaled escapements in each year were averaged to produce the escapement trend shown in Figure 1.

There is a significant correlation (r^2 = .56*) between fry density and parental escapement (Figures 1 and 3). In last year's report (Simpson et al 1999), we wrongly observed that when escapements were relatively high in 1990 and 1991 fry densities were not as proportionately high and that led us to conclude that fry densities were asymptoting at these spawner levels. In fact, the observation was the result of scaling on the graph. There is no evidence of non-linearity in Figure 3 and we now conclude that escapements through the 1990's, as measured in the three Basin locations, have not exceeded levels sufficient to produce maximum fall fry densities regionally. Surveying only one or two sites per stream once per year has provided a good indication of overall trends in parental escapement. On an individual stream level, Holtby showed this for Carnation Creek (Simpson et al. 1996; B. Holtby, pers. comm.). It's also seen at Black Creek and to a lesser degree at Salmon River (Figure 4). One would expect fry to de-couple from large escapements and the largest escapements at Black Creek (1999) and at Salmon River (1993), are associated with only moderate to moderately high fry densities. With fry densities reflecting parental escapement even after the summer mortality period, an even stronger relationship is probable if fry densities were measured earlier, say after emergence. This may be a worthwhile adjunct to the fall survey, especially when escapements are sufficiently large to result in substantial density dependent mortality in the summer. Obtaining useful adult escapement counts is extremely difficult and costly through most of the coast. A spring survey should not replace the fall survey since the latter is useful as a 'last chance' indicator of year class strength after the summer mortality period and before winter conditions preclude this data collection.

One cannot say that the optimum escapement was exceeded at Black Creek in 1999 or Salmon River in 1993. It is possible the fry populations disproportionately utilised marginal rearing habitat when very abundant. Also, late summer fry density is not a measure by itself of smolt production next spring: there is still a significant winter mortality period, which is inversely correlated with fry size which in turn is partly but not entirely related to their density.

On the basis of this fry: parent escapement relationship, the relatively large fry densities in 1999 suggest that spawners were also relatively abundant in most east coast of Vancouver Island and lower Fraser streams in 1998. Fry densities in some streams may have been near maximum, like at Black Creek, and densities in these streams would insufficiently indicate the escapement increases.

One possibility that will be considered in the review of fry assessments will be using the fry data to define the geographic matrix of escapement, smolt and fry indicators needed to accurately depict the status of Georgia Basin coho at least cost. Because of its low cost, the fry survey has the most geographic coverage of any assessment we do. Not all preliminary analyses are consistently favourable in this respect, however. For example, Salmon and Black escapements are not significantly correlated with fry densities the following year in the Fraser Valley and in Areas 13-14, respectively. Nor are the fry densities at the Coghlan–1 and Black–1 sites correlated with the median densities in the rest of these areas. These instances point to the need for a more thorough analysis of benefits and limitations of fry surveys and indicator stocks.

2.1.2 Smolts

The only time series of smolt counts from wild populations in the Basin come from Black Creek and Salmon River. The smolt estimates at Salmon River (based on mark rates of returning adults, Sect. 1.1.2) declined from the first estimate in 1986 of almost 300,000 to 58,000 in 1993. The estimates have varied since from 81,000 to 122,000 (Figure 6). Smolts can now be estimated by recapture at the lower fence of fish that were marked upstream. The first estimate was 59,800 in 1998, which is 74% of the estimate based on the mark rate of returning adults. The estimated run in 1999 was 86,667.

Black smolts have not trended as strongly (Figure 5). However, the four smallest smolt runs in the 17 year record have occurred in the last five years (1993, 1994, 1996 and 1997 brood years, Table 3).

Black Creek had a very good smolt run in the 1995 brood and a large escapement resulted in 1998. The 1996 brood had the fewest spawners recorded but the sparse fry were large and survived exceptionally well, yielding 21,324 age 1. smolts in 1998. This was a survival of 170 smolts/female, which compares to 66 smolts/female mean survival for the period of record (Table 3). The number of age 1. smolts last year (26,332) is the result of a more typical freshwater survival of the 1997 brood (41 age 1. smolts/female). Overall, there is a fairly good relationship between brood year females and smolts (Figure 7). There is no trend apparent in freshwater survivals of Black coho in the 1985 to 1997 brood years of record.

The low smolt production of the 1997 brood last year may be indicative of similarly low ocean recruitment through much of the Basin. Fry densities in 1998 were below average both in Black Creek and in other Georgia Basin areas, excluding the Fraser Valley.

The average number of smolts per female at Salmon River is 63, similar to Black (without allowance for the small age 2. component). The 1998 smolt run estimate using the mark rate of the 1999 escapement is 81,000. The smolt run estimate using the smolt recaptures of marked smolts is 59,800. The estimated number of smolts per km of mainstem length was very large in the early years. Using the mainstem length estimate of 27 km, admittedly a large underestimate of rearing length, the number of smolts per km averaged 5,319 and was over 7,000 before 1990. That is substantially more than reported for any other North American stream. The maximum mean smolts/km found in Bradford et al.'s (1997) review of North American data was 4,317 for Rust Creek, a very small tributary adjacent to a pond in the Chilliwack/Vedder system (Fedorenko and Cook 1982). The average number per km at Black Creek is 1,640. This observation and the common occurrence of lower tag rates of adults compared to the proportion of smolts tagged from April to June the year before (Sect. 1.1.2), casts some doubt on this index.

To summarise, the smolt outputs from the Lower Mainland indicator may not have changed much since 1993 but smolts from the central Vancouver Island indicator have gone from well above average to minimal twice in the same period. Both indicators are fairly productive coho systems For Black Cr., the intrinsic productivity , i.e. the Y intercept in the regression: $\log_{10}$(smolts/female) = f (females), is 93.5 smolts per female (95% CI: 60.6 – 146.0). The intrinsic productivity of Salmon R. coho is probably similar. This compares with 156 smolts/female at Carnation Cr. on the west coast of Vancouver Island (95% CI: 118.6 – 205.9) and 26 smolts/female (Kadowaki et al. 1996) at Snow Cr., near Port Townsend WA. Considering that Black and Salmon smolt runs have frequently been below average in the last several years despite their productivity, we submit that regional recruitment of wild smolts to the ocean has probably been below average also. The 1999 ocean recruitment was probably below average generally, as mentioned above.

Looked at over a longer term, there have probably been pervasive declines in smolt production linked to habitat losses (although perhaps not as rapid as it seems in the complete Salmon River time series). One can assume the documented loss of freshwater rearing habitat in the Georgia Basin has had a long-term serious impact. With further analysis it should be possible to draw more conclusions by using the fry data to estimate smolt densities.

US smolt releases from Puget Sound/Juan de Fuca hatcheries have varied between 17 and 20.5 million in the 1987 to 1996 brood year period and Strait of Georgia/Johnstone Strait production has increased fairly steadily at an average rate of 202,000/year from 7.6 million to 9.7 million in the same period (Fig. 8). The 1996 brood year smolt production from both 'inside' areas was 28.8 million, up 2.1 million (7.9%) from the 1995 brood year.

2.2 CATCH

About 148,000 coho were landed in 1997 in southern BC fisheries as indicated by sales slip records and creel surveys (Table 5). This was the last year when major retention fisheries occurred for coho. Up to 1986 the annual catch was usually in the 2.5 to 3.5 million range but then catches began to decline: the five year averages for 1983-87, 1988-92 and 1993-97 are 3.23, 2.96, and 1.34 million coho, respectively. The declining catches occurred both inside and outside the Strait of Georgia (Table 5) although the relative change in catch between these areas was variable between years.

Decreasing catches from 1990 to 1996 were due to actual declines in abundance. Firstly, exploitation rates only began decreasing in 1995 (see Section 2.5, below). Reduced abundances may be partly the result of decreased wild smolt production but we will show below that lower smolt-to-adult survival is the over-riding cause. Wild smolt production from Black Creek and Salmon River were not trending down in this period, although their smolt production averaged less in the 1990's (Figure 5 and 6). Smolt releases by Washington and Georgia Basin hatcheries were not declining either (Fig. 8).

These declines culminated in regulatory changes to salmon fisheries in 1998 and 1999 to conserve coho populations, which were the most significant ever implemented within the Pacific Region of Canada. Fisheries were managed with an objective of zero mortality on coho stocks of most concern (Thompson in southern BC and upper Skeena in northern BC) plus a move towards more selective fishing (Department of Fisheries and Oceans, 1999). BC fishing areas were categorised as red or yellow zones based on the anticipated prevalence of stocks of concern (red zones being total closures to salmon fishing and yellow zones being areas where there was some tolerance for incidental catches but still no coho retention allowed). In southern BC, 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, plus an assessment of stock distribution from 1998 (Irvine et al. 1999). Coho fisheries in Washington State were also reduced in 1999 relative to most recent previous years. A selective mark only recreational fishery was operated in Washington Management Units 5 and 6. In addition, Treaty and non-treaty troll and gillnet fisheries occurred in Washington Areas 4-6 which were expected to encounter BC coho.

The estimated kill of coho in southern BC in 1998 and 1999 based on catch monitoring programs was 23,030 and 30,103 (Table 6, B. Shaw, pers.com., DFO, 3225 Stephenson Point Rd. Nanaimo). These estimates include not only fish landings but also mortalities associated with catch and release, calculated by applying fisheries-specific mortality rates to the numbers of coho caught and released (Sect. 1.3.3). We present results from the DNA analysis of stock composition applied to these encounters in Sect. 2.5.2 Exploitation.

2.3 CATCH DISTRIBUTION

Prior to the major fishing restrictions imposed in 1998, Georgia Basin stocks[2] were mostly caught in the Strait of Georgia/Fraser River ('inside') sport and troll fisheries, in the "outside" troll, sport and net fisheries off the west coast of Vancouver Island and in Juan de Fuca and Johnstone straits. The Strait of Georgia troll fishery has had a coho non-retention restriction since 1995. Also in 1995, the recreational daily bag limit was reduced in Johnstone and Georgia straits from 4 to 2 coho and the size limit was increased from 30 cm to 41 cm. Bearing these influences in mind, we still think it is acceptable to use, as Kadowaki et al. (1996) did, the proportion of recoveries of tagged Georgia Basin coho in the Strait of

[2] Meaning coho originating in streams in the Georgia Basin as we have defined it, not coho present in the Strait of Georgia.

Georgia as an indicator of inside/outside distributions before 1998. The phenomenon is sufficiently marked that it overwhelms data problems like the above (and others such as a portion of the inside sport catch consisting of inward bound coho in the fall, which could be easily excluded, and exacerbation of high and low inside recoveries due to increases and declines in effort in response to high and low abundance). Fisheries closures increased in 1998 to an extent that these data are no longer useful for estimating inside/outside distributions.

Detailed catch distribution (tag recovery) data are given in Table 7 to Table 12 for Quinsam, Big Qualicum, Inch and Chilliwack hatchery stocks and Black and Salmon wild stocks, respectively. There is a key to the catch region codes in Table 4. They include the few recoveries made in southern BC but not recoveries in Washington, which are not yet available. All recoveries from Alaska are shown.

Recoveries before 1998 of tagged coho from the four hatchery and two wild indicator stocks indicate that an unusually high proportion of coho ranged out of the Strait of Georgia to the west coast of Vancouver Island in 1991 and from 1994 to 1997 (Figure 9). Using proportions averaged over the five groups, only 10, 33, 6, 10 and 5 percent of the recoveries of tagged coho were in the Strait of Georgia in those years. Such low proportions had not been seen since tagging began 20 years ago. By comparison, the inside proportion was 80% in 1993.

1999 was clearly another 'outside' year. The Strait of Georgia Guide Logbook project recorded only 6 legal sized coho encountered in 495 hours of fishing in Areas 17 and 18 (T. Carter, PBS Nanaimo, pers. comm.). The Georgia Strait Creel Survey estimated 154 legal sized coho encountered up to the end of August in Areas 17 and 18 (before spawners have returned from elsewhere). Total coho encounters up to the end of August in the Strait of Georgia sport fishery were estimated to be only 5,929 and 5,580 in 1998 and 1999, respectively (B. Shaw, pers. comm., DFO, 3225 Stephenson Point Rd. Nanaimo). Most of these would be sub-legal sized coho from the 1997 brood year.

We hope to utilise in future reports the trawl catch data being collected by the Fish Productivity Section in the Strait of Georgia and Juan de Fuca Strait areas. To date, these catches have confirmed the conclusions from other catch data but have the advantage of indicating distributions earlier in the final ocean year.

2.4 ESCAPEMENT

Escapements on the east coast Vancouver Island (ECVI) decreased from 1998 to 1999 in all but one stock (Chase R.; Table 14). Black Creek had the second lowest escapement since surveys began in 1975 (Figure 11) and on average the escapements in ECVI were more than 50 % lower than in 1998. Predation by harbour seals at the mouth of Black Creek would have contributed to the low escapement and one could hypothesise that depensatory mortality occurs but the poor escapement of coho at Black and throughout the area is most likely to have been largely due to the extremely poor brood year escapements (1996) in concert with poor survivals.[3] For Black Creek, the low escapement in 1999 represents only 16% of the adult coho numbers required for maximum sustained yield (3,150 adults; Kadowaki et al. 1995) and only about 16% of the long term average escapement of 3,301 adults. Other streams in Area 14 where lesser quality counts were made also showed significant escapement declines in 1999 (Table 14). Geometric mean escapement levels in Area 14 were 449 adults in 1998 and 184 adults in 1999.

[3] Few coho at the fence had injuries.

Further south on Vancouver Island, the estimated Chase River escapement (455 adults) improved by about 30% over 1998 and was more than double the brood year escapement of 162 adults in 1996 (Table 13; Figure 12). Still, the 1999 escapement is poor relative to 1988-95 when it averaged about 950 adults annually. The estimated wild component of the escapement in 1999 stayed about the same as in 1998 but the enhanced component more than doubled. Prior to 1998, wild escapements had been decreasing since 1994. Changes in escapements to those Area 17 streams that were surveyed in both years averaged a decline of 9%. (Table 14).

Further south still, the total escapement in 1999 to Cowichan River tributaries (Mesachie, Richards, Oliver, Patricia and Shaw creeks) was 687 (Table 13). There is a complete data set for these streams from 1990 and this is the second lowest total escapement in the period, the lowest being the previous brood escapement in 1996 (571). The average escapement up to 1998 was 2,172. While escapements in these streams increased in 1997 and 1998 with the virtual cessation of fishing, present levels in some of them like Mesachie and Oliver creeks are less than half those in 1941-44, when escapements averaged 1,852 and 462 coho, respectively (Holtby 1993; Figure 13). As late as 1984, escapements to Mesachie were estimated to be twice the 1998 escapement.

The two wild indicator stocks in the lower Fraser River once again showed very different results (Table 13). Simpson et al. (1999) noted earlier differences. The escapement to Salmon River in 1999 (2,123 adults) was the second lowest since the inception of Petersen mark-recapture estimates in 1987 and it was about 20% lower than the brood escapement from which it originated. In contrast, the upper Pitt River had the highest escapement (13,437 adults) since mark-recapture estimates began in 1994. That escapement was more than 150% larger than the brood escapement. Salmon River escapements have been trending downwards since 1995 while upper Pitt stocks have been increasing (Figure 14).

The lack of correspondence between Upper Pitt and Salmon escapements which are 50 km apart contrasts with a significant correlation between Chase escapements and those in the Cowichan system, 40 km south (Figure 15). Although Salmon River is very different from Upper Pitt River (Sections 1.1.2 and 1.1.3) and this might suggest the need for a sample of representative habitat types in assessment planning, an even broader correlation is found on the west coast of Vancouver Island between Carnation Creek, Stamp River and Gold River (Baillie et al. 1999). Carnation is a small stream, very different from the latter two rivers. The WCVI correlation is consistent with the observation that ocean survival is of over-riding importance at this time: correlations in escapement probably reflect similar ocean rearing conditions. We submit that there are likely more ocean rearing options available to inside stocks. While most WCVI coho appear to rear along the west coast of the island (at least in their catchable second year), Black Creek coho, for example, may rear in the Strait of Georgia or move north into and through Johnstone Strait or move out through Juan de Fuca Strait. And it is not unreasonable to expect the Strait itself to be a particularly diverse rearing environment. It is not surprising that Black Creek escapements should differ in pattern from stocks further south.

Although very different habitats, one might expect marine survivals, marine distributions and escapements to be similar or correlated in streams as close as upper Pitt and Salmon but their escapement patterns are dissimilar. In fact in the 1978 brood year when both Salmon and Pitt coho were CWT'd, Pitt smolts were subsequently caught 'outside' much more than Salmon coho: only 15% of the Pitt recoveries were in the Strait of Georgia but 44% of Salmon recoveries were 'inside'. While there appears to be some regional cohesiveness in our ability to detect major year class variations, it will require other data such as extensive fry and catch distribution data to define the network of escapement indicator streams.

Notwithstanding the difficulties mentioned earlier in escapement methods (Sect. 1.5.2), the female spawning indices (number/km) for the extensive set of streams in the Georgia Basin will increase in value as the time series is developed (Table 14). Because there were only from 2 to 11 streams examined in each area in 1998 and 1999, the confidence in making between-area escapement comparisons is diminished. We facilitated comparisons of escapements in Areas 28 and 29 with the rest of the Basin by using a survey life of 14 days everywhere that lacked specific data. The estimates using Salmon River SL's were used for analysis of the size of the Area 28 and 29 escapements relative to a provisional LRP.

These Salmon River SL's were 7.4 d in 1998 and 6.8 d in 1999 (further support for the assumption that inter-annual variation in survey lives is not excessive). Some streams where AUC estimates were employed were stocked with hatchery juveniles (Table 16). These were not excluded from the analysis. Annual comparisons only used those streams with estimates in both years.

The change in escapements from 1998 to 1999 was quite different between streams in the lower Fraser and elsewhere (Table 14). Averaging the changes in each stream, escapements to Vancouver Island and Squamish area streams decreased an average of 40%. Streams in the lower Fraser increased an average of 123%. The geometric mean (GM) escapements in the lower Fraser in 1998 and 1999 were 32 females /km and 48 females /km using a SL of 14 d and 57 females /km and 93 females /km using Salmon River values. Other stocks in the Basin went from a GM of 30 females /km to 14 females /km from 1998 to 1999.

Although included in the above summary, it is apparent that on the whole the better quality/longer time series data from Black Creek, Chase River, the Cowichan tributaries and Upper Pitt River correspond to the results from extensive AUC escapements. Salmon River is the exception, where escapements declined 29% while escapements to other streams in the lower Fraser increased.

The frequency of streams having different levels of female escapement (females/km) in 1998 and 1999 is shown in Table 15. Few streams in the Basin had fewer than three females /km (Table 15A) and most streams had >13 females/km. The frequency of streams having >13 females/km decreased from about 82% in 1998 to about 64% in 1999. There were two streams with <3 females/km in 1998 and 4 streams in 1999, representing 5% and 8% of the monitored stocks, respectively. None were in the lower Fraser. Which SL was used in the LFLM calculations had no effect on frequencies in the three classes (Table 15, B and C). More work needs to be done to define what levels of female escapement/km are required so as not to endanger the integrity of the stocks.

2.5 EXPLOITATION

2.5.1 Coded Wire Tag Analysis

Exploitations of indicator stocks due to catch in BC and Alaska, as determined by coded wire tag recoveries, are shown in Table 17 and in Figure 16. The highest marine exploitation was on Quinsam Hatchery coho (7.4%). There was a mark-only fishery allowed in Area 13, which is where over 80% of the recoveries took place (Table 7). This fishery did not occur in 1998 so Quinsam marine exploitations were greater in 1999. However, marine and total exploitations of Big Qualicum and Inch coho decreased from 1998 to 1999. The largest total exploitations occurred on the Inch and Chilliwack stocks where there were river fisheries (18.8% and 17% exploitations respectively).

Estimates of exploitation for the unmarked wild stocks in Salmon and Black were both zero (no catch recorded) but using Inch and Quinsam catches as minimum estimates of encounters, respectively, and assuming a 10% release mortality of these encounters yields exploitations of 1.2% for Black coho and 0.2% for Salmon. The estimate is higher for Black because of the marine encounters in the Area 13 mark-only fishery assumed on the basis of Quinsam catch in that fishery.

2.5.2 DNA Stock Composition / Encounter Rate Analysis

To calculate exploitation rates for each southern BC stock aggregate, we needed an estimate of the numbers of coho escaping fisheries and returning to freshwater to spawn. This was problematic since, with the exception of the Thompson watershed, coho escapements are not determined for all streams in any area. For streams in the lower Fraser, the last year that we have nearly complete escapement survey coverage was 1993. To estimate the total number of coho returning to the lower Fraser and tributaries we used the maximum estimate recorded to each stream during 1980-1993, and added to this the number of coho removed from the various enhancement facilities in 1999. We used the maximum estimate since most historical estimates, generally obtained by visual surveys, are biased low. Escapements to areas other than the lower Fraser were estimated by summing large hatchery and wild estimates where they existed, estimating the proportion of very small, small, moderate, and large runs that occur in the area and assigning an escapement to each category, using existing escapement estimates in each category if they existed. Time limitations and paucity of data made this mostly a subjective 'best guess' process. We recognise the uncertainty with these approaches and highlight the need for improved area-based escapement estimates if the stock composition estimates in marine fisheries are used to calculate mortalities in the future.

Exploitation estimates for southern BC coho ranged from 4.5 to 13.3% (Table 18). Exploitations for populations of specific interest in this document, i.e. East Coast of Vancouver Island and Lower Fraser, were both 13.3%. These exploitation rates are largely based on estimated encounters. Alaska was the only jurisdiction where catches were permitted and the data were available. The above exploitation estimates include the Alaska catch estimates. Exploitations exclusive of Alaska catch are 12.6% and 13.0% for ECVI and lower Fraser areas. If accurate (and our confidence in the escapement estimates is low), these results suggest that the exploitation of wild coho was about 13%. All indicator hatcheries had significant terminal catches. Exploitations due to catch of marked hatchery stocks, when added to the DNA derived estimates, provide the following estimates of total exploitation for Quinsam, Big Qualicum, Inch and Chilliwack: 21.9%, 15.7%, 32.1% and 30.4%, respectively.

The estimate of exploitation of WCVI coho may be lower than for other Vancouver Island coho because they were only rarely encountered in Washington fisheries. Upper Fraser coho appeared to have the lowest exploitation, but estimates for these fish are less precise than for other groupings.

2.6 MARINE SURVIVAL

Based on coded wire tag recoveries in catches and escapements, the 1995 brood year survival of smolts from Quinsam, Big Qualicum, Inch and Chilliwack hatcheries to the adult catch and escapement ranged from 0.4 to 1.0 percent (Table 19, Figure 17). These survivals of coho returning in 1998 were the lowest recorded (start of record: 1973 brood year). Survival estimates for the hatchery indicators improved in 1999 to a range of 0.8 to 2.6 percent and the 1999 data do not include Washington recoveries which are still unavailable. The addition of Washington recoveries is not expected to significantly increase the estimates, however. Quinsam Hatchery was the only hatchery to continue to decline.

Survivals would still be virtually the same if actual exploitations were as derived from the DNA stock composition estimates and regional escapement estimates. For all indicators, correcting with the DNA analysis increased the estimated survival rates by a maximum of 0.1%.

Black Creek coho survival declined like Quinsam but more markedly, from 4.4 and 4.5 percent in 1997 and 1998 to 1.7 percent in 1999. We are confident that the escapement estimate for Black is accurate. The minimum fishing mortality estimation, using Quinsam catch, was only 8 coho, which represents 1.2% exploitation. The decline in survival of Salmon coho finally abated, at 2.6%, essentially unchanged from the 2.5% in 1998. Hatchery coho continued to survive more poorly than the two wild stocks but they correlate very well with them overall (Figure 17).

Looking at the entire data record, the pattern of survival is different between the mainland indicators and Vancouver Island indicators. There was a multi-year peak in survival of mainland hatchery and wild indicators centred on the 1985 brood year and an overall decline since, broken by fairly stable survivals in the 1988 to 1993 brood years.

Fish culture problems at Big Qualicum in the 1980's cloud interpretation of the Vancouver Island pattern. The 1983 to 1986 brood year survivals for Big Qualicum should be given little or no weight. Big Qualicum and Black survivals were very high in the 1970's. Black was stable at a moderate survival through much of the 1980's. Up to this time Quinsam was stable at about 5 -10%. Coho from the Vancouver Island indicators began surviving more poorly starting between the 1987 and 1990 brood years, one to three years after the start of the mainland decline.

To summarise, survivals of coho in the Georgia Basin continued to be very poor in 1999. However, for the first time since 1992, the mean survival increased for southern Basin indicator stocks (Fraser Valley and Big Qualicum River). Mean survivals of Quinsam and Black indicators had been holding at about 2.6% from 1996 to 1998 (gradual decrease at Quinsam partly masked by Black survivals). This was a higher survival than the survival of southern stocks. However, the continued decline at Quinsam in 1999 was supplemented by the relatively large decrease at Black so the mean survivals of southern and northern stocks are now similar (1.6% and 1.3% respectively).

3 CONCLUSIONS

1. 1996 Brood. Escapements in 1999 were poor relative to 10 year averages in all areas of the Georgia Basin, particularly in the northwest (Area 13 and the northern part of Area 14). Escapements in the Fraser Valley were best in terms of the 10 year averages. In terms of the provisional limit reference point of 3 females/km, virtually all enumerated stocks in the Basin were above the limit. Escapements were the result of poor escapements in 1996 and poor marine survival.

2. Extremely low marine survival is the driving short term cause of poor abundances. A slight increase in 1999 everywhere except in the northern Strait provides some hope that the decline has stopped.

3. Exploitation due to release mortalities and catch in Alaska was 13.1% for ECVI and lower Fraser coho. Most of the exploitation was from release mortalities in BC, as estimated using DNA estimates of stock composition and estimates of regional escapements. If accurate, and our confidence in the escapement estimates is low, these values approximate the exploitation of wild coho. Exploitations due to catch of marked hatchery stocks, when added to the DNA derived estimates, provide estimates of their total exploitation ranging from 16% to about 32%.

4. 1997 Brood. Based on smolt estimates at Black Creek and Salmon River and using fry densities and sizes, smolt runs were probably below average in 1999 and possibly well below average on the Sunshine Coast. With marine survivals forecast to remain poor, we expect escapements in 2000 to be well below 1990's averages, similar to 1999 except in the Fraser Valley, which may see a decrease because escapements were not as depressed in 1999. Nevertheless, assuming continued near-abatement of exploitation, most monitored stocks will probably exceed the provisional limit reference point of three females per kilometre of stream as they did in 1999.

5. Considering the current low productivity of Georgia Basin coho, we recommend that fishing mortality remain similar to existing minimal levels in order to ensure that there is a sufficient proportion of escapements that exceed the provisional limit reference point.

6. 1998 Brood. The abundance of smolts this spring will probably be better than the 10 year average everywhere except possibly on the Sunshine Coast. Excluding this part of the Basin, fry densities were above average in 1999 in response to average to better than average escapements. Their sizes were probably sufficient to provide average winter survival with some regional variation. Smolt runs may be poor on the Sunshine Coast but sample sizes were too small to conclude this with any confidence.

7. Fry densities at both the individual stream level and summarised over the Basin are correlated with parental escapements throughout the 1990's, which is the period of the fry survey. Fry surveys are an economical and effective way to determine trends (at least) in escapements when escapements are low to moderate.

8. Regional rules or guidelines for the collection and analysis of escapement data are required, especially if stock assessment frameworks use Limit Reference Points which are absolute measures of spawner abundance, such as number of females per kilometre. The likelihood of obtaining reasonably accurate absolute, as opposed to annual trend, measures of escapement needs to be carefully considered.

9. A ‘full’ indicator facility is needed on the Sunshine Coast where juveniles are enumerated and tagged and adults are accurately counted and sampled. Another is required in the Fraser Valley. The existing indicator of Salmon River and the escapement indicator of Upper Pitt have different escapement trends and the area requires another full indicator facility.

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TABLES

Table 1. Number of coho fry per meter of stream length in September, 1991 –1999, from Georgia Basin sites. Data in the shaded areas were selected for analysis.

Stream-site[1]	1991	1992	1993	1994	1995	1996	1997	1998	1999	Mean
Central East Vancouver Island (Area 13 adjacent to Str. of Georgia and Area 14)										
Bear			15.0	16.5	5.8	16.2	10.5	4.0	15.5	11.9
Black-1	9.0	22.8	15.4	7.0	13.7	19.1	2.1	5.7	15.3	12.2
Black-2						7.1	2.4			4.7
Black-3							2.9	5.3	10.1	6.1
Black-Millar					4.9	1.5	2.7	5.1	8.4	4.5
Chef-1		6.7	13.8	6.6	20.4	23.8	6.3	10.3	12.6	12.6
Chef-2						15.6	1.3	3.7	8.0	7.1
Cook	12.1	9.1	37.5	1.6						15.1
Cougar-1	6.7	2.5	5.0	5.9	10.5	7.4	8.0	5.3	7.5	6.5
Cougar-2						3.5	3.3	2.8	4.5	3.5
Kingfisher	6.3	1.3	1.1	3.5						3.1
Kitty Coleman			4.1	0.0						2.0
Menzies	5.8									5.8
Millard	5.0	3.3	1.0	5.5	3.2	4.6	2.5	1.4	5.9	3.6
Morrison-1			1.5	1.0		1.4	1.7	1.4	1.5	1.4
Morrison-2					3.3	5.3	1.4	2.4	4.0	3.3
Nile	28.8	10.3	6.1	2.1	5.9	6.7	3.6	7.1	7.8	8.7
Oyster		11.0								11.0
Portugese			2.7	3.4	2.1	7.6	0.9	0.0	29.3	6.6
Rosewall			1.0	0.0						0.5
Waterloo	14.0	1.6	3.9	3.1	2.5	8.7	4.4	4.5	5.0	5.3
Willow-1					7.1	8.6	5.7	5.2	11.0	7.5
Willow-2						3.7	0.5	4.1	7.0	3.8
Area 13-14 Medians:										
All data	7.9	6.7	4.1	3.4	5.8	7.2	2.7	4.3	7.9	5.8
Selected data	9.0	3.3	4.1	3.4	5.3	6.9	2.7	4.3	7.6	5.0
South East Vancouver Island (Areas 17-19)										
Beck						3.1	1.4	0.3	1.7	1.6
Bings			6.4	5.2	9.8	6.3	4.6	6.9	18.6	8.3
Bush-1		7.8	14.0	11.6	8.6	15.9	0.5	2.0	3.4	8.0
Bush-2					32.0					32.0
Bush-3						6.0	5.2	5.3	9.5	6.5
Chase-1	4.4	4.4	3.1	2.0	2.0		1.2	1.7	0.6	2.4
Chase-2		18.7	16.0	12.9	10.9		9.7	7.7	12.9	12.7
Chase-3		4.6								4.6
Goldstream	4.8	8.1	0.7	1.5						3.8
Halfway-1	12.2	3.4	0.0	0.9	7.6	3.0	2.0	5.1	13.1	5.3
Halfway-2					6.6	12.4	4.0	4.1	8.5	7.1
Haslam						16.7	2.0	11.3	13.3	10.8
Head			2.8	6.3	10.5	8.3	8.6	5.3	7.4	7.0
Nanoose	3.7	4.8	6.4	10.0	10.4	10.2	2.8	8.1	9.6	7.3
Oliver-1		3.4	6.1	4.3	5.0	4.2	0.0	0.7	3.4	3.4
Oliver-2		4.2	11.1	12.0	3.9	11.4	2.0	0.7	5.8	6.4
Patricia			3.1	3.2	4.6	6.2	4.1	5.4	6.4	4.7
Richards-1			1.3	3.0	10.0	8.3	10.7	3.2	16.5	7.6
Richards-2							5.8	3.3	7.4	5.5
Whitehouse	10.2	6.6	15.2	8.6	8.3	9.5	2.1	2.0	4.1	7.4
Area 17-19 Medians:										
All data	4.8	4.7	6.1	5.2	8.4	8.3	2.8	4.1	7.4	6.8
Selected data	10.2	4.5	6.3	5.8	8.4	8.3	2.8	4.1	7.4	7.1

Table 1. (Continued) Fry densities for Georgia Basin streams.

Stream-site[1]	1991	1992	1993	1994	1995	1996	1997	1998	1999	Mean
Sunshine Coast and Howe Sound (Areas 15-16 and 28)										
Angus		4.5	6.0	1.4	4.5					4.1
Branch 100					26.5	10.1	21.4	19.4		19.3
Chaster		4.6	2.7	2.4						3.2
Dryden				5.6						5.6
Hastings		2.2	7.7	2.4						4.1
Klein	5.2	14.7	5.6	6.8						8.1
Little Stawamus-1	7.6	8.1	8.5	8.4	10.1					8.5
Little Stawamus-2		41.8	31.8	21.9	17.1	26.8	14.4		6.5	22.9
Little Stawamus-3						3.9	12.1	2.6	28.6	11.8
Meighan	5.7	2.6	2.5	1.7						3.1
Mixal					0.9					0.9
Myers-1		8.2	0.8							4.5
Myers-2				4.9	3.1		2.9		6.4	4.3
Myers-3					5.4		4.0	2.5	4.9	4.2
Okeover-1	10.9	3.4	2.5	1.8	2.2		0.2	0.8	2.3	3.0
Okeover-2		3.7	0.2	0.0	3.9		0.5	0.8	1.1	1.5
Ouillet		2.7	5.1	1.0						2.9
Whittall	35.1	19.5	10.7	11.5	4.8		1.2	2.3	2.7	11.0
Wilson-1		1.8	0.7	0.4	2.8		1.0	2.4	0.9	1.4
Wilson-2					1.6		3.3	4.4	1.8	2.8
Area 15-16,28 Medians:										
All data	10.8	9.1	6.1	5.0	6.9	(13.6)	6.1	4.4	2.7	6.9
Selected data	9.3	8.2	4.0	5.9	3.9	(15.4)	2.9	2.4	2.7	4.4
Lower Mainland (Areas 29B-E)										
Little Campbell	4.8	2.5	2.4	1.1			1.2	5.4		2.9
Lorenzetta					2.6					2.6
MacIntyre		15.0	19.6	12.1	10.9	18.3	9.6		7.7	13.3
Murray	8.0	7.7	7.1	7.9	13.4	10.0	6.8	17.5	19.8	10.9
Nathan-1	6.8	3.8	9.3	8.6	5.4	11.5	4.1	4.9	1.9	6.3
Nathan-2		5.4	15.6	17.3	10.5	10.6	7.4	33.6	22.4	15.3
Post					5.3	3.7	6.0	4.6	2.9	4.5
Salmon - 248th St							4.7			4.7
Salmon - 56th St							5.8			5.8
Salmon - 64th Ave							2.1			2.1
Salmon-Coghlan-1	12.2	7.6	6.0	5.2	5.0	6.7	2.2	11.1	7.2	7.0
Salmon-Coghlan-2					13.9	7.3	7.2	5.5	7.2	8.2
Salmon-Coghlan-3							0.8			0.8
Siddle		11.6	26.7	22.2	19.6	11.4	14.7	11.4	30.0	18.4
Whonnock-1	2.6	2.5	6.7	3.0	5.4	4.9	5.1	4.5	6.0	4.5
Whonnock-2					4.1	6.8	4.6	3.3	8.9	5.5
Lower Mnld. Medians:										
All data	6.9	7.0	11.7	9.7	8.7	9.1	5.5	10.2	11.4	7.1
Selected data	7.4	6.5	8.2	8.2	5.4	7.3	5.1	5.2	7.2	5.7
All Data:										
Median	6.7	4.6	5.6	3.9	5.6	7.6	3.3	4.5	7.3	5.5
Mean of Area Medians	7.6	6.9	7.0	5.8	7.5	8.2	4.3	5.7	7.4	6.6
Selected Data:										
Median	8.5	5.4	6.1	5.5	5.4	7.3	3.3	4.3	7.2	5.9
Mean of Area Medians	9.0	5.6	5.6	5.8	5.8	7.5[2]	3.4	4.0	6.3	5.5

[1] Sites are numbered where more than one site was surveyed.
[2] Does not include the single stream in the Area 15,16,28 group.

Table 2. Fork lengths of coho fry in September, 1991 to 1999, Georgia Basin sites. Data in the shaded areas were selected for analysis.

Stream-site[1]	1991	1992	1993	1994	1995	1996	1997	1998	1999	Mean
Central East Vancouver Island (Area 13 adjacent to Str. of Georgia and Area 14)										
Bear			67.0	52.8	62.7	57.4	64.1	57.4	59.4	60.1
Black-1	50.5	57.0	61.4	60.0	50.8	57.7		59.5	52.8	56.2
Black-2						73.4	73.5			73.5
Black-3							60.0	55.4	54.1	56.5
Black-Millar					59.1	58.4	61.4	56.2	53.1	57.6
Chef-1		68.8	58.8	66.6	51.7	53.9	66.5	60.4		61.0
Chef-2						55.5	70.4	57.5		61.1
Cook	60.4	55.7	50.6	55.7						55.6
Cougar-1	66.6	70.2	62.1	65.5	60.6	64.8	59.5	65.6	64.7	64.4
Cougar-2						61.5	69.8	65.0	?	65.4
Kingfisher	72.4	76.2	87.6	74.4						77.7
Kitty Coleman			85.7							85.7
Menzies	71.9									71.9
Millard	63.2	72.1	80.1	64.6	72.0	71.1	74.4	76.1	71.5	71.7
Morrison-1			68.7	72.1		67.1	70.9	69.3	70.1	69.7
Morrison-2					63.5	55.6	64.0	59.9	61.4	60.9
Nile	67.1	59.1	58.8	68.1	58.8	62.0	71.7	63.2	63.6	63.6
Oyster		82.1								82.1
Portugese			83.3	80.5	87.0	76.0	83.4	91.0	70.1	81.6
Rosewall			77.2	69.9						73.6
Waterloo	67.0	79.2	60.2	64.9	70.1	58.1	63.2	63.2	60.3	65.1
Willow-1					65.2	65.4	62.6	71.0	57.6	64.3
Willow-2						69.8	80.8	61.6	57.3	67.4
Area 13-14 Means:										
All data	64.9	68.9	69.4	66.3	63.8	63.0	68.5	64.5	61.2	67.2
Selected data	62.9	67.5	69.7	66.1	65.0	64.2	68.5	65.3	61.2	66.5
South East Vancouver Island (Areas 17-19)										
Beck						63.7	65.0	63.4	?	64.0
Bings			59.7	59.0	57.4	61.6	62.5	55.4	58.9	59.2
Bush-1		70.6	54.5	55.0	66.4	57.2	80.3	63.2	66.4	64.2
Bush-2					56.2					56.2
Bush-3						51.9	59.0	52.3	59.0	55.6
Chase-1	58.4	60.6	61.7	61.5	59.8		66.6	56.7	71.6	62.1
Chase-2		60.0	62.8	61.1	57.2		68.8	58.4	70.1	62.6
Chase-3		56.5								56.5
Goldstream	82.6	77.2	80.4	75.5						78.9
Halfway-1	47.6	57.8		65.4	48.8	61.2	72.1	50.7	48.1	56.5
Halfway-2					48.5	60.6	68.7	56.1	56.3	58.0
Haslam						59.9	65.2	60.4	64.1	62.4
Head			61.2	61.0	59.3	65.3	73.4	67.5	67.1	65.0
Nanoose	69.3	59.4	63.8	57.5	60.4	59.2	70.6	61.3	65.0	62.9
Oliver-1		50.5	52.1	50.6	52.1	59.9		61.5	53.2	54.3
Oliver-2		63.6	66.8	65.8	59.9	67.8	61.8	66.0	58.3	63.8
Patricia			57.4	55.9	51.5	53.9	63.1	53.3	52.1	55.3
Richards-1			58.0	54.1	57.1	58.1	58.5	52.4	62.1	57.2
Richards-2							59.3	49.4	58.5	55.7
Whitehouse	59.4	63.9	56.0	55.0	56.8	56.6	69.1	66.8	72.0	61.7
Area 17-19 Means:										
All data	63.5	62.0	61.2	59.8	56.5	59.8	66.5	58.5	61.4	60.6
Selected data	58.8	61.0	58.8	57.9	56.2	59.8	66.3	58.6	60.1	59.5

Table 2. (Continued) Fry fork lengths.

Stream-site[1]	1991	1992	1993	1994	1995	1996	1997	1998	1999	Mean
Sunshine Coast and Howe Sound (Areas 15-16 and 28)										
Angus		67.4	69.2	63.8	61.1					65.4
Branch 100					45.1	50.2	48.3	48.7		48.1
Chapman	74.3									74.3
Chaster		70.0	78.7	76.1						74.9
Dryden				60.3						60.3
Hastings		65.1	60.6	61.7						62.5
Klein	62.8	65.2	68.1	70.3						66.6
Little Stawamus-1	50.4	56.1	58.9	49.3	55.1					53.9
Little Stawamus-2		58.0	59.3	55.6	50.9	57.2	53.5		50.5	55.0
Little Stawamus-3						59.2	59.8	57.5	59.2	58.9
Meighan	55.0	54.7	58.9	55.0						55.9
Mixal					58.5					58.5
Myers-1		68.3	71.2							69.7
Myers-2				54.4	53.1				56.0	54.5
Myers-3					63.6			56.9	65.3	61.9
Okeover-1	62.4	67.0	74.3	73.2	69.8			73.8	73.6	70.6
Okeover-2		59.1	67.7	62.0	51.1			58.7	63.6	60.4
Ouillet		71.8	68.2	64.6						68.2
Whittall	50.7	64.2	63.1	63.2	75.1			63.5	?	63.3
Wilson-1		74.1	78.8	80.1	58.8			56.7	68.1	69.4
Wilson-2					62.9		56.3	51.7	61.0	58.0
Area 15,16,28 Means:										
All data	59.3	64.7	67.5	63.5	58.8	55.5	54.5	58.4	62.2	62.4
Selected data	56.6	64.0	67.7	63.5	60.0	(58.2)	56.5	59.8	62.2	61.9
Lower Mainland (Areas 29B-E)										
Little Campbell	65.6	67.3	72.4	62.6			75.9	64.4		68.0
Lorenzetta					74.0					74.0
MacIntyre		53.7	51.2	51.9	53.5	48.6	53.6		59.3	53.1
Murray	74.0	56.1	69.0	51.8	57.7	65.0	76.2	62.4	59.8	63.5
Nathan-1	74.4	74.1	76.7	76.7	85.6	69.3	83.5	82.3	88.7	79.0
Nathan-2		68.0	58.8	57.5	61.4	65.1	72.7	63.0	64.3	63.8
Post					60.4	53.5	55.3	56.1	60.8	57.2
Salmon - 248th St							77.6			77.6
Salmon - 56th St							69.8			69.8
Salmon - 64th Ave							71.7			71.7
Salmon-Coghlan-1	57.2	65.6	66.2	58.6	66.0	60.1	79.2	55.0	59.0	63.0
Salmon-Coghlan-2					57.6	58.5	68.6	60.8	62.4	61.6
Salmon-Coghlan-3							71.7			71.7
Siddle		53.0	48.6	51.2	53.8	51.7	56.9	59.0	63.5	54.7
Whonnock-1	63.6	65.1	61.4	71.0	63.9	57.8	76.0	64.6	67.7	65.7
Whonnock-2					51.1	48.5	53.0	47.1	48.7	49.7
Lower Mnld. Means:										
All data	67.0	62.8	63.0	60.2	62.3	57.8	69.4	61.5	63.4	65.3
Selected data	67.3	63.7	63.9	61.3	63.1	58.5	69.9	61.4	63.4	65.8
<u>All Data:</u>										
Grand Mean	63.6	64.6	65.6	62.6	60.1	60.2	67.1	61.0	61.9	63.9
Mean of Area Means	63.6	64.6	65.3	62.4	60.3	59.0	64.7	60.7	62.1	63.9
<u>Selected Data:</u>										
Grand Mean	61.6	63.9	65.0	62.0	60.9	61.0	67.4	61.5	61.5	63.4
Mean of Area Means	61.4	64.1	65.0	62.2	61.1	60.8	65.3	61.3	61.7	63.4

[1] Sites are numbered where more than one site was surveyed.

[2] Does not include the single stream in the Area 15,16,28 group.

Table 3. Coho smolt production from Black Creek, 1985 to 1997 brood years: numbers per age and per female spawner.

Brood Year	Females	Smolts			Total smolts per female
		Age 1.	Age 2.	Total	
1985	2,848	66,543	3,850	70,393	24.7
1986	2,420	73,150	4,667	77,817	32.2
1987	346	25,834	9,765	35,598	103.0
1988	1,267	109,317	3,905	113,222	89.3
1989	1,627	51,095	4,424	55,519	34.1
1990	713	45,847	9,515	55,362	77.6
1991	1,849	55,656	2,661	58,317	31.5
1992	815	75,610	4,980	80,590	98.9
1993	389	15,020	99	15,119	38.8
1994	419	14,079	1,608	15,687	37.5
1995	910	74,984	3,414	78,397	86.2
1996	126	21,324	38	21,362	169.5
1997	644	26,332	-	26,332 [1]	40.9 [1]

[1] Not including age 2. smolts (leaving spring, 2000)

Table 4. Key to catch region abbreviations.

NTR	Northern BC Troll	GSN	Str. of Georgia Net
NCTR	North/Central BC Troll	FGN	Fraser R. Gillnet
SCTR	South/Central BC Troll	JFN	Juan de Fuca Str. Net
NWTR	NW Vancouver Is. Troll	FSN	Fraser Seine Net
SWTR	SW Vancouver Is. Troll	NSPT	Northern BC Sport
GSTR	Str. of Georgia Troll	CSPT	Central BC Sport
JFTR	Juan de Fuca Str. Troll	ACSP	Alberni Canal Sport
NN	Northern BC Net	WSPT	West Coast Vancouver Is. Sport
CN	Central BC Net	GSPTN	Str. of Georgia Sport, North
NWVN	NW Vancouver Is. Net	GSPTS	Str. of Georgia Sport, South
SWVN	SW Vancouver Is. Net	JFSP	Juan de Fuca Str. Sport
JSN	Johnstone Str. Net	FWSP	Freshwater Sport

Table 5. Ocean catches of southern BC coho salmon in commercial and recreational fisheries by catch region and year, 1970 to 1997. Catch region abbreviations are explained in Table 4.

YEAR	SCTR	GSTR	JFTR	SWTR	NWTR	FGN	FSN	Fraser Net[1]	JSN	GSN	JFN	SWVN	NWVN
1970	262,330	162,103	16,789	526,594	252,839	99,076	0	99,076	190,041	20,157	463,978	6,018	22,013
1971	134,687	238,985	7,130	1,509,385	666,334	70,636	145	70,781	226,741	26,663	597,689	10,317	30,967
1972	194,910	62,881	7,434	601,387	387,038	80,922	0	80,922	73,636	11,841	158,261	9,917	23,723
1973	171,408	92,497	1,508	1,127,748	278,553	53,521	0	53,521	145,999	17,357	474,034	13,437	23,608
1974	179,855	148,074	5,664	1,230,483	413,520	26,144	20	26,164	106,485	16,026	437,892	2,572	63,890
1975	115,696	112,609	4,094	524,507	256,741	43,226	12	43,238	116,468	21,401	408,213	4,041	72,406
1976	372,286	80,635	3,365	1,136,783	503,476	13,915	94	14,009	204,552	12,174	248,510	11,047	28,736
1977	159,925	143,194	7,314	1,244,496	323,383	41,427	692	42,119	226,896	11,510	505,842	9,636	41,160
1978	205,822	326,372	1,831	955,328	404,946	51,002	0	51,002	199,830	6,846	104,174	26,219	3,114
1979	186,351	224,239	1,496	1,365,077	547,801	7,661	0	7,661	135,435	1,142	255,340	23,057	2,321
1980	212,457	150,819	2,202	1,325,602	412,868	34,587	0	34,587	167,641	6,911	158,611	12,019	3,151
1981	196,917	63,867	5,270	1,026,915	358,408	5,181	0	5,181	201,216	12,353	278,186	6,319	1,073
1982	145,783	115,693	1,593	1,315,815	461,621	19,365	0	19,365	194,242	9,021	127,641	3,949	9,451
1983	351,635	57,938	0	1,689,250	478,188	11,302	21	11,323	243,265	16,279	16,907	9,053	155
1984	226,130	80,416	3,642	1,668,409	503,757	9,194	0	9,194	119,104	13,563	74,851	7,787	2,772
1985	89,266	191,207	310	1,012,020	377,035	18,229	0	18,229	147,276	31,764	224,735	4,859	2,656
1986	430,083	181,419	2,892	1,546,331	610,502	32,790	1,604	34,394	126,711	16,237	202,501	6,709	3,872
1987	141,049	217,538	190	1,295,914	525,108	6,528	0	6,528	60,746	14,045	216,400	6,741	501
1988	145,363	256,480	187	1,039,887	555,914	26,899	2,994	29,893	84,306	3,478	56,719	10,968	0
1989	94,888	73,306	69	1,373,216	578,793	9,954	0	9,954	116,300	5,051	342,055	39,660	0
1990	165,128	163,202	92	1,134,092	729,516	12,748	0	12,748	106,638	8,014	154,133	2,740	0
1991	47,384	11,583	0	1,225,300	664,646	10,085	6	10,091	70,292	7,168	180,362	5,234	0
1992	164,425	137,289	0	736,329	935,493	6,963	0	6,963	76,073	5,675	105,963	9,167	572
1993	56,726	275,953	0	531,812	421,999	3,000	0	3,000	58,356	7,216	6,211	3,406	71
1994	36,074	50,754	0	1,044,142	207,675	5,664	0	5,664	37,574	716	131,026	4,661	91
1995	6,369	15	0	1,076,442	277,561	832	0	832	17,856	19	38,166	1,470	74
1996	1,944	21	720	555,227	237,349	874	0	874	5,517	0	4,155	1,013	0
1997	1,001	19	0	3	35	753	0	753	5,913	0	402	10	3

[1] FGN plus FSN

Table 5. (Continued) Coho catches.

YEAR	GSPN	GSPS	JFSP	GS Sport+ JFSP[2]	ACSP	WSPT	WVI Sport[3]	Gear Totals Net	Troll	Sport	Grand Total
1970				500,000				801,283	1,220,655	500,000	2,521,938
1971				800,000				963,158	2,556,521	800,000	4,319,679
1972				335,000				358,300	1,253,650	335,000	1,946,950
1973				373,000				727,956	1,671,714	373,000	2,772,670
1974				772,000				653,029	1,977,596	772,000	3,402,625
1975				454,000				665,767	1,013,647	454,000	2,133,414
1976				415,000				519,028	2,096,545	415,000	3,030,573
1977				682,000				837,163	1,878,312	682,000	3,397,475
1978				1,103,000				391,185	1,894,299	1,103,000	3,388,484
1979				708,734				424,956	2,324,964	708,734	3,458,654
1980	291,200	86,600	15,700	393,500				382,920	2,103,948	393,500	2,880,368
1981	219,626	72,210	25,255	317,091				504,328	1,651,377	317,091	2,472,796
1982	333,700	57,996	19,990	411,686				363,669	2,040,505	411,686	2,815,860
1983	310,246	52,420	41,365	404,031				296,982	2,577,011	404,031	3,278,024
1984	318,302	83,462	41,826	443,590	2,995		2,995	227,271	2,482,354	446,585	3,156,210
1985	569,722	133,171	25,304	728,197	628	1,562	2,190	429,519	1,669,838	730,387	2,829,744
1986	442,432	94,842	34,706	571,980	1,458	1,121	2,579	390,424	2,771,227	574,559	3,736,210
1987	472,127	107,886	61,559	641,572	2,215	24,619	26,834	304,961	2,179,799	668,406	3,153,166
1988	824,298	184,614	75,878	1,084,790	303	5,323	5,626	185,364	1,997,831	1,090,416	3,273,611
1989	332,647	75,149	89,427	497,223	816	44,452	45,268	513,020	2,120,272	542,491	3,175,783
1990	493,105	67,519	69,409	630,033	334	19,843	20,177	284,273	2,192,030	650,210	3,126,513
1991	34,977	11,544	110,590	157,111	239	49,847	50,086	273,147	1,948,913	207,197	2,429,257
1992	358,494	117,328	119,732	595,554	195	37,459	37,654	204,413	1,973,536	633,208	2,811,157
1993	552,115	177,698	108,918	838,731	587	13,735	14,322	78,260	1,286,490	853,053	2,217,803
1994	147,991	28,159	118,617	294,767	19	16,378	16,397	179,732	1,338,645	311,164	1,829,541
1995	11,208	3,476	71,461	86,145	416	41,155	41,571	58,417	1,360,387	127,716	1,546,520
1996	26,737	7,139	94,014	127,890	564	25,148	25,712	11,559	795,261	153,602	960,422
1997	2,620	2,786	105,063	110,469	529	29,052	29,581	7,081	1,058	140,050	148,189

[2] Total of GSPN, GSPS AND JFSP. [3] ACSP plus WSPT

Table 6. Coho encounters and associated mortalities by type of fishery in Southern British Columbia, 1998 and 1999.

Fishery	1998				1999			
	Encounters	% of total encounters	Mortality	% of total mortality	Encounters	% of total encounters	Mortality	% of total mortality
Commercial	21,268	14.3	8,887	38.6	4,061	3.7	1,243	4.1
Recreational	88,136	59.3	8,814	38.3	79,407	71.7	16,146	53.6
First Nations[1]	191	0.1	115	0.5	11,354	10.3	7,843	26.1
Experimental	32,020	21.6	3,270	14.2	7,765	7.0	1,765	5.9
Test Fisheries	6,910	4.7	1,945	8.4	8,121	7.3	3,106	10.3
Total	148,525	100	23,031	100	110,708	100	30,103	100

[1]The difference in aboriginal encounters in 1998 and 1999 is largely due to improved monitoring.

Table 7. Expanded CWT recoveries by catch region for adult coho released from Quinsam Hatchery, 1977 to 1999. Escapements, exploitations, survivals and 'inside' catch distributions are also given.

Return Year:	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
No.Smolts Rel'd:	1,439,951	661,667	447,803	1,331,237	1,066,444	714,197	740,626	948,180	1,174,047	1,853,852	1,201,640	1,287,066
Fishery:												
NTR	178	751	79	980	305	113	161	114	57	379	382	540
NCTR	1,163	1,018	164	2,332	546	236	555	191	114	331	642	581
SCTR	3,690	5,735	1,593	13,158	10,973	2,746	8,794	5,333	4,510	24,835	5,760	6,946
NWTR	2,333	3,186	1,413	8,084	3,909	2,497	4,792	3,885	2,745	4,775	4,080	8,805
SWTR	2,516	1,699	791	5,311	2,317	1,472	1,226	2,571	2,421	3,115	2,534	1,444
GSTR	2,924	6,009	1,154	7,415	1,639	1,200	2,897	1,388	3,886	5,587	13,307	6,480
JFTR	-	-	-	-	-	-	-	-	-	-	-	-
NN	25	-	227	198	-	31	-	-	24	-	95	-
CN	24,730	880	499	1,497	116	379	238	86	348	165	308	468
NWVN	1,531	-	-	-	-	-	-	4	-	25	-	-
SWVN	-	-	-	110	15	-	-	-	31	-	-	-
JSN	19,137	10,066	3,677	23,104	20,679	7,970	12,042	7,229	16,792	17,258	6,011	12,218
GSN	78	35	-	57	155	55	125	111	218	461	169	176
FGN	-	65	15	19	139	39	69	48	12	145	-	-
JFN	758	31	23	757	1,038	181	26	71	852	773	744	263
FSN	-	-	-	-	-	-	-	-	-	-	-	-
NSPT	-	-	-	-	-	-	-	-	6	-	-	-
CSPT	164	216	181	786	618	320	581	593	864	2,326	850	2,395
ACSP	-	-	-	-	-	-	-	-	-	26	-	-
WSPT	-	-	-	70	-	-	109	34	7	15	601	-
GSPTN	26,069	20,160	10,088	35,326	12,696	5,188	8,275	10,442	35,894	29,275	39,065	37,246
GSPTS	530	746	488	1,088	448	220	419	745	1,005	1,825	1,522	863
JFSP	88	189	29	-	-	-	96	159	180	353	643	1,112
FWSP	-	-	-	-	-	-	36	95	355	110	179	232
WASHINGTON	935	326	163	1,591	1,284	321	256	206	1,112	1,086	1,050	84
ALASKA	-	-	25	748	37	101	-	32	19	193	-	-
TOTAL BC TROLL	12,804	18,398	5,195	37,279	19,688	8,264	18,425	13,482	13,732	39,022	26,705	24,795
TOTAL BC NET	46,258	11,078	4,440	25,742	22,141	8,654	12,500	7,549	18,277	18,826	7,325	13,125
TOTAL BC SPORT	26,851	21,311	10,787	37,270	13,762	5,728	9,516	12,068	38,310	33,930	42,860	41,847
ESCAPEMENT	16,613	13,118	8,363	23,239	17,779	8,875	12,011	16,242	21,549	33,949	17,364	22,405
% SURVIVAL	7.2	9.7	6.5	9.5	7.0	4.5	7.1	5.2	7.9	6.9	7.9	7.9
%EXPLOITATION[1]	83.9	79.6	71.1	81.5	76.2	72.2	77.2	67.2	76.8	73.3	81.8	78.1
%MARINE EXPLOIT'N[2]	83.9	79.6	71.1	81.5	76.2	72.2	77.1	67.0	76.4	73.2	81.6	77.9
% INSIDE[3]	34.4	53.0	57.4	43.4	26.6	29.1	28.7	38.1	58.3	39.9	70.3	56.1

[1]FWSP as part of catch. [2] FWSP as part of escapement. [3] Recoveries in the inside troll and sport fisheries as proportions of total marine recoveries, excluding recoveries from Washington.

Table 7. (continued) Quinsam Hatchery.

Return Year:	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
No.Smolts Rel'd:	1,347,697	1,057,725	1,172,118	1,176,616	1,220,201	1,224,754	1,128,936	1,193,987	1,215,267	1,249,119	1,411,259
Fishery:											
NTR	867	143	139	-	-	-	-	-	33	-	-
NCTR	92	-	56	212	-	-	-	-	-	-	-
SCTR	4,218	3,846	558	4,695	646	351	-	-	-	-	-
NWTR	8,081	3,546	5,834	6,330	1,151	1,734	3,252	951	-	-	-
SWTR	3,839	1,473	11,045	1,156	182	6,024	7,388	1,711	-	-	-
GSTR	13,372	10,244	540	6,191	4,891	1,482	-	-	-	-	-
JFTR	-	-	-	-	-	-	-	-	-	-	-
NN	4	65	-	-	-	-	-	-	-	-	-
CN	408	219	-	327	-	94	-	-	111	-	-
NWVN	-	-	-	-	-	-	-	-	-	-	-
SWVN	575	-	-	-	-	54	21	-	-	-	-
JSN	16,453	11,139	4,309	4,852	3,391	985	827	473	1,080	-	-
GSN	112	122	155	-	-	-	-	-	-	-	-
FGN	14	-	-	-	-	-	-	-	22	-	-
JFN	2,073	836	2,628	224	-	571	851	-	-	-	-
FSN	-	-	-	-	-	-	-	-	-	-	-
NSPT	-	-	-	-	-	-	-	-	-	-	-
CSPT	1,845	1,432	1,208	3,524	854	133	-	554	768	-	-
ACSP	-	-	-	-	-	-	-	-	-	-	-
WSPT	30	-	590	-	-	296	916	988	43	-	-
GSPTN	39,383	32,784	3,004	23,875	20,474	7,300	1,663	1,074	94	-	885
GSPTS	3,055	1,746	-	2,602	446	698	-	-	182	-	-
JFSP	637	440	408	330	-	509	993	634	2,394	-	-
FWSP	33	275	-	-	-	-	-	-	-	-	127
WASHINGTON	1,523	141	2,309	326	-	67	1,188	205	670	132	-
ALASKA	316	178	-	-	-	68	-	141	-	214	50
TOTAL BC TROLL	30,467	19,252	18,173	18,584	6,870	9,591	10,640	2,662	33	-	-
TOTAL BC NET	19,638	12,381	7,092	5,403	3,391	1,704	1,699	473	1,213	-	-
TOTAL BC SPORT	44,984	36,676	5,209	30,330	21,773	8,935	3,571	3,250	3,481	-	885
ESCAPEMENT	40,484	13,782	16,209	14,538	10,261	7,329	11,133	9,671	8,400	11,584	9,939
% SURVIVAL	10.2	7.8	4.2	5.9	3.5	2.3	2.5	1.4	1.1	1.0	0.8
%EXPLOITATION[1]	70.5	83.3	66.9	79.0	75.7	73.5	60.6	41.0	39.1	2.9	8.6
%MARINE EXPLOIT'N[2]	70.5	82.9	66.9	79.0	75.7	73.5	60.6	41.0	39.1	2.9	7.4
% INSIDE[3]	58.5	65.6	11.6	60.1	80.6	46.7	10.4	16.5	5.8	0.0	94.7

[1]FWSP as part of catch. [2] FWSP as part of escapement. [3] Recoveries in the inside troll and sport fisheries as a proportion of total marine recoveries, excluding recoveries from Washington.

Table 8. Expanded CWT recoveries by catch region for adult coho released from Big Qualicum Hatchery, 1976 to 1999. Escapements, exploitations, survivals and 'inside' catch distributions are also given.

Return Year:	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
No.Smolts Rel'd:	377,765	672,372	783,081	837,830	615,242	750,195	1,197,409	1,182,746	1,169,263	1,254,712	3,450,163	2,591,461
Fishery:												
NTR	290	112	372	336	425	-	79	-	293	-	-	-
NCTR	1,492	493	1,680	510	637	946	497	381	334	-	-	-
SCTR	11,205	2,826	8,499	5,000	6,695	9,109	5,719	20,743	7,552	1,101	2,323	8
NWTR	4,694	2,233	6,748	3,772	6,703	4,754	4,426	9,579	10,032	2,164	1,214	1,611
SWTR	7,609	5,422	6,948	6,059	9,665	7,877	14,073	6,887	9,048	4,218	4,678	1,288
GSTR	6,448	6,690	12,726	16,145	14,896	4,771	11,981	970	3,609	5,111	3,741	1,787
JFTR	-	30	-	-	-	-	-	-	-	-	-	-
NN	94	93	-	160	-	-	-	-	-	-	-	-
CN	1,990	7,847	1,340	853	521	359	321	668	-	200	-	-
NWVN	91	126	-	-	-	-	163	-	-	-	-	-
SWVN	23	-	131	-	12	22	-	-	73	-	-	-
JSN	11,763	14,999	16,969	9,195	14,989	12,024	18,681	19,380	7,084	4,818	1,264	765
GSN	3,005	787	331	-	435	1,144	2,204	6,850	3,833	6,296	1,043	730
FGN	297	-	278	208	-	-	93	24	-	-	-	-
JFN	2,173	1,622	568	833	1,268	1,317	1,083	44	516	1,589	538	431
FSN	-	-	-	-	-	-	-	-	-	-	-	-
NSPT	-	-	-	-	-	-	-	-	-	-	-	-
CSPT	26	71	-	346	259	140	675	502	668	187	-	333
ACSP	-	-	-	-	-	-	-	-	-	-	-	-
WSPT	-	-	35	-	-	-	86	-	-	-	-	-
GSPTN	35,933	30,251	23,117	65,071	64,408	19,123	27,521	35,186	16,440	23,205	9,135	6,461
GSPTS	2,661	3,036	3,504	6,895	7,321	2,118	3,144	2,637	1,630	1,772	188	327
JFSP	289	292	185	275	102	282	1,041	715	662	114	198	376
FWSP	-	-	-	-	-	-	-	72	276	490	-	310
WASHINGTON	7,448	2,487	2,490	1,172	9,875	2,112	5,825	2,028	601	1,564	2,103	118
ALASKA	213	-	-	213	-	-	253	-	200	-	-	-
TOTAL BC TROLL	31,737	17,805	36,973	31,822	39,021	27,457	36,775	38,561	30,869	12,593	11,956	4,694
TOTAL BC NET	19,435	25,473	19,618	11,249	17,226	14,866	22,546	26,966	11,506	12,903	2,845	1,926
TOTAL BC SPORT	38,910	33,650	26,841	72,587	72,090	21,662	32,468	39,112	19,676	25,768	9,521	7,807
ESCAPEMENT	9,157	30,715	33,126	44,351	38,204	29,262	25,363	25,086	29,265	10,076	9,100	5,217
% SURVIVAL	28.3	16.4	15.2	19.3	28.7	12.7	10.3	11.1	7.9	5.0	1.0	0.8
%EXPLOITATION[1]	91.4	72.1	72.2	72.5	78.3	69.3	79.4	81.0	68.2	84.0	74.4	73.6
%MARINE EXPLOIT'N[2]	91.4	72.1	72.2	72.5	78.3	69.3	79.4	80.9	67.9	83.2	74.4	72.0
% INSIDE[3]	49.9	52.0	47.2	76.0	67.5	40.7	46.3	37.1	35.0	59.3	53.7	60.7

[1]FWSP as part of catch. [2] FWSP as part of escapement. [3] Recoveries in the inside troll and sport fisheries as a proportion of total marine recoveries, excluding recoveries from Washington.

Table 8. (Continued) Big Qualicum hatchery.

Return Year:	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
No.Smolts Rel'd:	1,423,982	1,008,692	701,855	1,016,919	1,062,989	1,142,312	1,168,887	1,158,714	1,391,025	1,302,866	1,278,697	1,322,872
Fishery:												
NTR	-	-	-	-	-	181	-	-	451	-	-	-
NCTR	80	-	-	-	198	-	-	-	-	-	-	-
SCTR	1,620	-	1,077	594	1,479	824	62	178	-	-	-	-
NWTR	1,264	350	2,126	8,050	6,878	2,349	4,822	4,416	4,439	-	-	-
SWTR	15	1,298	862	17,677	3,393	834	19,082	10,927	5,199	-	-	-
GSTR	1,465	332	3,062	327	5,869	11,502	2,598	-	-	-	-	-
JFTR	-	-	-	-	-	-	-	-	-	-	-	-
NN	-	-	-	-	-	-	-	-	-	-	-	-
CN	5	-	54	-	275	-	-	-	-	-	-	-
NWVN	-	-	-	-	-	-	-	-	-	-	-	-
SWVN	-	-	-	209	114	37	149	43	-	-	-	-
JSN	2,150	598	1,591	1,115	4,041	3,115	895	392	321	442	-	-
GSN	842	251	918	2,909	826	626	324	-	-	-	-	-
FGN	-	147	-	-	-	31	-	-	-	-	-	-
JFN	194	712	805	2,767	591	-	3,650	123	-	-	-	-
FSN	-	-	-	-	-	-	-	-	-	-	-	-
NSPT	-	-	-	-	-	-	-	-	-	-	-	-
CSPT	599	-	256	881	1,419	1,092	307	104	-	621	-	-
ACSP	-	-	-	-	-	-	-	-	-	-	-	-
WSPT	-	-	1,011	480	-	-	1,099	1,069	651	335	-	-
GSPTN	10,230	4,479	9,820	4,299	19,097	32,343	15,708	354	594	493	-	-
GSPTS	538	-	680	-	2,073	2,790	1,239	64	-	-	-	-
JFSP	-	-	562	994	508	123	1,995	422	-	2,719	-	-
FWSP	-	-	193	239	148	335	2,270	316	533	258	105	215
WASHINGTON	167	90	916	4,819	400	126	-	363	317	1,264	136	-
ALASKA	136	-	-	65	-	110	-	163	79	-	64	121
TOTAL BC TROLL	4,444	1,980	7,127	26,648	17,817	15,690	26,564	15,521	10,089	-	-	-
TOTAL BC NET	3,191	1,708	3,367	7,000	5,846	3,808	5,018	557	321	442	-	-
TOTAL BC SPORT	11,367	4,479	12,521	6,893	23,246	36,681	22,618	2,329	1,777	4,427	105	215
ESCAPEMENT	4,758	5,201	10,660	20,263	14,811	19,775	25,811	15,115	8,608	12,065	2,518	13,777
% SURVIVAL	1.7	1.3	4.9	6.5	5.8	6.7	6.8	2.9	1.5	1.4	0.4 [4]	1.1
%EXPLOITATION[1]	80.2	61.4	69.2	69.2	76.2	74.0	67.7	55.6	59.4	33.7	17.1 [4]	2.4
%MARINE EXPLOIT'N[2]	80.2	61.4	68.6	68.8	75.9	73.6	64.9	54.7	56.9	32.3	9.4 [4]	0.9
% INSIDE[3]	63.9	58.9	59.4	11.5	57.8	83.3	37.6	2.3	5.1	10.7	0.0	-

[1]FWSP as part of catch. [2] FWSP as part of escapement. [3] Recoveries in the inside troll and sport fisheries as a proportion of total marine recoveries, excluding recoveries from Washington. [4] Recoveries include pelvic fin clip (P) coho but they were excluded for survival and exploitation calculations.

Table 9. Expanded CWT recoveries by catch region for adult coho released from Inch Hatchery, 1985 to 1999. Escapements, survivals, exploitations and 'inside' catch distributions are also given.

Return Year:	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
No.Smolts Rel'd:	70,595	80,268	99,414	53,863	59,721	82,129	184,526	153,120	183,104	229,647	242,949	257,049
Fishery:												
NTR	-	-	43	-	-	-	-	-	-	-	-	-
NCTR	5	-	-	-	8	-	-	91	-	-	-	-
SCTR	-	162	149	41	29	32	18	194	18	-	-	-
NWTR	105	141	269	193	51	260	1,092	1,493	311	529	666	1,374
SWTR	759	557	1,007	786	999	1,289	5,262	2,083	575	5,533	6,903	4,642
GSTR	964	1,026	1,565	2,308	277	775	180	1,901	3,387	1,130	-	-
JFTR	-	-	-	-	-	-	-	-	-	-	-	-
NN	-	-	-	-	-	-	-	-	-	-	-	-
CN	-	-	-	-	-	-	-	-	-	-	62	-
NWVN	-	-	-	-	-	-	-	-	-	-	-	-
SWVN	-	3	31	23	69	-	21	26	-	61	-	-
JSN	28	56	111	127	40	72	-	121	123	10	154	-
GSN	47	18	46	18	-	11	-	13	14	-	-	-
FGN	15	63	-	106	-	102	359	193	-	27	-	-
JFN	170	104	240	33	434	250	811	209	-	1,075	295	29
FSN	-	8	-	-	-	-	-	-	-	-	-	-
NSPT	-	-	-	-	-	-	-	-	-	-	-	-
CSPT	-	12	46	22	-	46	25	47	63	-	-	-
ACSP	-	-	-	-	-	-	-	-	-	-	-	-
WSPT	-	-	5	-	-	-	-	-	-	20	121	-
GSPTN	1,406	974	2,224	3,982	1,241	1,559	173	2,647	5,148	2,113	112	307
GSPTS	554	364	793	1,498	466	494	581	1,542	1,926	438	1,165	312
JFSP	19	16	89	103	69	127	225	268	98	335	256	577
FWSP	28	15	28	85	59	11	69	21	76	105	124	359
WASHINGTON	286	305	431	358	669	614	1,598	522	249	31	471	560
ALASKA	-	-	-	-	-	-	9	-	-	-	-	-
TOTAL BC TROLL	1,833	1,885	3,032	3,328	1,365	2,356	6,551	5,762	4,290	7,193	7,569	6,016
TOTAL BC NET	259	253	429	307	544	435	1,191	563	137	1,174	511	29
TOTAL BC SPORT	2,007	1,380	3,184	5,689	1,834	2,236	1,072	4,525	7,312	3,010	1,777	1,554
ESCAPEMENT	451	970	1,350	1,233	2,074	902	2,594	3,581	3,216	2,486	3,027	1,790
% SURVIVAL	6.8	6.0	8.5	20.3	10.9	8.0	7.1	9.8	8.3	6.0	5.5	3.9
%EXPLOITATION[1]	90.7	79.8	84.0	88.7	68.0	86.2	80.1	76.1	78.8	82.1	77.3	82.0
%MARINE EXPLOIT'N[2]	90.1	79.5	83.6	87.9	67.1	86.0	79.5	75.9	78.3	81.3	76.4	78.4
% INSIDE[3]	71.8	67.5	69.2	84.3	53.8	56.4	10.7	56.2	89.7	32.7	13.1	8.5

[1]FWSP as part of catch. [2] FWSP as part of escapement. [3] Recoveries in the inside troll and sport fisheries as a proportion of total marine recoveries, excluding recoveries from Washington.

Table 9. (Continued) Inch hatchery.

Return Year:	1997	1998	1999
No.Smolts Rel'd:	231,092	477,089	209,702
Fishery:			
NTR	-	-	
NCTR	-	-	
SCTR	-	-	
NWTR	-	-	
SWTR	-	-	
GSTR	-	-	
JFTR	-	-	
NN	-	-	
CN	-	-	
NWVN	-	-	
SWVN	-	-	
JSN	13	13	
GSN	-	-	
FGN	-	-	
JFN	-	-	
FSN	-	-	
NSPT	-	-	
CSPT	-	-	
ACSP	-	-	
WSPT	-	-	
GSPTN	-	-	
GSPTS	-	9	110
JFSP	105	-	
FWSP	100	394	723
WASHINGTON	601	84	
ALASKA	-	14	
TOTAL BC TROLL	-	-	0
TOTAL BC NET	13	13	0
TOTAL BC SPORT	205	403	833
ESCAPEMENT	1,519	1,790	3604
% SURVIVAL	1.0	0.6 [4]	2.1
%EXPLOITATION[1]	35.0	24.9 [4]	18.8
%MARINE EXPLOIT'N[2]	30.7	17.8 [4]	2.5
% INSIDE[3]	0.0	25.2	100.0

[1]FWSP as part of catch. [2] FWSP as part of escapement. [3] Recoveries in the inside troll and sport fisheries as a proportion of total marine recoveries, excluding recoveries from Washington. [4] Recoveries include pelvic fin clip (P) coho but they were excluded for survival and exploitation calculations.

Table 10. Expanded CWT recoveries by catch region for adult coho released from Chilliwack Hatchery, 1983 to 1999. Escapements, survivals and 'inside' catch distributions are also given. Survivals are calculated from Inch Hatchery exploitation rates until 1998 (see text).

Return Year:	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
No.Smolts Rel'd:	59,358	31,516	393,925	2,119,869	1,788,359	1,799,232	1,706,288	1,728,963	1,828,481	1,908,265	1,942,508	2,083,037
Fishery:												
NTR	40	-	63	-	1,243	165	222	253	219	-	-	-
NCTR	37	15	19	237	107	158	73	122	-	-	-	-
SCTR	547	100	300	4,498	5,229	2,819	318	2,286	671	1,895	247	101
NWTR	365	265	2,091	8,019	16,526	9,694	10,406	14,006	20,098	13,624	6,595	12,139
SWTR	882	921	6,308	36,011	41,518	20,494	40,253	26,948	57,429	12,413	11,142	54,045
GSTR	397	348	11,822	31,361	40,098	53,645	8,083	22,944	235	11,127	22,425	3,221
JFTR	-	1	-	-	-	-	-	-	-	-	-	-
NN	5	-	-	132	-	-	-	-	-	-	-	-
CN	13	-	11	73	49	-	-	-	-	-	-	-
NWVN	-	-	-	-	-	-	-	-	-	-	-	-
SWVN	-	-	18	-	168	490	2,192	-	-	140	56	4
JSN	623	79	959	1,516	2,307	4,833	2,676	2,653	1,300	1,983	1,175	303
GSN	53	6	537	792	876	168	-	190	-	151	390	-
FGN	80	18	1,056	3,935	1,774	7,418	1,355	2,201	825	451	605	603
JFN	15	32	1,042	3,040	8,017	1,086	14,513	6,377	8,983	2,407	210	3,487
FSN	-	-	-	541	-	211	-	-	-	-	-	-
NSPT	-	-	-	-	-	-	-	-	-	-	-	-
CSPT	20	-	43	277	239	2,101	218	-	338	-	465	256
ACSP	-	-	-	-	-	-	-	-	-	-	-	-
WSPT	-	4	-	247	1,077	-	1,251	741	899	1,011	-	887
GSPTN	1,259	471	16,908	39,078	68,712	116,550	35,878	40,905	1,526	20,182	34,261	12,396
GSPTS	373	226	4,600	8,924	15,871	28,480	14,264	6,378	1,767	6,452	6,285	2,182
JFSP	27	13	129	1,292	2,800	1,963	1,903	1,293	1,878	831	190	2,920
FWSP	429	137	1,705	9,830	9,701	7,825	11,713	6,413	4,503	2,071	5,422	5,192
WASHINGTON	312	101	4,635	15,996	17,726	12,944	19,583	7,405	19,610	2,381	4,166	846
ALASKA	15	4	11	-	80	-	69	-	111	-	-	153
TOTAL BC TROLL	2,269	1,649	20,604	80,125	104,721	86,974	59,355	66,559	78,652	39,060	40,409	69,506
TOTAL BC NET	789	134	3,622	10,029	13,191	14,206	20,737	11,421	11,108	5,132	2,436	4,397
TOTAL BC SPORT	2,108	850	23,384	59,647	98,400	156,920	65,226	55,730	10,911	30,546	46,622	23,832
ESCAPEMENT	1,643	1,763	19,825	45,480	69,253	55,862	47,009	43,136	45,154	31,115	20,165	31,434
% SURVIVAL[1]			14.2	9.3	15.0	16.6	13.4	9.1	8.0	5.2	5.8	5.5
% INSIDE[2]	42.7	41.8	72.6	56.7	60.3	79.4	43.6	55.2	3.7	52.0	74.9	19.2

[1] 1985 to 1998 survivals were estimated assuming marine exploitations of Inch coho (see text). [2] Recoveries in the inside troll and sport fisheries as a proportion of total marine recoveries, excluding recoveries from Washington.

Table 10. (Continued) Chilliwack Hatchery.

Return Year:	1995	1996	1997	1998	1999
No.Smolts Rel'd:	1,939,584	1,795,181	1,702,085	1,943,961	1,857,069
Fishery:					
NTR	-	-	188	-	-
NCTR	-	-	-	-	-
SCTR	319	-	-	-	-
NWTR	5,782	9,581	-	-	-
SWTR	29,212	20,298	-	-	-
GSTR	-	-	-	4	-
JFTR	-	-	-	-	-
NN	-	-	-	-	-
CN	-	-	-	-	-
NWVN	-	-	-	-	-
SWVN	-	-	-	-	-
JSN	-	332	276	4	-
GSN	-	-	-	-	-
FGN	457	-	133	4	-
JFN	1,959	-	164	-	-
FSN	-	-	-	-	-
NSPT	-	-	-	-	-
CSPT	182	-	355	-	-
ACSP	-	-	-	-	-
WSPT	542	854	1,274	-	-
GSPTN	88	1,112	-	-	-
GSPTS	-	315	-	91	-
JFSP	321	4,737	3,266	-	-
FWSP	1,953	3,670	4,388	719	4,090
WASHINGTON	5,120	2,695	3,832	411	-
ALASKA	-	281	-	75	130
TOTAL BC TROLL	35,312	29,879	188	4	-
TOTAL BC NET	2,416	332	573	7	-
TOTAL BC SPORT	3,087	10,686	9,282	741	4,090
ESCAPEMENT	27,223	27,404	28,285	14,755	20,414
% SURVIVAL[1]	3.0	2.9	1.8	0.6 [3]	1.3
% INSIDE[2]	0.2	3.8	0.0	53.3 [3]	0.0
%EXPLOITATION[1]					17.1
%MARINE EXPLOIT'N[2]					0.5

[1] 1985 to 1998 survivals were estimated assuming marine exploitations of Inch coho (see text). [2] Recoveries in the inside troll and sport fisheries as a proportion of total marine recoveries, excluding recoveries from Washington. [3] Inch and Chilliwack recoveries include pelvic clipped coho but these recoveries were excluded for the survival calculation.

Table 11. Estimated CWT recoveries by catch region for adult coho from Salmon River (Langley), 1979-1981 and 1987-1999. Escapements, survivals, exploitations and 'inside' catch distributions are also given.

Return Year:	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
No.Tagged Smolts:	13,473	31,965	30,232						7,891	20,022	24,634	26,911
Fishery:												
NTR	-	4	-						-	-	-	6
NCTR	-	6	3						-	-	-	5
SCTR	5	25	122						7	31	-	31
NWTR	-	43	117						22	94	96	131
SWTR	106	482	638						111	266	563	553
GSTR	275	609	289						205	680	101	563
JFTR	-	-	-						-	-	-	-
NN	-	-	-						-	-	-	-
CN	-	11	-						-	2	-	2
NWVN	-	-	-						-	-	-	-
SWVN	-	3	1						-	5	36	-
JSN	24	50	240						2	61	32	38
GSN	-	3	18						3	5	8	3
FGN	-	140	-						1	108	6	94
JFN	23	100	118						56	33	263	43
FSN	-	-	-						-	5	-	-
NSPT	-	-	-						-	-	-	-
CSPT	-	5	-						12	37	-	7
ACSP	-	-	-						-	-	-	-
WSPT	-	-	-						16	-	26	-
GSPTN	302	919	640						260	1,235	529	789
GSPTS	179	401	283						44	512	301	151
JFSP	4	13	8						26	-	95	36
FWSP	-	-	4						7	8	-	-
WASHINGTON	98	597	340						71	205	366	224
ALASKA	-	-	-						-	-	-	-
TOTAL BC TROLL	386	1,169	1,169						345	1,071	760	1,289
TOTAL BC NET	48	307	377						62	218	344	180
TOTAL BC SPORT	485	1,337	935						365	1,791	951	982
ESCAPEMENT			1						373	1,102	903	801
% SURVIVAL									15.4	21.9	13.5	12.9
%EXPLOITATION[1]									69.3	74.9	72.8	77.0
%MARINE EXPLOIT'N[2]									68.8	74.7	72.8	77.0
% INSIDE[3]	82.3	68.6	48.9						66.6	79.0	45.3	61.3

[1]FWSP as part of catch. [2] FWSP as part of escapement. [3] Recoveries in the inside troll and sport fisheries as a proportion of total marine recoveries, excluding recoveries from Washington.

Table 11. (Continued) Salmon River.

Return Year:	1991	1992	1993	1994	1995	1996	1997	1998	1999
No.Tagged Smolts:	20,390	29,435	28,141	15,611	35,256	30,052	22,049	5,676	38,368
Fishery:									
NTR	-	-	-	-	-	-	-	-	-
NCTR	-	-	-	-	-	-	-	-	-
SCTR	1	71	19	-	5	-	-	-	-
NWTR	96	318	69	48	142	303	-	-	-
SWTR	707	317	79	550	746	759	-	-	-
GSTR	15	398	516	57	-	-	-	-	-
JFTR	-	-	-	-	-	-	-	-	-
NN	-	-	-	-	-	-	-	-	-
CN	-	3	-	-	-	-	2	-	-
NWVN	-	-	-	-	-	-	-	-	-
SWVN	-	2	-	-	-	-	-	-	-
JSN	-	16	10	6	3	7	8	-	-
GSN	-	3	-	2	-	-	-	-	-
FGN	24	52	3	19	-	-	-	-	-
JFN	129	39	8	66	54	2	12	-	-
FSN	-	-	-	-	-	-	-	-	-
NSPT	-	-	-	-	-	-	-	-	-
CSPT	-	30	10	-	-	-	-	-	-
ACSP	-	-	-	-	-	-	-	-	-
WSPT	26	50	-	28	19	18	6	-	-
GSPTN	10	456	403	167	-	63	10	-	-
GSPTS	-	217	149	26	54	55	-	-	-
JFSP	12	60	8	32	49	114	103	-	-
FWSP	-	-	-	-	5	-	-	-	-
WASHINGTON	184	74	18	-	127	66	61	3	-
ALASKA	-	3	-	-	-	8	-	-	-
TOTAL BC TROLL	818	1,104	683	655	892	1,062	-	-	-
TOTAL BC NET	153	114	21	92	57	10	21	-	-
TOTAL BC SPORT	47	813	570	253	127	251	119	-	-
ESCAPEMENT	371	730	1,079	495	1,248	982	720	141	1005
% SURVIVAL	7.7	9.6	8.4	9.6	7.0	7.9	4.2	2.5	2.6 [4]
%EXPLOITATION[1]	76.4	74.3	54.5	66.9	49.1	58.7	21.8	1.7	
%MARINE EXPLOIT'N[2]	76.4	74.3	54.5	66.9	48.9	58.7	21.8	1.7	0.2 [4]
% INSIDE[3]	2.4	52.6	83.9	25.0	5.0	8.9	7.4	-	-

[1] FWSP as part of catch. [2] FWSP as part of escapement. [3] Recoveries in the inside troll and sport fisheries as a proportion of total marine recoveries, excluding recoveries from Washington.
[4] Survivals for 1999 calculated by applying 10% release mortality to the Inch exploitation rate (see text).

Table 12. Estimated CWT recoveries by catch region for adult coho from Black Creek, 1979-1980 and 1986-1999. Escapements, survivals and 'inside' catch distributions are also given.

Return Year:	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
No.Smolts Rel'd:	29,426	39,357						24,134	31,648	35,640	74,997	29,203
Fishery:												
NTR	31	13						16	94	36	88	42
NCTR	64	123						23	25	40	15	26
SCTR	416	684						656	363	379	451	348
NWTR	366	602						308	375	519	993	334
SWTR	314	392						161	131	141	561	138
GSTR	461	598						128	467	346	209	303
JFTR	-	-						-	-	-	-	-
NN	-	3						-	9	-	32	-
CN	26	46						15	19	23	32	13
NWVN	-	-						-	-	-	-	-
SWVN	3	17						-	-	-	9	5
JSN	828	1,086						322	275	326	1,166	354
GSN	-	5						6	18	6	32	44
FGN	-	-						-	-	-	6	-
JFN	66	76						29	23	3	223	61
FSN	-	-						-	-	-	-	-
NSPT	-	-						-	-	-	-	-
CSPT	-	22						39	13	59	65	36
ACSP	4	-						-	-	-	-	-
WSPT	-	-						8	12	-	45	6
GSPTN	2,250	2,317						418	1,163	1,248	1,646	877
GSPTS	195	215						19	38	75	202	36
JFSP	4	12						9	6	-	25	22
FWSP	-	-						5	5	-	-	-
WASHINGTON	92	312						28	47	23	191	25
ALASKA	-	4						3	4	10	21	12
TOTAL BC TROLL	1,651	2,413						1,291	1,455	1,460	2,316	1,190
TOTAL BC NET	923	1,232						373	343	358	1,499	477
TOTAL BC SPORT	2,454	2,566						498	1,236	1,382	1,984	977
ESCAPEMENT	475	1,278						824	531	1,279	2,502	944
% SURVIVAL	19.0	19.8						12.5	11.4	12.7	11.4	12.4
%EXPLOITATION[1]	91.5	83.6						72.7	85.3	71.7	70.6	73.9
%MARINE EXPLOIT'N[2]	91.5	83.6						72.5	85.2	71.7	70.6	73.9
% INSIDE[3]	57.8	50.4						26.2	55.0	52.0	35.4	45.8

[1]FWSP as part of catch. [2] FWSP as part of escapement. [3] Recoveries in the inside troll and sport fisheries as a proportion of total marine recoveries, excluding recoveries from Washington.

Table 12. (Continued) Black Creek.

Return Year:	1991	1992	1993	1994	1995	1996	1997	1998	1999
No.Smolts Rel'd:	118,382	52,351	49,860	54,996	75,970	18,152	13,736	69,996	24,582
Fishery:									
NTR	66	69	52	22	73	25	13	-	-
NCTR	21	79	4	13	13	-	-	-	-
SCTR	143	896	133	50	18	-	214	-	-
NWTR	1,831	1,023	182	294	421	92	-	-	-
SWTR	1,049	209	37	647	636	72	-	-	-
GSTR	75	345	319	189	-	-	-	-	-
JFTR	-	-	-	-	-	-	-	-	-
NN	4	-	9	8	10	-	-	-	-
CN	21	64	11	18	29	-	1	-	-
NWVN	-	-	-	-	-	-	-	-	-
SWVN	5	4	-	5	1	-	-	-	-
JSN	780	529	304	185	154	9	28	6	-
GSN	28	23	12	-	-	-	-	-	-
FGN	10	-	-	-	-	-	-	-	-
JFN	473	31	-	114	34	-	-	-	-
FSN	-	-	-	-	-	-	-	-	-
NSPT	-	-	-	-	-	-	-	-	-
CSPT	232	311	108	55	67	42	17	-	-
ACSP	-	-	-	-	-	-	-	-	-
WSPT	138	99	-	29	68	-	-	-	-
GSPTN	1,032	1,117	1,192	752	94	77	14	-	-
GSPTS	14	100	33	38	-	-	-	-	-
JFSP	44	21	2	81	48	37	47	-	-
FWSP	-	-	6	-	10	-	-	-	-
WASHINGTON	412	29	17	8	87	6	27	15	-
ALASKA	39	60	97	59	204	70	5	73	-
TOTAL BC TROLL	3,186	2,622	725	1,214	1,161	188	226	-	-
TOTAL BC NET	1,320	651	337	331	229	9	29	6	-
TOTAL BC SPORT	1,459	1,647	1,341	954	287	156	78	-	-
ESCAPEMENT	2,616	1,388	638	584	1,494	182	235	3,085	407
% SURVIVAL	7.6	12.2	6.3	5.7	4.6	3.4	4.4	4.5	1.7 [4]
%EXPLOITATION[1]	71.0	78.3	79.8	81.5	56.8	70.2	60.8	3.0	
%MARINE EXPLOIT'N[2]	71.0	78.3	79.6	81.5	56.6	70.2	60.8	3.0	1.2 [4]
% INSIDE[3]	18.7	31.4	61.9	38.3	5.0	18.1	4.2	-	-

[1]FWSP as part of catch. [2] FWSP as part of escapement. [3] Recoveries in the inside troll and sport fisheries as a proportion of total marine recoveries, excluding recoveries from Washington.

[4] Survivals for 1999 calculated by applying 10% release mortality to the Quinsam exploitation rate (see text).

Table 13. Adult coho escapements to Strait of Georgia/Lower Fraser River indicator streams, including Black Creek and Salmon River (Langley). All except Chase River have no juvenile coho enhancement.

Return Year	Black	Chase*	Cowichan Tributaries: Mesachie	Richards	Rotary Channel	Oliver	Robertson Side Chan.	Patricia	Shaw	Salmon (Langley)	Upper Pitt
1941			1,291			890					
1942			999			307					
1943			1,826			394					
1944			3,292			258					
1945											
1975	7,989										
1976											
1977			1,697		719		1,575	816			7,500
1978	7,587										17,500
1979											5,000
1980											2,500
1981											4,512
1982											7,297
1983											3,545
1984			1,153								
1985	5,992										
1986	4,818		291				366				
1987	785		431				393			11,947	
1988	3,122	318	170				285			9,152	
1989	3,273	579	156		242	528	475	1,106		8,427	
1990	1,237	1,615	574	1,201	553	811	621	1,320	1,626	4,942	
1991	3,574	1,888	77	393	155	97	199	550	1,161	4,321	
1992	1,722	508	13	124	69	5	30	274	591	2,604	
1993	959	900	41	246	111	313	217	320	573	5,913	
1994	900	1,300	133	446	69	306	57	715	1,588	1,941	6,976
1995	1,760	450	374	372	10	95	83	366	701	4,214	5,053
1996	284	162	26	97	31	5	22	78	365	2,639	5,269
1997	1,200	200	171	476		35		179	322	3,949	9,386
1998	7,616	349	602	746		109		627	302	2,993	8,296
1999	515	455	107	124		106		192	158	2,123	13,437

* There have been hatchery smolt releases in Chase River since 1990. See Fig. 16 for estimates of wild and enhanced escapement components.

Table 14. Estimates of escapements of adult coho to Georgia Basin streams in 1998 and 1999. (All except Black Creek and Salmon River are AUC escapement). Females per kilometre estimates are based on an assumed 50:50 sex ratio and accessible mainstem and major tributary lengths.

Area	Stream	Stream life mostly 14 days				% difference in Total Escapement	Stream life - 7.37 days		Stream life - 6.79 days	
		1998		1999			1998		1999	
		Total Escapement	Females/km	Total Escapement	Females/km	1998-99 [a]	Total Escapement	Females/km	Total Escapement	Females/km
13	Bird Cove	43	19							
	Menzies			4	1					
	Mohan			54	9					
	Nunn's			9	3					
	Village Bay	3,500		105		-97				
	White Rock Pass	11	2							
	Geometric Mean	**119**	**6**	**22**	**3**	**-97**				
14	Black	7,616	115	515	8	-93				
	Coal	477	65	144	19	-70				
	Cowie	357	27	406	30	14				
	Dove	48	2							
	Kitty Coleman			19	5					
	Millard	179	60	59	20	-67				
	Morison	544	181							
	Nile	227	17	179	13	-21				
	Trent	2,108	105	566	28	-73				
	Tsable	1,068	80	948	71	-11				
	Waterloo	107	15	75	11	-30				
	Geometric Mean	**449**	**39**	**184**	**17**	**-44**				
16	Anderson			99	24					
	Chaster			11	2					
	Halfmoon			34	57					
	Haskins			83	119					
	Langdale			10	10					
	Mixal			106	76					
	Myers			79	26					
	Roberts			18	15					
	Wilson			79	14					
	Geometric Mean			**42**	**23**					

[a] With a stream lives of mostly 14 days

[b] All streams other than lower Fraser streams

Table 14. (Continued) Coho escapements.

Area	Stream	Stream life mostly 14 days				% difference	Stream life - 7.37 days		Stream life - 6.79 days	
		1998		1999		in Total	1998		1999	
						Escapement				
		Total Escapement	Females/km	Total Escapement	Females/km	1998-99 [a]	Total Escapement	Females/km	Total Escapement	Females/km
17	Beck	226	42	65	12	-71				
	Bonell	91	10	132	14	44				
	Bonsall	334	21	386	24	16				
	Bush	112	23	72	15	-36				
	Chase	349	39	455	51	30				
	Departure			4	2					
	Millstone			33	7					
	Nanoose	386	34	469	42	21				
	North Nanaimo			130	18					
	Rockey			12	15					
	Walker	27	7	8	2	-71				
	Geometric Mean	**161**	**21**	**65**	**12**	**-9**				
18	Glenora			37	3					
	Kelvin	71	6							
	Mesachie	602	301	107	53	-82				
	Oliver	109	18	106	18	-2				
	Patricia	627	314	192	96	-69				
	Richards	746	62	146	12	-80				
	Shaw	302	50	158	26	-48				
	Geometric Mean	**295**	**57**	**111**	**21**	**-56**				
28B	Little Stawamus	94	15	28	4	-70	179	28	58	9
	Mashiter	32	20	16	10	-50	60	38	32	20
	Pillchuck	228	38	113	19	-51	433	72	233	39
	Geometric Mean	**88**	**22**	**37**	**9**	**-57**	**167**	**42**	**76**	**19**
29B	Nathan	183	14	529	41	189	347	27	1,092	84
	Salmon R. (Langley)	2,992	55	2,123	39	-29	2,992	55	2,123	39
	Geometric Mean	**740**	**28**	**1,060**	**40**	**80**	**1,019**	**38**	**1,523**	**57**

[a] With a stream lives of mostly 14 days

[b] All streams other than lower Fraser streams

Table 14. (Continued) Coho escapements.

Area	Stream	Stream life mostly 14 days				% difference in Total Escapement	Stream life - 7.37 days		Stream life - 6.79 days	
		1998		1999			1998		1999	
		Total Escapement	Females/km	Total Escapement	Females/km	1998-99 [a]	Total Escapement	Females/km	Total Escapement	Females/km
29C	Blaney c	186	58	35	11	-81	353	110	73	23
	MacIntyre	183	51	450	125	146	347	96	929	258
	U. Pitt	8,296		13,437						
	Geometric Mean	**656**	**54**	**599**	**37**	**33**	**350**	**103**	**260**	**77**
29D	Lagace	38	3	33	3	-15	73	6	67	6
	Whonnock	261	18	472	33	80	496	34	973	68
	Geometric Mean	**100**	**8**	**124**	**9**	**33**	**190**	**14**	**255**	**19**
29E	Fourteen Mile	247	154	318	199	29	469	293	656	410
	Hopedale	61	56	73	67	20	116	105	151	137
	Kawkawa	226	71	302	94	34	429	134	623	195
	Post	591	118	2,427	485	311	1,121	224	5,006	1,001
	Street	6	4	49	27	667	12	7	100	56
	Geometric Mean	**105**	**48**	**242**	**110**	**212**	**199**	**91**	**499**	**228**
	Coastal[b]	**237**	**30**	**69**	**14**	**-40**	**167**	**42**	**76**	**19**
	Lower Fraser	**228**	**32**	**347**	**48**	**123**	**295**	**57**	**481**	**93**
	Total	**234**	**30**	**99**	**19**	**11**	**261**	**53**	**323**	**66**

[a] With a stream lives of mostly 14 days

[b] All streams other than lower Fraser streams

Table 15. Frequency of different escapement indices of female coho salmon in Georgia Basin streams, 1998-99. The identical frequency distributions shown for 1998 in B. and C. are correct.

(A. All Georgia Basin streams - stream life (SL) in lower Fraser/lower Mainland (LFLM) streams converted to 14 days to align them with stream lives used in most Vancouver Island streams

	1998		1999	
Females/km	No. of streams	% of total	No. of streams	% of total
<3	2	5.0	4	7.7
3-13	5	12.5	15	28.8
>13	33	82.5	33	63.5
Total	40	100.0	52	100.0

(B Lower Fraser/lower Mainland (LFLM) streams only - recalculated using a stream life of 14 days like that used for most Vancouver Island streams.

	1998		1999	
Females/km	No. of streams	% of total	No. of streams	% of total
<3	0	0.0	0	0.0
3-13	2	14.3	4	28.6
>13	12	85.7	10	71.4
Total	14	100.0	14	100.0

(C. Lower Fraser/lower Mainland streams - using stream residence times derived each year from Salmon River (Langley) and applied to all other LFLM streams, 7.37 days in 1998 and 6.79 days in 1999

	1998		1999	
Females/km	No. of streams	% of total	No. of streams	% of total
<3	0	0.0	0	0.0
3-13	2	14.3	2	14.3
>13	12	85.7	12	85.7
Total	14	100.0	14	100.0

Table 16. Estimates of the wild and hatchery component of Vancouver Island and Sunshine Coast streams surveyed for escapement estimates.

Area	Stream	Estimated Escapement					
		1998			1999		
		Total	Enhanced[1]	Wild	Total	Enhanced[1]	Wild
13	Bird Cove	43	11	32			
	Menzies				4	28	0
	Mohun				54	41	13
	Nunn's				9	16	0
	Village Bay	3,500	0	3,500	105	51	54
	White Rock Pass	11	0	11			
14	Coal	477	0	477	144	0	144
	Cowie	357	0	357	406	5	400
	Dove	48	1	47			
	Kitty Coleman				19	0	19
	Millard	179	44	135	59	61	
	Morison	544	6	538			
	Nile	227	0	227	179	0	179
	Trent	2,108	608	1,501	566	191	374
	Tsable	1,068	169	899	948	6	942
	Waterloo	107	101	6	75	5	70
16	Anderson				99	0	99
	Chaster				11	0	11
	Halfmoon				34	26	9
	Haskins				83	0	83
	Langdale				10	0	10
	Mixal				106	59	47
	Myers				79	0	79
	Roberts				18	0	18
	Wilson				79	0	79
17	Beck	226	0	226	65	0	65
	Bonell	91	0	91	132	0	68
	Bonsall	334	284	50	386	64	322
	Bush	112	69	43	72	8	64
	Chase	349	20	329	455	114	341
	Departure				4	0	4
	Millstone				33	129	0
	Nanoose	386	0	386	469	0	469
	North Nanaimo				130	100	30
	Rockey				12	0	12
	Walker	27	12	15	8	0	8
18	Glenora				37	0	37
	Kelvin	71	0	71			
	Mesachie	602	0	602	107	0	107
	Oliver	109	0	109	106	0	106
	Patricia	627	0	627	192	0	192
	Richards	746	0	746	146	0	146
	Shaw	302	0	302	158	0	158

[1]Assuming a fry to smolt survival of 15% and the same survival to escapement as Black Creek coho.

Table 17. Percent exploitation rates of adults from four hatchery and two wild coho stocks. Marine exploitation rates are more likely to reflect exploitation rates of wild stocks. Exploitations are only those attributed to catch and are not corrected for release mortality.

Return	Quinsam		Big Qualicum		Inch		Chilliwack		Black		Salmon	
Year	Total[1]	Marine[1]	Total	Marine	Total	Marine	Total	Marine	Total	Marine	Total	Marine
1976			91.4	91.4								
1977	83.9	83.9	72.1	72.1								
1978	79.6	79.6	72.2	72.2								
1979	71.1	71.1	72.5	72.5					91.5 [2]	91.5 [2]		
1980	81.5	81.5	78.3	78.3					83.6 [2]	83.6 [2]		
1981	76.2	76.2	69.3	69.3								
1982	72.2	72.2	79.4	79.4								
1983	77.2	77.1	81.0	80.9								
1984	67.2	67.0	68.2	67.9								
1985	76.8	76.4	84.0	83.2	90.7	90.1						
1986	73.3	73.2	74.4	74.4	79.8	79.5			72.7	72.5		
1987	81.8	81.6	73.6	72.0	84.0	83.6			85.3	85.2	69.3	68.8
1988	78.1	77.9	80.2	80.2	88.7	87.9			71.7	71.7	74.9	74.7
1989	70.5	70.5	61.4	61.4	68.0	67.1			70.6	70.6	72.8	72.8
1990	83.3	82.9	69.2	68.6	86.2	86.0			73.9	73.9	77.0	77.0
1991	66.9	66.9	69.2	68.8	80.1	79.5			71.0	71.0	76.4	76.4
1992	79.0	79.0	76.2	75.9	76.1	75.9			78.3	78.3	74.3	74.3
1993	75.7	75.7	74.0	73.6	78.8	78.3			79.8	79.6	54.5	54.5
1994	73.5	73.5	67.7	64.9	82.1	81.3			81.5	81.5	66.9	66.9
1995	60.6	60.6	55.6	54.7	77.3	76.4			56.8	56.6	49.1	48.9
1996	41.0	41.0	59.4	56.9	82.0	78.4			70.2	70.2	58.7	58.7
1997	39.1	39.1	33.7	32.3	35.0	30.7			60.8	60.8	21.8	21.8
1998	2.9	2.9	17.1	9.4	24.9	17.8			3.0	3.0	1.7	1.7
1999 [4]	8.6	7.4	2.4	0.9	18.8	2.5	17.1	0.5	0.0	1.2 [3]	0.0	0.2 [3]

[1]Total Exploitation: FWSP catch was included in the total catch. Marine Exploitation: FWSP catch was included in the escapement. [2] Probably over-estimates due to under-estimations of escapement.
[3] Marine exploitation calculated from nearby hatchery indicators assuming a 10% catch and release mortality (see text).
[4] Does not include Washington catches.

Table 18. Summary estimates of 1999 escapements, fishing mortalities (morts), and exploitations for southern BC coho populations in fisheries in Alaska, northern and central BC, southern BC, and Washington State (WA).

	Lower Fraser	Thompson	Upper Fraser	West Coast Vancouver Island	East Coast Vancouver Island	Southern Mainland	Northern Vancouver Island
Approximate Escapement	92,000	17,000	5,400	285,000	70,000	145,000	45,000
Alaska Exploitation[1]	0.003	0.003	0.003	0.000	0.007	0.007	0.007
North/Central BC Morts	1,213	80	28	2,019	1,879	6,591	1,716
North/Central BC Exploit.	0.013	0.005	0.005	0.007	0.026	0.043	0.037
Southern BC Morts	4,365	353	148	12,120	3,191	2,300	1,954
Southern BC Exploitation	0.045	0.020	0.027	0.041	0.044	0.016	0.042
Washington Morts[2]	7,157	1,164	56	2,461	4,228	4,047	1,328
Washington Exploitation	0.072	0.064	0.010	0.009	0.057	0.027	0.029
Total Exploitation[3]	0.133	0.092	0.045	0.057	0.133	0.093	0.114

[1] Obtained from MRP estimates for 1999 returns. WCVI estimated from releases from Robertson Creek; ECVI the mean exploitation from Quinsam and Big Qualicum; LFr the mean of Chilliwack and Inch Creek. Thompson and UFr assumed to be the same as LFr; NVI and SoMnLnd assumed to be same as ECVI.

[2] Does not include retention mortalities in mark only fisheries in US Areas 5 and 6.

[3] Does not include terminal freshwater exploitations which can be high for some enhanced populations (e.g. Chilliwack, Inch, and Quinsam).

Table 19. Percent smolt to adult survivals of four hatchery and three wild coho stocks.

Return	Hatchery Indicator Stocks				Wild Indicator Stocks		
Year	Quinsam	Big Qualicum	Inch	Chilliwack[1]	Black	Salmon	Mesachie
1976		28.3					
1977	7.2	16.4					
1978	9.7	15.2					
1979	6.5	19.3			19.0 [2]		
1980	9.5	28.7			19.8 [2]		
1981	7.0	12.7					
1982	4.5	10.3					
1983	7.1	11.1					
1984	5.2	7.9					
1985	7.9	5.0	6.8	14.2			
1986	6.9	1.0	6.0	9.3	12.5		
1987	7.9	0.8	8.5	15.0	11.4	15.4	
1988	7.9	1.7	20.3	16.6	12.7	21.9	6.9
1989	10.2	1.3	10.9	13.4	11.4	13.5	4.9
1990	7.8	4.9	8.0	9.1	12.4	12.9	7.0
1991	4.2	6.5	7.1	8.0	7.6	7.7	3.2
1992	5.9	5.8	9.8	5.2	12.2	9.6	2.5
1993	3.5	6.7	8.3	5.8	6.3	8.4	2.0
1994	2.3	6.8	6.0	5.5	5.7	9.6	2.7
1995	2.5	2.9	5.5	3.0	4.6	7.0	
1996	1.4	1.5	3.9	2.9	3.4	7.9	
1997	1.1	1.4	1.0	1.8	4.4	4.2	
1998	1.0	0.4	0.6	0.6	4.5	2.5	
1999[3]	0.8	1.1	2.1	1.3	1.7	2.6	

1 Calculated before 1999 as survival of Chilliwack adults to the marine fisheries divided by marine exploitations of Inch adults.
2 Probably under-estimates due to under-estimated escapements.
3 Does not include Washington catches yet.

FIGURES

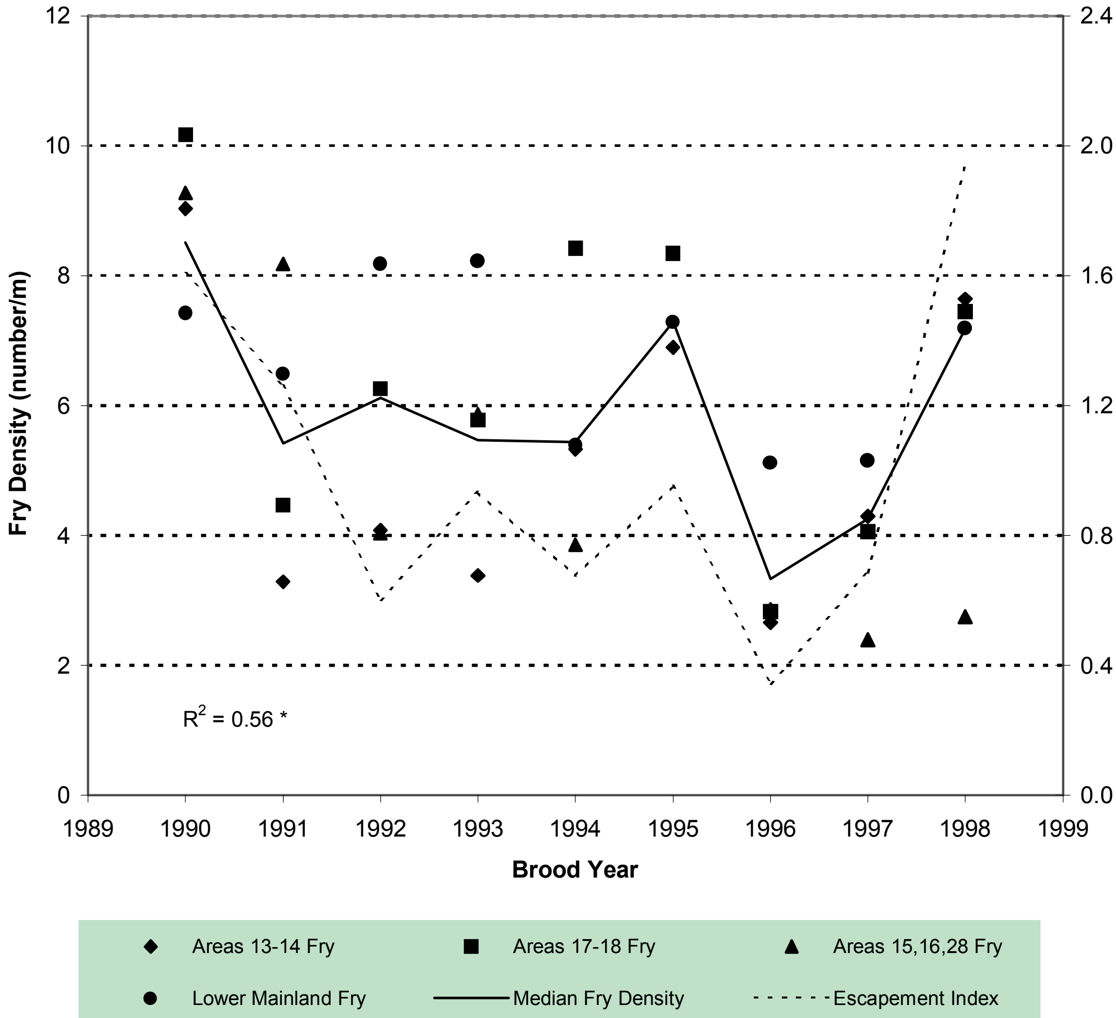


Figure 1. Median densities of coho fry in sub-areas of the Georgia Basin and an index of the parental escapement, 1990 to 1998 brood years. Density data consisted of September abundances of age 0. and age 1. fry per meter of reach length in selected streams. Points are median densities for the sub-area and the fry line is a plot of the annual median density in all selected streams in the Basin. Streams with significant enhancement were excluded. The index escapement calculation is described in the text.

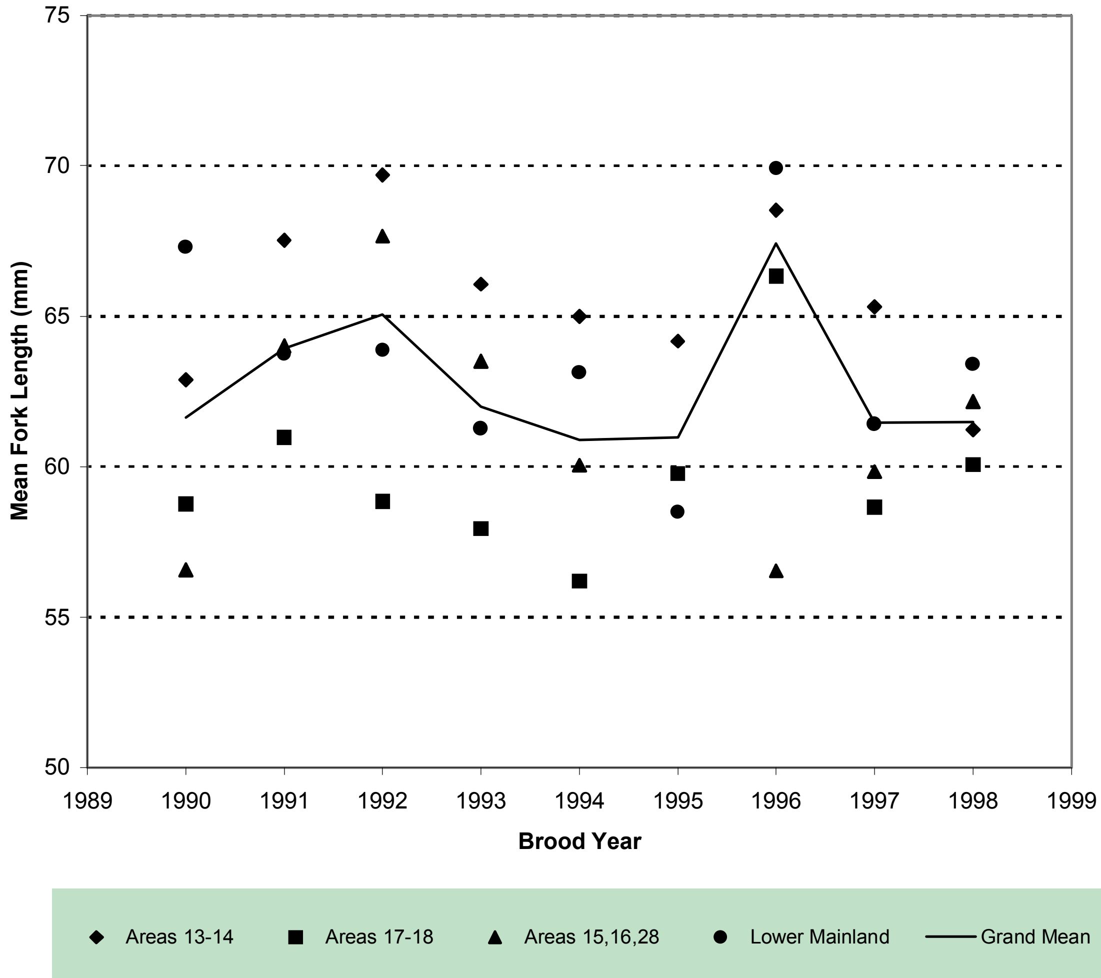


Figure 2. Mean fork length of coho fry in sub-areas of the Georgia Basin, 1990 to 1998 brood years. Points are mean sizes of age 0. fry in selected streams of each sub-area and the line is a plot of the annual mean size in all selected streams in the Basin. Streams with significant enhancement were excluded.

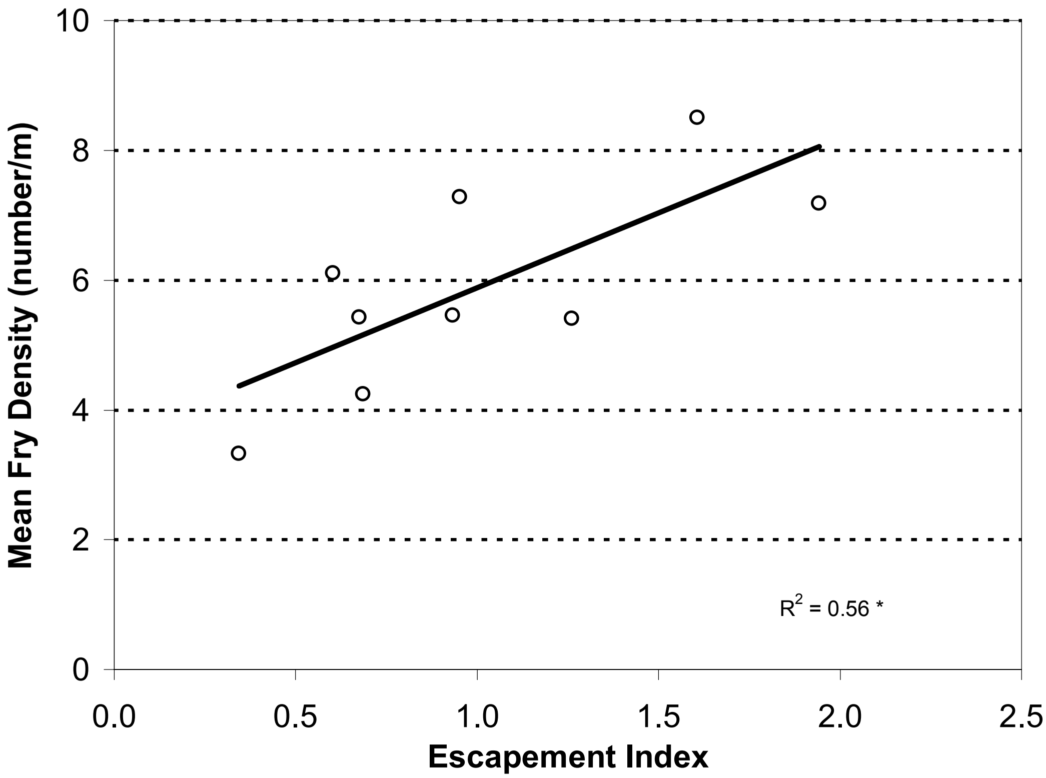


Figure 3. Density of coho fry related to parental escapements, 1990 to 1998 brood years.

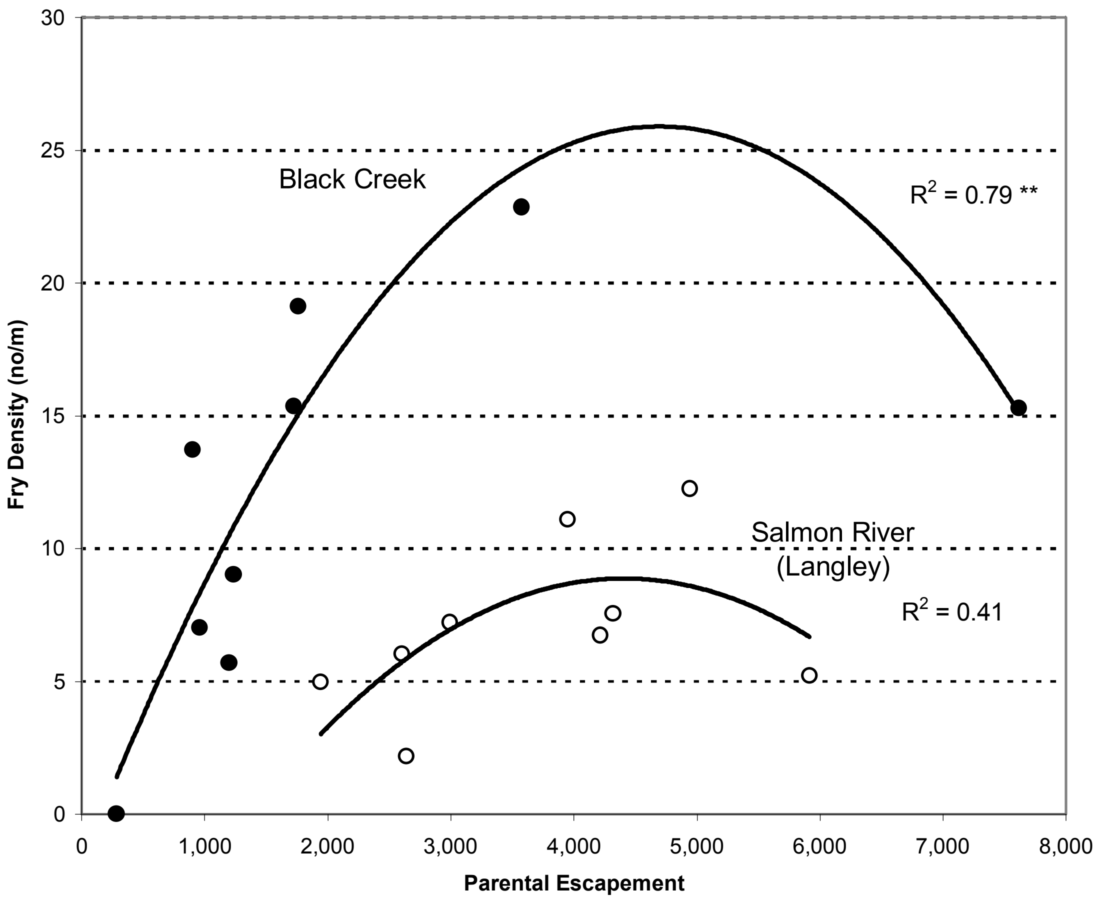


Figure 4. Density of coho fry at one site in Black Creek and one site in Salmon River related to their parental escapements, 1990 to 1998 brood years.

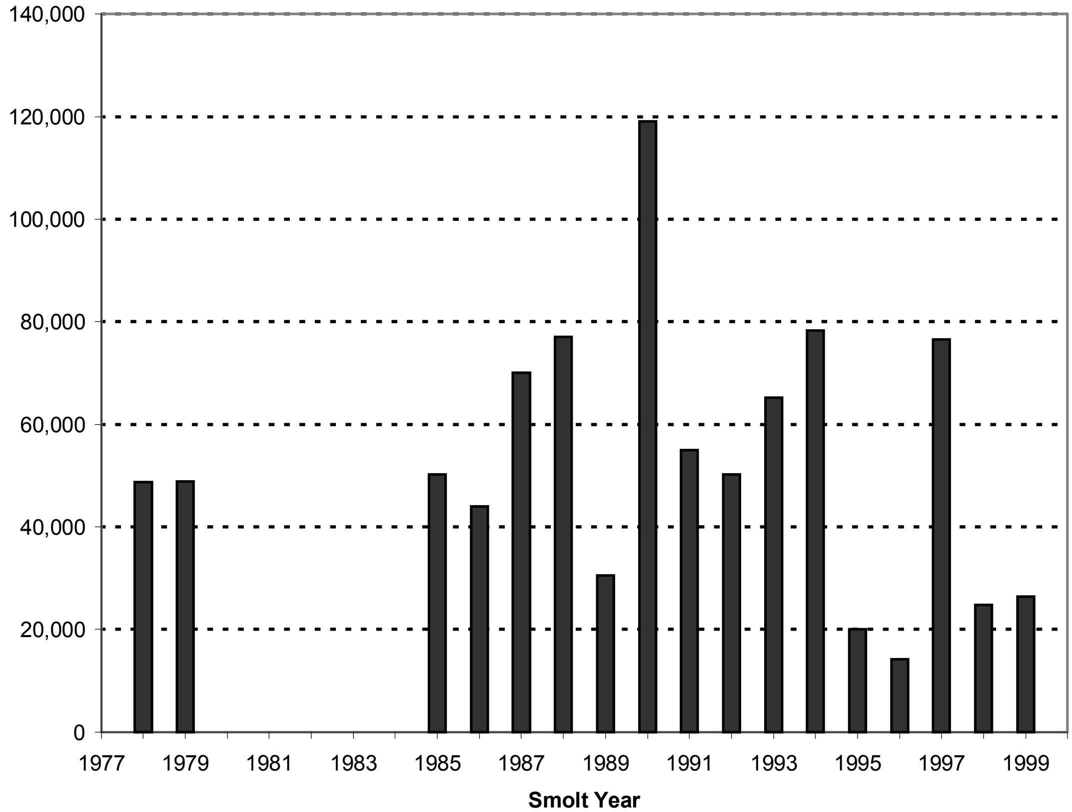


Figure 5. Coho smolt production from Black Creek estimated from fence counts.

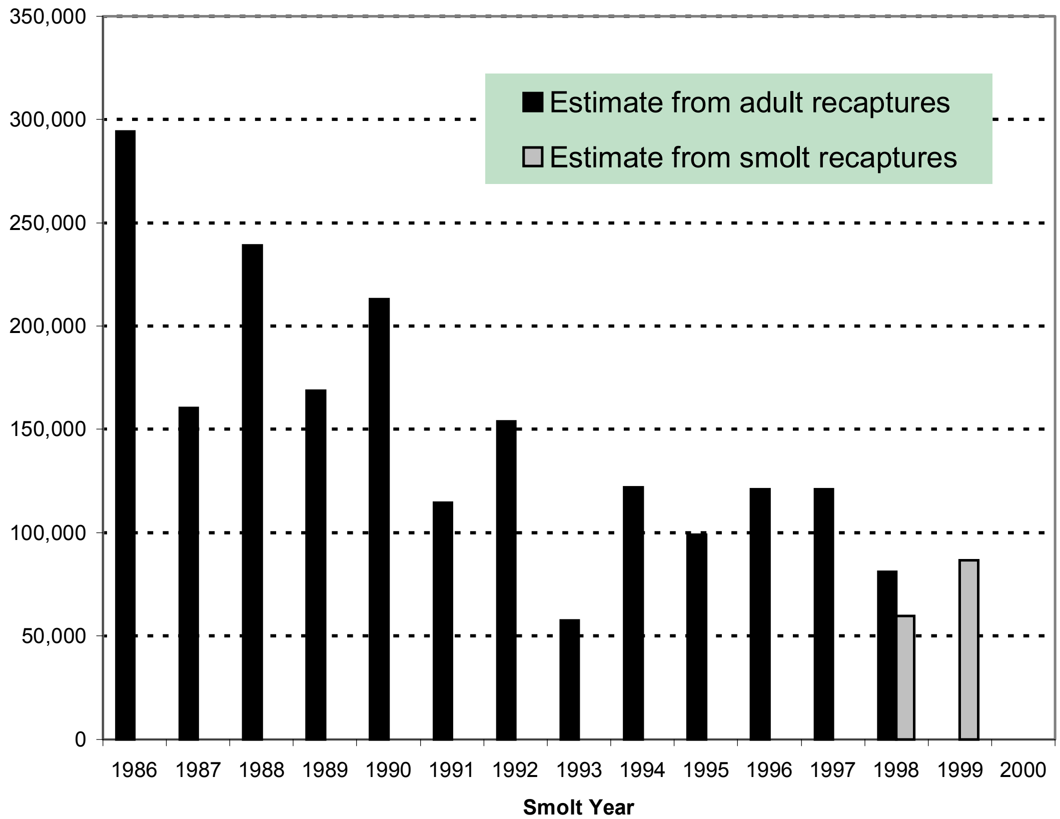


Figure 6. Coho smolt production from Salmon River (Langley). Salmon River abundances are derived as Petersen MR estimates using the number of marked adult recoveries and since 1998 also using marked smolt recoveries.

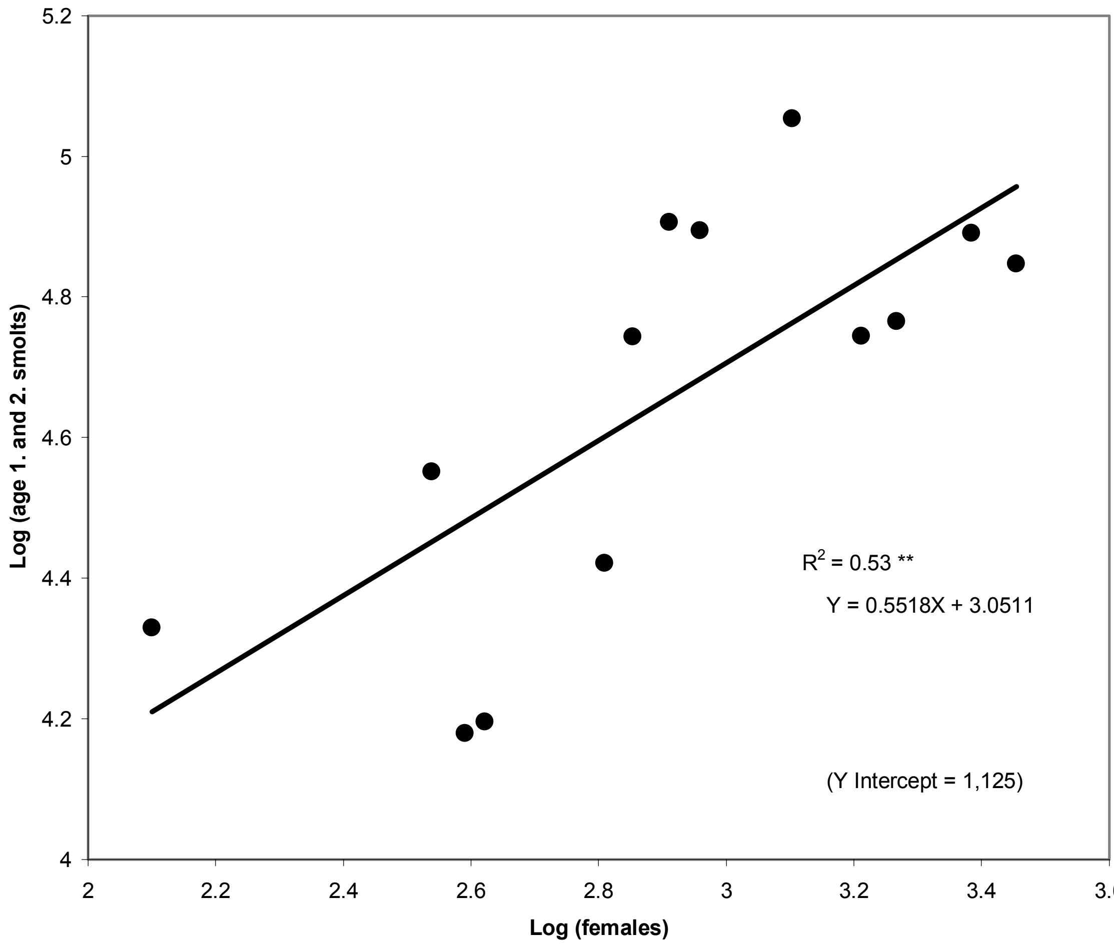


Figure 7. Log-log relationship between smolt abundance and female abundance of Black Creek coho to 1999.

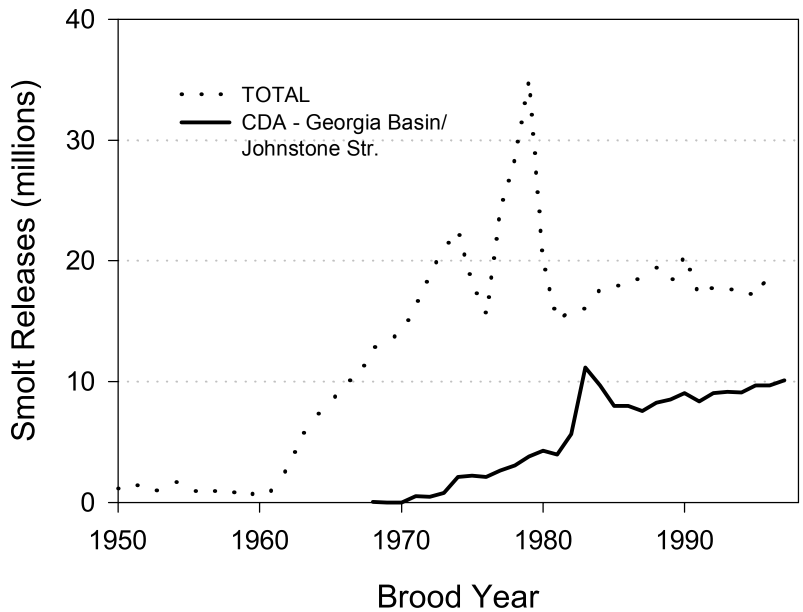


Figure 8. Total releases of 1950 – 1997 brood year smolts from Puget Sound/Juan de Fuca Strait hatcheries in Washington and Johnstone Strait/Georgia Basin hatcheries. Johnstone Strait/Georgia Strait releases are also shown separately.

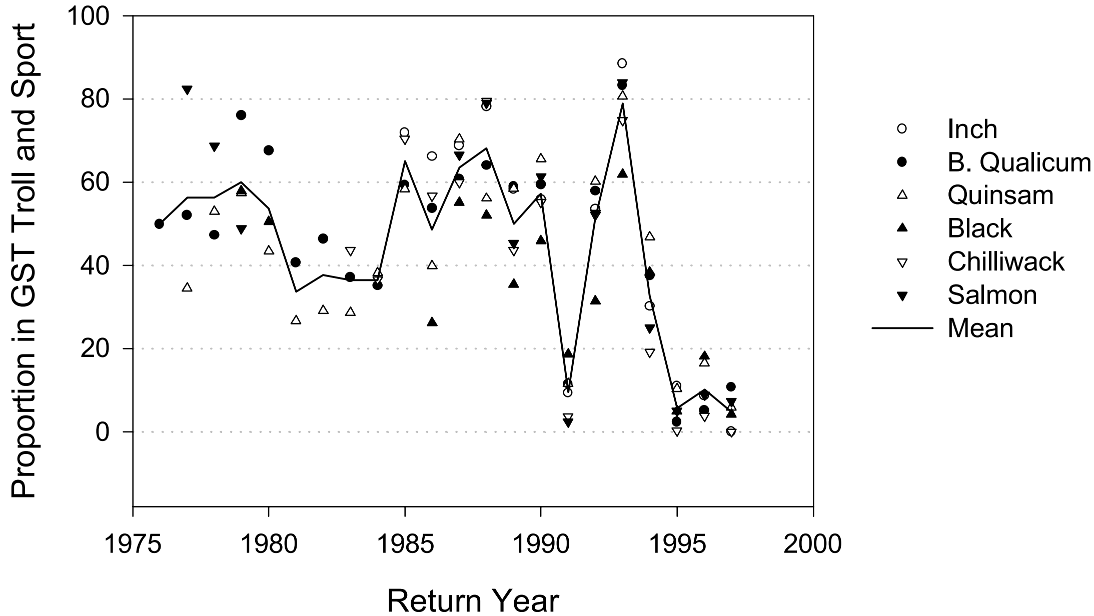
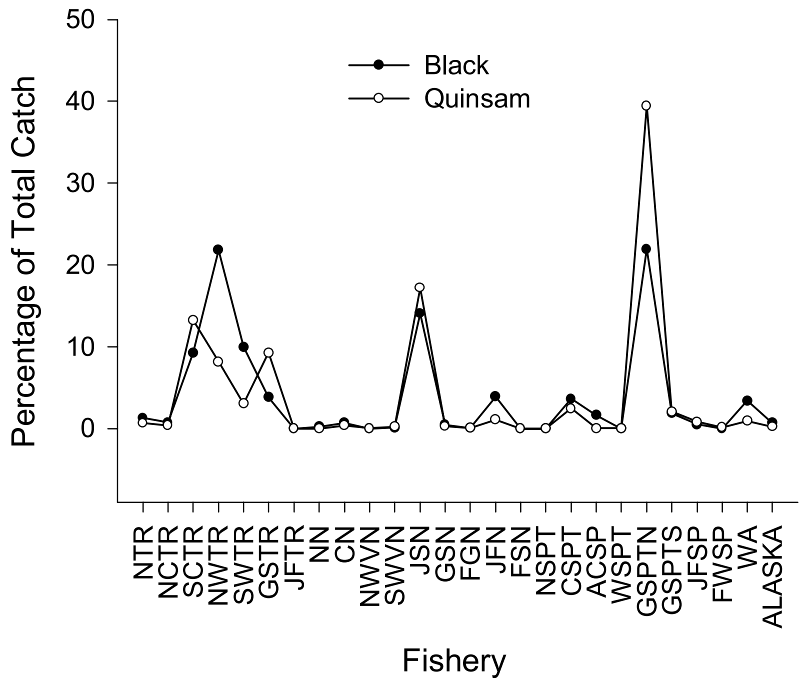


Figure 9. The proportion of the total marine catch of CWT'd coho that were caught in the Strait of Georgia troll and sport fisheries for four hatcheries and Black and Salmon (Langley) wild indicators, 1976 to 1997. Washington state estimates are excluded.



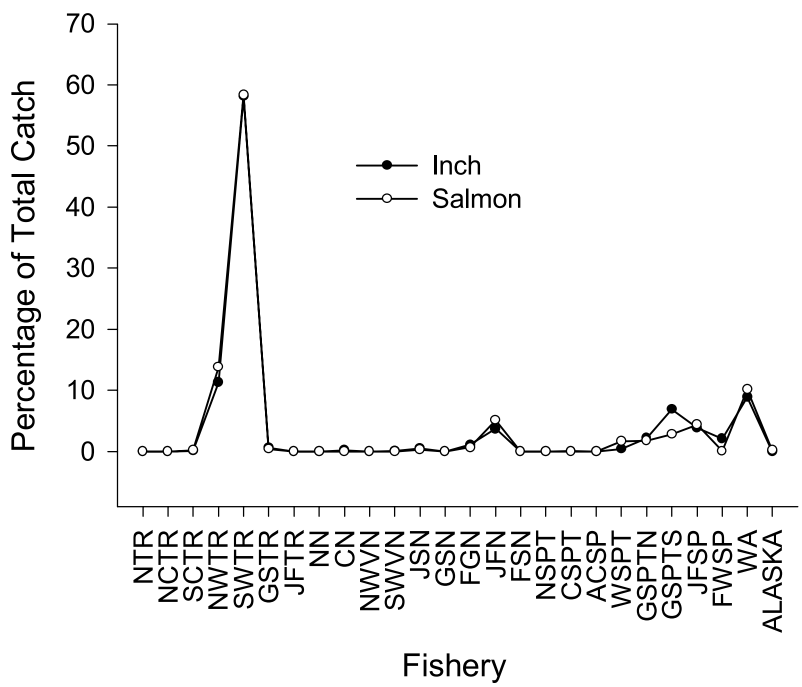


Figure 10. Comparison of the catch distribution of wild and hatchery stocks. Black Creek and Quinsam Hatchery are shown above and Salmon River (Langley) and Inch Hatchery below.

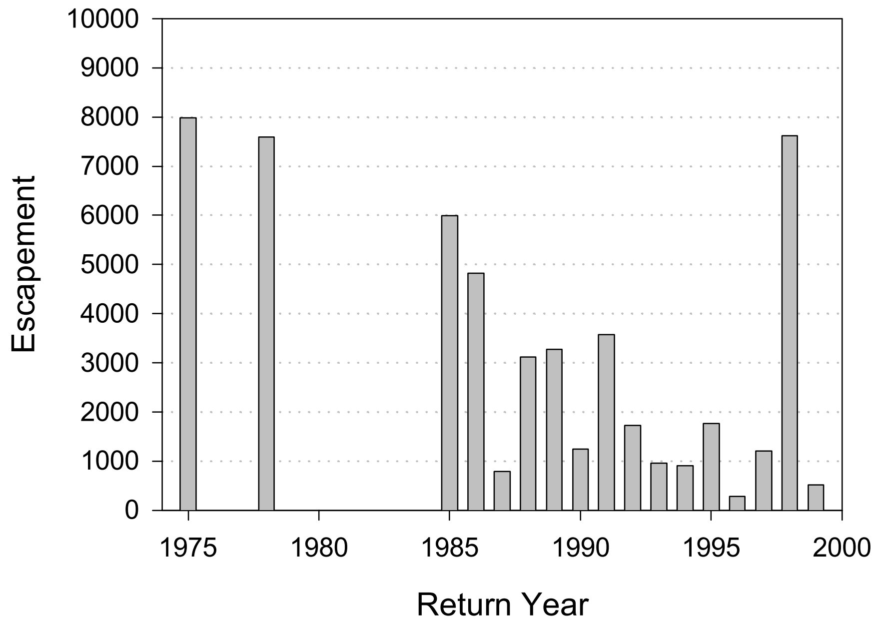


Figure 11. Total escapement estimates of adult coho to Black Creek, 1974 to 1999.

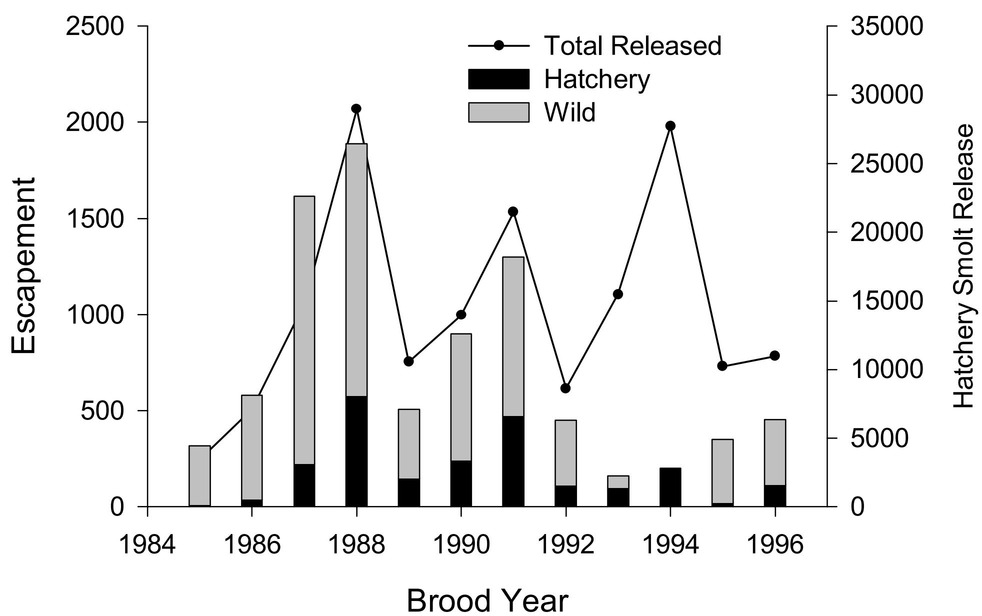


Figure 12. Escapement estimates of adult coho to Chase River in Nanaimo, 1985 to 1996 brood years. Smolt releases by the Chase River Hatchery are also shown.

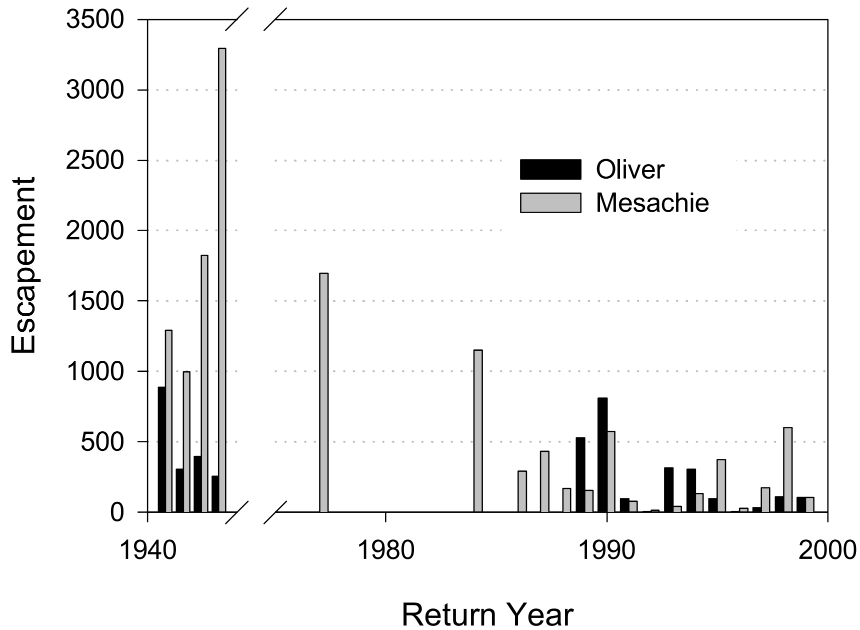


Figure 13. Escapement estimates of adult coho to Oliver and Mesachie creeks in the upper Cowichan River system, 1941 to 1999.

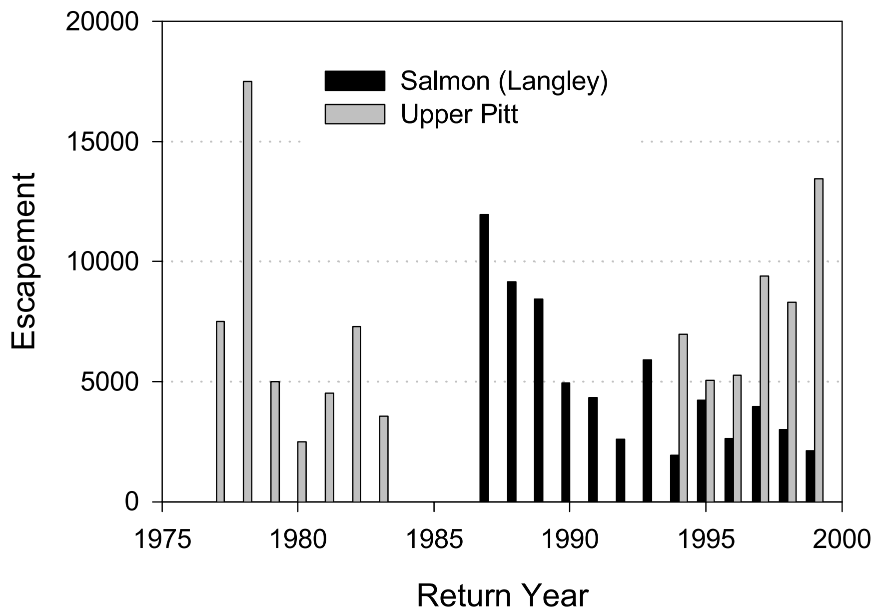


Figure 14. Escapement estimates of adult coho to Salmon River (Langley) and Upper Pitt River, 1977 to 1999.

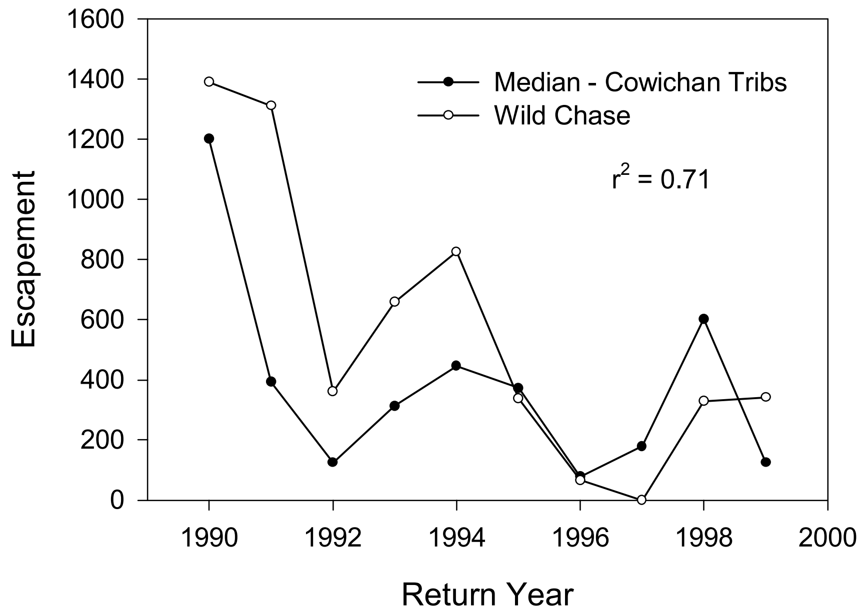


Figure 15. The median adult coho escapement for monitored Cowichan River tributaries, 1990 to 1999, with the 1990 to 1999 Chase River escapements for comparison.

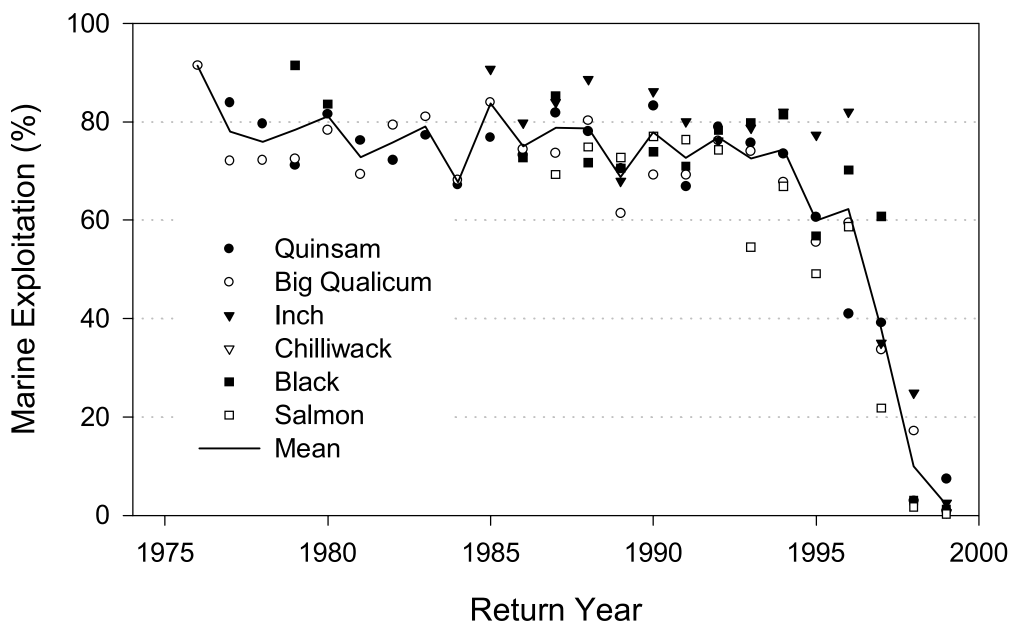


Figure 16. Marine exploitation of coastal Georgia Basin hatchery and wild stocks, 1976 to 1999 return years. Freshwater sport catches were treated as part of the escapement.

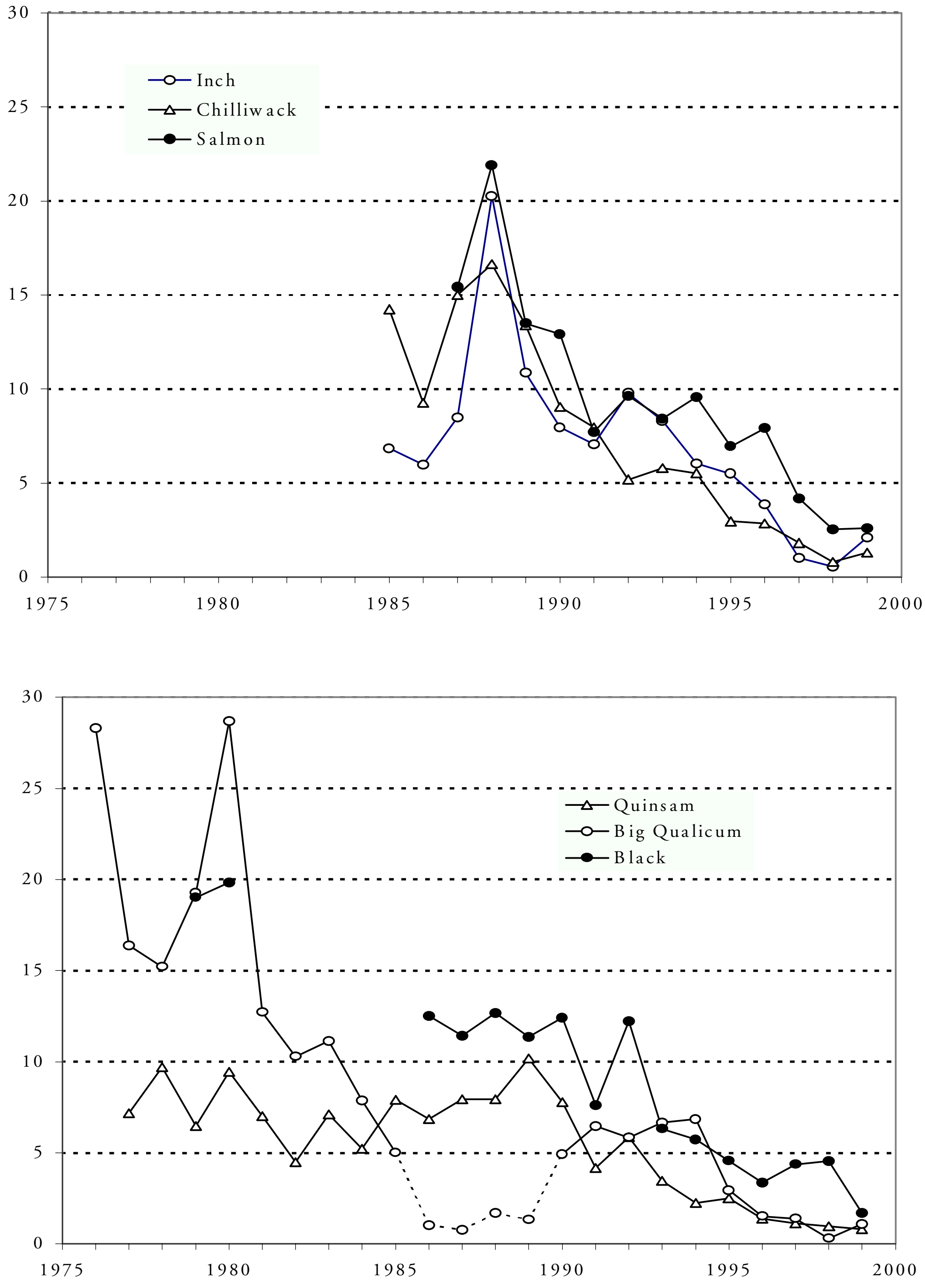


Figure 17. Coho smolt to adult survival of coastal Georgia Basin hatchery and wild indicators, 1976 to 1999 return years. The top graph shows Lower Fraser indicators and the bottom Vancouver Island indicators. The dashed line indicates a period from 1985 to 1990 when Big Qualicum was experiencing fish culture problems.

APPENDIX 1

Survey life (SL) is defined as the time a spawning fish is available for observation in a particular survey area. Being the denominator in the area-under-the-curve estimate of escapement, the choice of SL has a direct effect (doubling the life halves the estimate). Perrin and Irvine (1990) reviewed estimates that were reported in the literature and gathered from questionnaires. Although their review was exhaustive, examples documenting SL's in the literature were quite sparse. For coho they found only 15 references. There have been more studies since, but these studies are mostly concerned with developing accurate statistical estimators instead of associating the variance with biological or environmental variables (Bue et al. 1998, Lady and Skalski 1998). Since the cost of estimating SL on every stream surveyed is prohibitive and often not feasible, it is usually necessary to assume a value. Our objective in reviewing the available information again was to estimate the variability of survey lives: the annual variability within a stream and variability between streams. Most AUC estimates are used as indicators of annual trends. An assumed SL need not be accurate for this purpose if its error is not highly variable, i.e. if within-stream annual variation is not great. Secondly, we wanted to examine between-stream variation in an effort to refine the accuracy of the assumed SL. Most field observers feel that SL's are positively correlated with stream size. We stratified the size of streams with SL data to see if using a mean SL for each strata or group of strata was justified and possible.

Data came from Perrin and Irvine (1990) and references therein and was also augmented with recent examples from the literature (Manske and Schwarz 2000) and unpublished data (S. Baillie and B. Finnegan). Perrin and Irvine (1990) tested for a location effect using latitude but did not examine the effect of system size on survey life. A very rough index of system size was assigned to each BC stream by multiplying the stream watershed area with November precipitation normals from the nearest weather station. Although this measure oversimplifies hydrology, it provides at least some index of system size. The results for coho are summarised in Tables 20 and 21 and Figure 18. In Figure 18 standard error bars are displayed for streams on which estimates of survey life have been generated in multiple years.

As noted by Perrin and Irvine (1990), there is a great deal of variation in survey lives between streams. No clear trend was observed between stream size indices and SL although this may be an effect of sample size. There have been only a few studies conducted on larger systems. In those studies, the survey life was somewhat higher. The two largest systems (Little Qualicum and Keogh) with reported survey lives are both located on the East Coast Vancouver Island. While survey life has been calculated for Kirby, a smaller West Coast Vancouver Island system, there is no reliable data for larger West Coast streams. Field data suggests survey lives in these systems can be quite long (e.g. between 20 and 30 days). The suggestive trend and these observations are compatible and there is little justification at this point in changing these assumed SL's for most of the large chinook survey streams on the WCVI. On the other hand, there is insufficient data to support using other than the overall mean SL for streams being monitored in the Georgia Basin, all of whose size indices are less than approximately 15,000 and most are less than 5,000. For all streams with reported survey lives in BC, Oregon and Washington, the weighted average for coho is 14 days. The standard error of the mean is 1.5 days.

In most examples available, we would characterise annual within-stream variation as not severe (Table 20, Figure 18). The largest coefficient of variation was recorded at Black Creek where two estimates were made: 10 days and 15 days. Others had less variation relative to the mean.

One difficulty with comparing the data between studies is that methods used to calculate survey life vary. Also, in some cases, survey life is equivalent to stream residence time whereas in others survey life is only a portion of stream residence time. This inconsistency occurs when the survey area is limited to a portion of the stream. Clearly, more estimates are needed, especially on larger systems to see if the suspected positive correlation between system size and survey life is accurate. There are also potential regional differences in survey lives – e.g. between interior and coastal fish (R. Bailey, DFO, Kamloops, pers. comm.). If so, ascribing survey lives according to system size and regional variation may address some of the inaccuracies in AUC estimates without the prohibitive job of estimating survey life yearly on every system. Indicator streams, where fences are already in place, could be used to calibrate estimates on a year to year basis if need be. In summary, with more data, we may be able to refine SL assumptions to make AUC estimates more accurate. We also need more annual replications to further define the confidence limits for these SL's.

In the meantime, we opted to apply a uniform survey life of 14 days corresponding to the weighted average of coastal North American systems. When local estimates were available for a particular stream they were used. This practice is similar to other jurisdictions, such as Oregon and Washington, who apply a uniform survey life to every escapement estimate pending more detailed information survey life variation (S. Jacobs, Dept. F & W, Oregon, pers. comm.).

Table 20. Summary of survey lives for coho reported in the literature and from unpublished estimates.

River	Region	Survey Life Estimates			Mean SL	CV	Reference(s)
		1	2	3			
Keogh R.	Johnstone Str.	13.0			13.0		Johnston et al. (1986)
Kirby	Juan de Fuca Str.	13.0	13.5	15.6	14.0	9.8	S. Baillie, unpubl. data (1997-1999)
Bella Coola trib.	Central Coast	20.0			20.0		Finnegan, unpubl. data
Lachmach	North Coast	18.0	25.0		21.5	23.0	Finnegan, unpubl. data
Big Qualicum	Str. of Georgia	33.0			33.0		Fraser et al. (1993)
Black Cr.	Str. of Georgia	15.1	9.6		12.4	31.5	J. Irvine, unpubl. data (1987, 1988)
Chase	Str. of Georgia	16.0	10.4	8.9	11.8	31.8	Manske and Schwarz (2000), J. Irvine et al. (1992)
French Cr	Str. of Georgia	13.3	12.5		12.9	4.4	Irvine, unpubl. data (1987, 1988)
Lake Cowichan tribs	Str. of Georgia	8.2			8.2		Baillie, unpubl. data
Little Qualicum	Str. of Georgia	13.3			13.3		Johnston et al. (1987)
Shaw	Str. of Georgia	12.9			12.9		S. Baillie, unpubl. data
Trent R.	Str. of Georgia	7.1	9.6		8.4	21.2	J. Irvine, unpubl. data (1987, 1988)
Salmon R. (Langley)	Lower fraser	7.4	6.8		7.1	6.0	R. Semple, unpubl.data (1999)
Adams	Thompson	10.0			10.0		Whelen et al. (1983)
Coldwater	Thompson	12.5			12.5		Whelen et al. (1983)
Eagle	Thompson	12.5			12.5		Whelen et al. (1983)
Salmon R.	Thompson	15.0			15.0		Whelen et al. (1983)
Deer Cr.	Oregon	13.7			13.7		Koski (1966)
Flynn Cr.	Oregon	13.1			13.1		Koski (1966)
Spring Cr.	Oregon	11.5			11.5		Willis (1954)
Deer Cr.	Washington	9.2			9.2		van den Berghe and Gross (1986)
Harris Cr.	Washington	10.0			10.0		Flint (1984)
Little Bear Cr	Washington	24.0			24.0		Flint and Zillges (1980)

Table 21. Stream index for BC streams with reported survey life estimates for coho.

River	November precipitation (mm)	Station	Watershed Area	Stream Index = Nov. precip * watershed area
Keogh R.	261	Port Hardy	129.8	33904
Kirby	209	Victoria Marine	24.1	5053
Bella Coola trib.	189	Bella Coola	40.2	7611
Lachmach	272	Prince Rupert	41.6	11332
Big Qualicum	187	Comox	147.6	27661
Black Cr.	210	Campbell River	74.8	15705
Chase	180	Nanaimo	37.1	6658
French Cr	187	Comox	68.1	12758
Lake Cowichan tribs	180	Nanaimo	20.0	3590
Little Qualicum	187	Comox	247.7	46416
Shaw	180	Nanaimo	75.9	13628
Trent R.	187	Comox	81.5	15281
Salmon R. (Langley)	188	Langley	76.4	14359
Adams	60	Revelstoke	3337.9	201612
Coldwater	12	Kamloops	917.2	10639
Eagle	60	Revelstoke	1251.2	75575
Salmon R.	48	Lytton	1553.1	74704

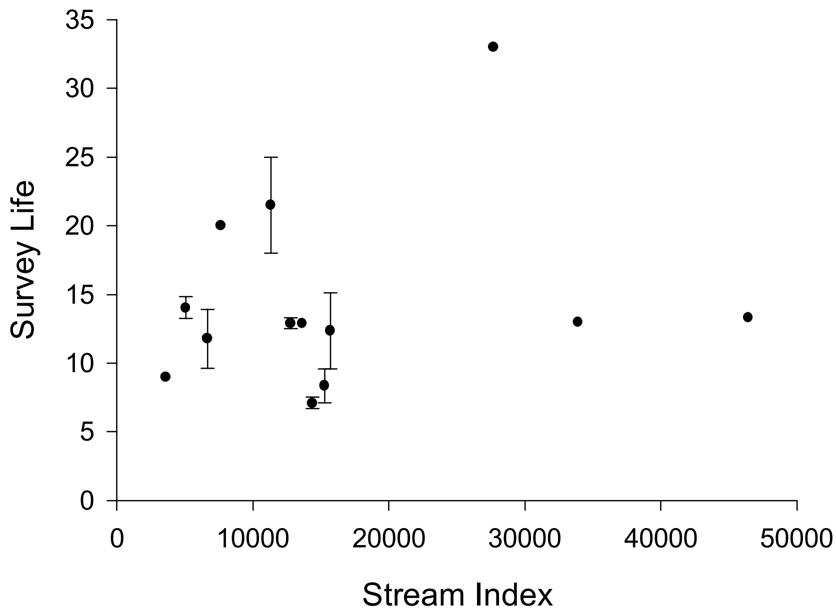


Figure 18. Plot of survey lives versus stream index for BC coastal systems. The average for all coastal systems is 14.5 days. The outlier estimate at 33 days is from Big Qualicum River.

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